4.8 Alternative 4 Analysis

The goal of Alternative 4 is to seek to adopt highly precautionary approaches to managing fisheries under scientific uncertainty. The intent is to minimize the likelihood that fisheries will impose detrimental effects on the environment. This alternative is described in detail in Section 2.6.5.

4.8.1 Target Groundfish Species Analysis

This section examines the potential direct, indirect, and cumulative effects that the implementation of Alternative 4 is expected to have on the target groundfish species. The potential effects of two policy "bookends" are analyzed, FMP 4.1 and FMP 4.2. These represent the policy boundaries of Alternative 4. As actually implemented, Alternative 4 could include policy measures anywhere within the range between the two bookends. The impact analyses start with the baseline (2002) status of the BSAI and GOA target groundfish stocks described in Section 3.5.1, including past trends that are likely to persist into the foreseeable future. Then, a computer-based analytic model is used to project how specific characteristics of the target groundfish stocks would respond directly and indirectly to management actions under each FMP. These projections from the model are the predicted direct and indirect effects (impacts) of the FMP on the target groundfish stocks. Section 4.1.5 describes the analytic model and explains how it is applied.

The model output for each target groundfish stock is defined in terms of collected data and calculated measures that are standards used by fisheries managers to regulate the number of fish removed from the sea so that the fisheries will be sustainable over the long-term. These data and measures include the fishing mortality rate (F), the overfishing level (OFL), total and spawning biomass levels (B), the minimum stock size threshold (MSST), maximum sustainable yield (MSY), mean age of the stock in years, and the sex ratio of the stock (number of males compared to number of females). As discussed in the following subsections, relevant data are not always available for all stocks. When data gaps prevent application of the model to a specific stock, the projected direct or indirect effect is evaluated as unknown (U).

Each target groundfish stock is modeled with respect to the following direct and indirect effects:

Direct Effects

<u>Fishing Mortality</u>: This is the rate at which the stock is depleted by direct mortality imposed by removing the fish from the sea.

<u>Change in Biomass Level</u>: This is the change over time in the biomass of the stock, as measured in metric tons (mt). Two measures are used: total biomass, which is the estimated biomass of the entire stock, and spawning biomass, which is the estimated biomass of all of the spawning females in the stock.

<u>Spatial/Temporal Concentration of Catch</u>: This is the degree to which the fishery will concentrate in a particular geographic area during a particular period of time each season. This pattern in space and time can affect fishing mortality and can also influence habitat suitability for spawning, rearing, and feeding.

Direct and/or Indirect Effects

Habitat Suitability: This is the degree to which habitat has the right characteristics to support the target stock at one or more life-history stages (spawning, rearing of juveniles, availability of food at all stages, availability of refuge areas to allow escape from predators at all stages). Habitat suitability can be affected directly, for example by mechanical damage from bottom trawling, or influenced indirectly, for example by the gradual depletion of corals that provide hard substrate.

Prey Availability: This is the extent to which prey species are present in the environment and available as food to the target stock. Like habitat suitability, this measure can be affected directly, for example by the direct removal of prey species by the fishery, or indirectly, for example by a change in the structure of the food web.

To determine their probable significance, the projected direct and indirect effects in each of the impact categories listed above are evaluated against significance criteria. The criteria are designed to be relevant and meaningful in terms of the target groundfish stocks. Each significance criterion includes a threshold value above (or below) which the projected effect would be considered significant. Each criterion also includes a definition of what would constitute a beneficial (positive, +) or adverse (negative, -) effect. The possible evaluations are significant and beneficial (S+), Insignificant (I), significant and adverse (S-), and Unknown (U). Evaluations of Conditionally Significant (CS + or -) are not made for projected direct and indirect effects on target groundfish species, because the model can show only whether the significance threshold is or is not exceeded. The significance criteria used for the target groundfish stocks are presented in Appendix A, Table 4.1-1.

Each of the following subsections presents the model results and rationale for the expected direct and indirect effects of FMPs 4.1 and 4.2 on the target groundfish stocks. The significance ratings for these potential direct and indirect effects are presented in Appendix A, Table 4.8-1. Following the direct and indirect effects discussions on each stock, the expected cumulative effects on that stock are evaluated and discussed. The evaluation of potential cumulative effects builds on the direct and indirect effects evaluations as a starting point, and then brings in persistent past effects as well as reasonably foreseeable future natural events and human activities external to fisheries management. The cumulative effects assessment method uses the same impact categories and significance criteria discussed above for direct and indirect effects. This method is described further in Section 4.1.4.

4.8.1.1 Pollock

This section provides the direct, indirect and cumulative effects analysis for BSAI and GOA pollock for each of the bookends under Alternative 4. Numerous fishery management actions have been implemented that affect the pollock fisheries in the EBS and GOA. These actions are described in more detail in Sections 3.5.1.1 and 3.5.1.15 of this Programmatic SEIS. Pollock is managed as separate stocks in the BSAI and GOA, and falls under Tier 1 in both the BSAI and GOA groundfish FMPs.

Direct/Indirect Effects FMP 4.1

FMP 4.1 includes the following measures:

- Individual stocks would be removed from stock complexes whenever possible.

- The max F_{ABC} would be capped at $F_{75\%}$ for all stocks of pollock, Pacific cod, Atka mackerel, and rockfish managed in Tiers 1-3, and the max F_{ABC} for each stock or stock complex in Tiers 1-5 would be adjusted downward based on the lower bound of a confidence interval surrounding the survey biomass estimate for that stock or stock complex.

- The OY would be specified separately for each stock or stock complex and set equal to the respective TAC.

- An MSST would be specified in the FMP for all tiers where possible, and a limit would be set equal to $B_{40\%}$ for Tier 3.

Total Biomass

Total biomass (ages 1 through 15+) of EBS pollock at the start of 2002 is estimated to be 12.97 million mt. Model projections of future total EBS pollock biomass are shown in Table H.4-1 of Appendix H. Under FMP 4.1, model projections indicate that EBS pollock biomass is expected to increase to a value of about 14.7 million mt in 2007. The 2003-2007 average total biomass is 13.3 million mt.

In the Aleutian Islands region, the assessments are based trawl surveys that occur every other year. The most recent assessment indicates a biomass level of 175,000 mt. Given that under FMP 4.1 there may be no directed fishing for pollock in this region (the exploitation level is quite low, <1 percent), the expectation is that the stock will remain stable or increase in the future. A similar pattern is expected for the Bogoslof region.

For GOA pollock, the age 2-10+ biomass is expected to increase under this FMP from a 2003 low of 800,000 mt to 1,389,000 mt by 2007. The average biomass over this period is expected to be 1,110,000 mt (Table H.4-23 of Appendix H). This increase is anticipated primarily because recruitment is expected to improve from the recent series of relatively low levels.

Spawning Biomass

Female spawning biomass of EBS pollock in 2002 is estimated to be about 3.68 million mt. Model projections of future levels are shown in Table H.4-1 of Appendix H. Under FMP 4.1, projections indicate that EBS pollock spawning biomass will increase to about 20 percent of the 2002 level by 2007. The projected average for 2003- 2007 is 3.98 million mt.

In the Aleutian Islands region, spawning biomass is monitored by biannual trawl surveys. In the Bogoslof Island region, spawning stock is monitored by echo-integration trawl surveys. Since these areas are likely to be kept at bycatch-only levels under FMP 4.1, it is expected that the spawning stock size will remain stable or increase in these regions.

The 2002 GOA female spawning biomass is estimated at about 136,000 mt and is anticipated to increase steadily to 301,000 mt by 2007 under FMP 4.1. This is above the estimated B_{MSY} level of 210,000 mt as is the average from 2003-2007 of 217,000 mt. Model projections of future levels are shown in Table H.4-23 of Appendix H.

Fishing Mortality

The estimated fishing mortality for the EBS pollock stock in 2002 is 0.187. Model projections show this fishing mortality will decrease by about 76 percent and average 0.045 for the period 2003-2007 (Table H.4-1 of Appendix H). These values are well below the $F_{35\%}$ level of 0.448 and the $F_{75\%}$ level of 0.066, which are taken as proxies for F_{ABC} and F_{OFL}, respectively. The proportion of SPR conserved under these mortality rates is 53 percent in 2002, increasing to 81 percent for 2003-2007. Fishing mortality for the Bogoslof and Aleutian Islands region is expected to remain at less than one percent under FMP 4.1 (Table H.4-2 of Appendix H).

For the GOA, fishing mortality in 2002 is estimated at 0.174 with projections suggesting a decrease to 0.029 in 2003 followed by increases to 0.043 by 2007 (Table H.4-23 of Appendix H). The values for $F_{35\%}$ and $F_{75\%}$ are 0.350 and 0.079, respectively. The SPR rate in 2002 is estimated at 55 percent and averages about 87 percent for the period 2003-2007. This fishing mortality rate pattern is due to the fact that under this FMP, the catch is affected by other factors (such as reduced PSC limits and survey uncertainty corrections).

Spatial/Temporal Concentration of Fishing Mortality

The harvest of EBS pollock occurs largely along the western edge of the EBS shelf during the summer and around the southern areas east of 170°W during the winter season (January 20-March). Under FMP 4.1, an average of 0.401 million mt of EBS pollock is projected to be harvested annually from 2003-2007 with spatial/temporal allocations as presented in Section 3.5.1.1. The Bogoslof and Aleutian Island concentration of fishing mortality is anticipated to remain unchanged over this projection period.

In the GOA, pollock fishery in a broad variety of locales and regional quotas are allocated by season as presented in Section 3.5.1.15 Under FMP 4.1, an average of 21,900 mt of GOA pollock is projected to be harvested annually during 2003-2007 with the largest catch expected to be 33,100 mt in 2007. As the density and quotas of pollock change during this period, the concentration of the pollock fishery will likely change from the 2002 pattern. The effect of these changes is unknown.

Status Determination

Under FMP 4.1, the ABC is set at a lower level than the OFL, creating a buffer between these two harvest regulations. Model projections of future catches of EBS pollock are below the ABC and OFL levels in all years. The EBS pollock are above their respective MSST in the year 2002 and in all subsequent projection years.

For FMP 4.1, GOA pollock spawning biomass is below the B_{MSY} (taken as $B_{35\%}$) in 2002 and remains below this level until 2005. However, based on 10-year status determinations projections, the stock is above the MSST for all years 2003-2007. In FMP 4.1 $B_{40\%}$ is taken as a lower limit of stock size, so catches may be substantially lower than that presented from the projection model. Lower catches would likely lead to higher stock sizes.

Age and Size Composition

Under FMP 4.1, the mean age of the EBS pollock stock at the end of 2007, as computed in model projections, is 2.94 years. This compares with a mean age in an equilibrium unfished stock of 3.16 years. For GOA pollock the 2007 value is 3.34 years compared with an unfished estimate of 3.60 years (note that the GOA pollock assessment is modeled from age 2-10+ while the EBS pollock is modeled from age 1-15+).

Sex Ratio

In the models, the sex ratio of GOA and BSAI pollock is assumed to be 50:50. However, observer data and information from surveys are routinely collected and used to monitor the sex ratios of these stocks. Based on these data, it is unlikely that the sex ratio will be affected under FMP 4.1.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under FMP 4.1.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. An evaluation of potential trophic interactions is presented in Section 3.10. It seems unlikely that significant qualitative changes in predator-prey interactions would be a result of actions taken under FMP 4.1 (for the period 2003-2007).

Summary of Effects of FMP 4.1 – Pollock

Because pollock are fished at less than the OFL and are above the MSST, the direct and indirect effects under FMP 4.1 are considered insignificant. Fishing rates are well below accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity. Based on extended 20-year projections (with the same model assumptions as used in the base 2003-2007 period), both the EBS and GOA pollock are expected to stabilize with catches lower than the expected long-term F_{ABC} catch levels and spawning biomass levels well above the B_{MSY} levels (Table 4.8-1).

Cumulative Effects of FMP 4.1 – EBS Pollock

Cumulative effects for pollock are summarized in Tables 4.5-1 and 4.5-2.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the EBS pollock stock is insignificant under FMP 4.1 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects of the foreign, JV, and domestic fisheries are not expected for the EBS pollock stock. While large removals of pollock did occur in the past, there does not appear to be a lingering effect on the BSAI pollock populations (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** Removals of pollock occur in the Russian pollock fishery, and the catch is not accounted for in the annual harvest rates set for the U.S. fishery. Therefore, the removals can be considered a potential adverse effect on fishing mortality. Catch and bycatch of pollock in the State of Alaska pollock fisheries are not considered to be contributors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels for pollock and do not add additional fishing mortality. Marine pollution is also identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to pollock mortality.

- **Cumulative Effects.** Cumulative effects are identified for mortality of EBS pollock, and the effects are judged to be insignificant. Pollock are fished at less than the OFL and are above the minimum stock size. The combined effect of internal removals and removals due to reasonably foreseeable external events are not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis. The stock is presently above MSY and with the reduced or removed fishing pressure it is likely to remain well above MSY.

<u>Change in Biomass</u>

- **Direct/Indirect Effects.** Change in biomass of the EBS pollock stock is expected to be insignificant under FMP 4.1 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While past large removals of pollock and other past effects on biomass have been identified (see Section 3.5.1.1), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to removals in the Russian and State of Alaska pollock fisheries. However, the effects of any future removals are not expected to affect the ability of the stock to maintain MSST. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to pollock mortality, and therefore would not directly affect biomass.

- **Cumulative Effects**. Cumulative effects for change in biomass are identified; however, the effects are insignificant since the combination of internal and external factors is not expected to sufficiently reduce the pollock biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized. The stock is presently above MSST and the reduced fishing and removal of fishing under the FMP will allow it to remain as such.

Spatial/Temporal Concentration of Catch

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** The spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of pollock and other past effects (see Section 3.5.1.1) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had a beneficial effect on pollock recruitment by reducing the adult pollock biomass, lingering beneficial effects are identified for change in reproductive success. In addition, past commercial whaling and sealing also removed large predators of pollock adding to the potential for reproductive success of the stock. Lingering past effects are also identified due to Climate Changes and Regime Shifts (refer to Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** The Russian and State of Alaska pollock fisheries, have the potential to cause adverse effects. However, the removals are not expected to be sufficiently concentrated to alter the genetic structure of the population. On the other hand, removals in these fisheries, with the exception of the herring fishery, could have a potential beneficial effect on pollock recruitment by reducing the adult pollock biomass. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects**. Cumulative effects are possible under FMP 4.1 for the spatial/temporal concentration; and the effects are insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 4.1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that the FMP would have insignificant effects on pollock prey availability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic fisheries catch and bycatch of pollock prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on pollock prey species (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on pollock prey species could have potentially beneficial or potential adverse effects. A strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries shown on Table 4.5-1 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability under the FMP; however, the effects are insignificant since the combination of internal and external removals of prey species is not expected to increase prey availability such that the ability of the pollock stock to sustain itself at or above MSST is enhanced.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1, as with prey-mediated impacts, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that FMP 4.1 would have insignificant effects on pollock habitat suitability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects identified for EBS pollock stocks include past foreign, JV, and domestic fisheries, and climate changes and regime shifts (refer to Section 3.5.1.1) Intense bottom trawling for pollock in the past fisheries likely disrupted habitat in areas of the EBS. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6 for additional information on the effects of trawling on benthic habitat).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the Russian and State of Alaska fisheries, since any of these may impact bottom habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the EBS pollock stock could be either beneficial or adverse since a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability; however, their significance on the EBS pollock stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the pollock stock to sustain itself at or above MSST is enhanced.

Cumulative Effects of FMP 4.1 – GOA Pollock

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA pollock stock is insignificant under FMP 4.1 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, State of Alaska, and bait fisheries are not expected for the GOA pollock stock. While large removals of pollock did occur in the past, there does not appear to be a lingering effect on the GOA pollock populations (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** Catch and bycatch of pollock in the State of Alaska pollock fisheries and State of Alaska shrimp fisheries are not considered to be contributors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels for pollock and do not add additional fishing mortality. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to pollock mortality.

- **Cumulative Effects.** Cumulative effects are identified for mortality of GOA pollock, but the effects are judged to be insignificant for the FMP. Pollock are fished at less than the OFL and are above the minimum stock size. The combined effect of internal removals and removals due to reasonably foreseeable external events is to jeopardize the capacity of the stock to produce MSY on a continuing basis. The stock is presently well above MSY and the reduction and/or complete removal of fishing will allow it to remain well above MSY.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA pollock stock is expected to be insignificant under FMP 4.1 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While past large removals of pollock and other past effects on biomass have been identified (see Section 3.5.1.15), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to removals in the State of Alaska pollock fisheries. However, any future removals are not expected to affect the ability of the stock to maintain MSST. Marine pollution is identified as having a potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to pollock mortality, thereby would not directly affect biomass.

- **Cumulative Effects**. Cumulative effects for change in biomass are identified; however, the effects are judged to be insignificant. The combination of internal and external factors is not expected to sufficiently reduce the pollock biomass such that the ability of the stock to maintain itself at or above MSST is enhanced.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** As the density and quotas of pollock change during the modeled period, the concentration of the pollock fishery will change from the 2002 pattern; it is not possible to predict exactly how the pattern will change. However, for GOA pollock under FMP 4.1, the stock is expected to be above MSST for the years 2003-2007 (see Direct/Indirect Effects discussion in this section). Therefore, impacts of the spatial/temporal changes should have an insignificant effect on the genetic structure and reproductive success of the population.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of pollock and other past effects (see Section 3.5.1.15) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, there are lingering past effects due to Climate Changes and Regime Shifts (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** State of Alaska pollock fisheries, and the State of Alaska shrimp fishery are identified as potential adverse contributors. However, these fisheries are unlikely to be sufficiently concentrated to alter the genetic structure of the population. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** Cumulative effects are possible for spatial/temporal concentration under FMP 4.1; however, the effects are judged to be insignificant. The combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 4.1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, as described under direct/indirect effects, the FMP would have insignificant effects on pollock prey availability.

- **Persistent Past Effects.** While lingering population level effects from past foreign, State of Alaska, and domestic fisheries catch and bycatch of pollock prey species, and the effects of EVOS on these species, are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on pollock prey species (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** As described for EBS pollock, climate changes and regime shifts could have potential adverse or beneficial effects on pollock prey species. The other fisheries shown on Table 4.5-2 are determined to be potential adverse contributors.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effects are judged to be insignificant. The combination of internal and external removals of prey is not expected to increase prey availability such that the ability of the pollock stock to sustain itself at or above MSST is enhanced.

<u>Change in Habitat Suitability</u>

- **Direct/Indirect Effects.** Under FMP 4.1, as with prey-mediated impacts, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that the FMP would have insignificant effects on pollock habitat suitability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects**. Past effects on habitat suitability identified for GOA pollock stocks include past foreign, JV, and State of Alaska, domestic fisheries, EVOS, and climate changes and regime shifts (see Section 3.5.1.15). Intense bottom trawling for pollock in the past fisheries likely disrupted habitat in areas of the GOA. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6 for additional information on the effects of trawling on benthic habitat).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska Pollock and Shrimp fisheries, since any of these may impact bottom habitat through the use of fishing gear. Impacts on habitat from climate changes and regime shifts on the GOA pollock stock would either be adverse or beneficial since a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability; however, their significance on the GOA pollock stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the pollock stock to sustain itself at or above MSST is enhanced.

Direct/Indirect Effects of FMP 4.2

Under FMP 4.2, it would be required that each individual TAC be set to zero unless it is proven that a higher TAC would have no adverse effect on the environment. For the purposes of the projection model, this was taken to be zero in all cases (since it can be argued that it is impossible to prove that any level of fishing is without adverse effects on the environment).

Total Biomass

Total biomass (ages 1 through 15+) of EBS pollock at the start of 2002 is estimated to be 12.97 million mt. Model projections of future total EBS pollock biomass are shown in Table H.4-1 of Appendix H. Under FMP 4.2, model projections indicate that EBS pollock biomass is expected to increase to a value of about 15.9 million mt in 2007. The 2003-2007 average total biomass is 13.9 million mt.

In the Aleutian Islands region, the assessments are based trawl surveys that occur every other year. The most recent assessment indicates a biomass level of 175,000 mt. The expectation is that the stock will remain stable or increase in the future. A similar pattern is expected for the Bogoslof Island region.

For GOA pollock, the age 2-10+ biomass is expected to increase under this FMP from a 2003 low of 800,000 mt to 1,450,000 mt by 2007. The average biomass over this period is expected to be 1,136,000 mt. This increase is anticipated primarily because recruitment is expected to improve from the recent series of relatively low levels (Table H.4-23 of Appendix H).

Spawning Biomass

Female spawning biomass of EBS pollock in 2002 is estimated to be about 3.68 million mt. Model projections of future levels are shown in Table H.4-1 of Appendix H. Under FMP 4.2, projections indicate that EBS pollock spawning biomass will increase to about 120 percent of the 2002 level by 2007. The projected average for 2003-2007 is 4.31 million mt.

In the Aleutian Islands region, spawning biomass is monitored by biannual trawl surveys. In the Bogoslof Island region, spawning stock is monitored by echo-integration trawl surveys. Since under FMP 4.2 these areas are kept at bycatch-only levels, it is expected that the spawning stock size will remain stable or increase in these regions.

The 2002 GOA female spawning biomass is estimated at about 136,000 mt and is anticipated to increase steadily to 327,000 mt by 2007 under FMP 4.2. This is above the estimated B_{MSY} level of 210,000 mt as is the 2003-2007 average of 228,000 mt. Model projections of future levels are shown in Table H.4-23 of Appendix H.

Fishing Mortality

Under FMP 4.2, the projected TAC has been set to zero for all species unless the harvesting of a species has been shown to have no adverse effect on the environment. Thus, there is no fishery for GOA and BSAI pollock from 2003-2007 (Tables H.4-1, H.4-2, and H.4-23 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 4.2, there is no projected fishing mortality.

Status Determination

The EBS and GOA pollock are above their MSST in the year 2002. Because of the removal of fishing mortality under FMP 4.2, these stocks of pollock are also projected to be above the MSST level from 2003-2007.

Age and Size Composition

Under FMP 4.2, the mean age of the EBS pollock stock at the end of 2007, as computed in model projections, is 3.11 years. This compares with a mean age in an equilibrium unfished stock of 3.16 years. For GOA pollock the 2007 value is 3.45 years compared with an unfished estimate of 3.60 years (note that the GOA pollock assessment is modeled from age 2-10+ while EBS pollock is modeled from age 1-15+).

Sex Ratio

It is unknown how the sex ratio may change under FMP 4.2. For model purposes, a 50:50 sex ratio was assumed for all pollock stocks.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under this FMP 4.2.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 4.2.

Summary of Effects of FMP 4.2 – Pollock

With the removal of fishing for pollock, the direct and indirect effects under FMP 4.2 are considered insignificant with the exception of change in biomass which is rated as significantly beneficial. The removal of fishing is anticipated to move the stock to above $B_{60\%}$, and the spawning biomass is expected to increase by more than 15 percent (Table 4.8-1).

Cumulative Effects of FMP 4.2 – EBS Pollock

Cumulative effects for pollock are summarized in Tables 4.5-1 and 4.5-2.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the EBS pollock stock is insignificant under FMP 4.2 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects of the foreign, JV, and domestic fisheries are not expected for the EBS pollock stock. While large removals of pollock did occur in the past, there does not appear to be a lingering effect on the BSAI pollock populations (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, removals of pollock that occur in the Russian pollock fishery are considered to be a potential adverse contribution while removals in the State of Alaska pollock fisheries are not considered to be contributors to fishing mortality in the cumulative case. Marine pollution is also identified as having a reasonably foreseeable potential adverse contribution, and climate changes and regime shifts are not identified as being contributors to pollock mortality.

- **Cumulative Effects.** Cumulative effects are identified for mortality of EBS pollock, but the effects are judged to be insignificant. Pollock are fished at less than the OFL and are above the minimum stock size. The combined effect of internal removals and removals due to reasonably foreseeable external events are not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis. The stock is presently above MSY and with the reduced or removed fishing pressure it is likely to remain well above MSY.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the EBS pollock stock is expected to be significantly beneficial under the FMP (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While past large removals of pollock and other past effects on biomass have been identified (see Section 3.5.1.1), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are the same as those described for FMP 4.1 and include the Russian and State of Alaska pollock fisheries and marine pollution.

- **Cumulative Effects.** Cumulative effects for change in biomass are identified; the effects are judged to be significantly beneficial since the reduction in pollock biomass is such that the ability of the stock to maintain itself at or above MSST is enhanced. The stock is presently above MSST and the reduced fishing and removal of fishing under the FMP will allow it to remain as such.

Spatial/Temporal Concentration of Catch
– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.2, model projections assume that 0 mt of pollock would be harvested over the same period. There is no spatial/temporal distribution of catch so there is an insignificant effect on the genetic structure and reproductive success of the population (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects under FMP 4.2 are identical to those described for FMP 4.1 and include lingering beneficial effects on reproductive success.

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, the Russian and State of Alaska pollock fisheries, have the potential to cause adverse effects on genetic structure and on pollock recruitment by reducing the adult pollock biomass. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** Cumulative effects are possible under FMP 4.2 for the spatial/temporal concentration; however, the effects are insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is enhanced.

<u>Change in Prey Availability</u>

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that the FMP would have insignificant effects on pollock prey availability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic fisheries catch and bycatch of pollock prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on pollock prey species (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on pollock prey species could have potential beneficial or potential adverse effects (see Direct/Indirect Effects discussion in this section). Marine pollution has been identified as a reasonably foreseeable future external contributing factor and the other fisheries shown on Table 4.8-1 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue since these other fisheries are assumed to continue.

- **Cumulative Effects**. Cumulative effects are identified for prey availability; however, the effects are insignificant since the combination of internal and external removals of prey species is not expected to increase prey availability such that the ability of the pollock stock to sustain itself at or above MSST is enhanced.

<u>Change in Habitat Suitability</u>

- **Direct/Indirect Effects.** Under FMP 4.2, as with prey-mediated impacts, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that the FMP would have insignificant effects on pollock habitat suitability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects identified for EBS pollock stocks include past foreign, JV, and domestic fisheries, and climate changes and regime shifts (see Section 3.5.1.1) Intense bottom trawling for pollock in past fisheries likely disrupted habitat in areas of the EBS. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6 for additional information on the effects of trawling on benthic habitat).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, adverse effects are possible from the Russian and State of Alaska fisheries, and marine pollution. Impacts on habitat from climate changes and regime shifts on the EBS pollock stock could be beneficial or adverse.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability; however, their significance on the EBS pollock stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the pollock stock to sustain itself at or above MSST is enhanced.

Cumulative Effects of FMP 4.2 – GOA Pollock

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA pollock stock is insignificant under FMP 4.2 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, State of Alaska, and bait fisheries are not expected for the GOA pollock stock. While large removals of pollock did occur in the past, there does not appear to be a lingering effect on the GOA pollock populations (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, catch and bycatch of pollock in the State of Alaska pollock fisheries and State of Alaska shrimp fisheries are not considered to be contributors to fishing mortality in the cumulative case. Marine pollution is identified as having a potential adverse contribution, and climate changes and regime shifts are not identified as being contributors to pollock mortality.

- **Cumulative Effects.** Cumulative effects are identified for mortality of GOA pollock, but the effects are judged to be insignificant for FMP 4.2. Pollock are fished at less than the OFL and are above the minimum stock size. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis. The stock is presently well above MSY and the reduction and/or complete removal of fishing will allow it to remain well above MSY.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA pollock stock is expected to be insignificant under FMP 4.2 (see Section 4.8.1.1).

- **Persistent Past Effects.** While past large removals of pollock and other past effects on biomass have been identified (see Section 3.5.1.15), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, effects on biomass are indicated due to removals in the State of Alaska pollock fisheries. Marine pollution is identified as having a potential adverse contribution, and climate changes and regime shifts are not identified as being contributors to pollock mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** Cumulative effects for change in biomass are identified, but the effects are judged to be insignificant for FMP 4.2. The combination of internal and external factors is not expected to sufficiently reduce the pollock biomass such that the ability of the stock to maintain itself at or above MSST is enhanced.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** As described in the direct/indirect discussion, impacts of the spatial/temporal changes should have an insignificant effect on the genetic structure and reproductive success of the population.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of pollock and other past effects (see Section 3.5.1.15) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, there are lingering past effects due to Climate Changes and Regime Shifts (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, the State of Alaska pollock fisheries, the State of Alaska shrimp fishery, and marine pollution could contribute adversely to genetic changes and reduced recruitment.

- **Cumulative Effects.** Cumulative effects are possible for spatial/temporal concentration, but the effects are judged to be insignificant for FMP 4.2. The combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify (see direct/indirect effects discussion). However, it is determined that the FMP would have insignificant effects on pollock prey availability.

- **Persistent Past Effects.** While lingering population level effects from past foreign, state, and domestic fisheries catch and bycatch of pollock prey species, and the effects of EVOS on these species, are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on pollock prey species (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, climate changes and regime shifts could have potential adverse or beneficial effects on pollock prey species. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor, and the other fisheries shown on Table 4.5-2 are determined to be potential adverse contributors since they are assumed to continue.

- **Cumulative Effects**. Cumulative effects are identified for prey availability, but the effects are judged to be insignificant for FMP 4.2. The combination of internal and external removals of prey is not expected to increase prey availability such that the ability of the pollock stock to sustain itself at or above MSST is enhanced.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.2, as with prey-mediated impacts, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify (see Direct/Indirect Effects discussion in this section). However, it is determined that the FMP would have insignificant effects on pollock habitat suitability.

- **Persistent Past Effects.** Past effects on habitat suitability identified for GOA pollock stocks include past foreign, JV, and, State of Alaska, and domestic fisheries, EVOS, and climate changes and regime shifts (see Section 3.5.1.15). Intense bottom trawling for pollock in the past fisheries likely disrupted habitat in areas of the GOA. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6 for additional information on the effects of trawling on benthic habitat).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska pollock and shrimp fisheries, since any of these may impact bottom habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the GOA pollock stock would be either adverse or beneficial as described for EBS pollock, although a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability for FMP 4.2; however, their significance on the GOA pollock stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the pollock stock to sustain itself at or above MSST is enhanced.

4.8.1.2 Pacific Cod

This section provides the direct, indirect, and cumulative effects analysis for BSAI and GOA Pacific cod for each of the bookends under Alternative 4. The goal of Alternative 4 is to seek to adopt highly precautionary approaches to managing fisheries under scientific uncertainty. The intention is to minimize the likelihood that fisheries impose any detrimental effects on the environment.

Direct/Indirect Effects of FMP 4.1

Total Biomass

Total (ages 1 through 12+) biomass of BSAI Pacific cod at the start of 2002 is estimated to be 1,933,000 mt. Model projections of future total BSAI biomasses are shown in Table H.4-3 of Appendix H. Under FMP 4.1, model projections indicate that total BSAI biomass is expected to increase steadily to a value of 2,683,000 mt in 2007, with a 2003-2007 average value of 2,401,000 mt.

Total (ages 1 through 12+) biomass of GOA Pacific cod at the start of 2002 is estimated to be 568,000 mt. Model projections of future total GOA biomasses are shown in Table H.4-24 of Appendix H. Under FMP 4.1, model projections indicate that total GOA biomass is expected to increase steadily to a value of 793,000 mt in 2007, with a 2003-2007 average value of 688,000 mt.

Spawning Biomass

Spawning biomass of female BSAI Pacific cod at the start of 2002 was estimated to be 404,500 mt. Model projections of future BSAI spawning biomasses are shown in Table H.4-3 of Appendix H. Under FMP 4.1, model projections indicate that BSAI spawning biomass is expected to increase steadily to a value of 672,000 mt in 2007, with a 2003-2007 average value of 557,000 mt. Projected spawning biomass never decreases below the B_{MSY} proxy value of 361,000 mt for the years 2003-2007.

Spawning biomass of female GOA Pacific cod at the start of 2002 was estimated to be 97,900 mt. Model projections of future GOA spawning biomasses are shown in Table H.4-24 of Appendix H. Under FMP 4.1, model projections indicate that GOA spawning biomass is expected to decrease to a value of 91,100 mt in 2003, then increase to a value of 127,200 mt in 2007, with a 2003-2007 average value of 106,600 mt. Projected spawning biomass never decreases below the B_{MSY} proxy value of 79,000 mt for the years 2003-2007.

Fishing Mortality

The fishing mortality rate imposed on the BSAI Pacific cod stock in 2002 was estimated to be 0.228. Model projections of future BSAI fishing mortality rates are shown in Table H.4-3 of Appendix H. Under FMP 4.1, model projections indicate that BSAI fishing mortality will decrease to a value of 0.066 in 2003, then remain there through 2007, with a 2003-2007 average of 0.066. These values are well below the F_{MSY} proxy value of 0.409, which is the rate associated with the OFL for stocks above $B_{40\%}$.

The fishing mortality rate imposed on the GOA Pacific cod stock in 2002 was estimated to be 0.255. Model projections of future GOA fishing mortality rates are shown in Table H.4-24 of Appendix H. Under FMP 4.1, model projections indicate that GOA fishing mortality is expected to decrease steadily to a value of 0.066 in 2007, with a 2003-2007 average of 0.068. These values are well below the F_{MSY} proxy value of 0.421, which is the rate associated with the OFL for stocks above $B_{40\%}$.

Under FMP 4.1, the TAC for a stock complex would be computed by applying the appropriate max_{ABC} control rule to each of the component stocks and then setting the TAC equal to the minimum of the resulting values. Therefore, TAC for stock complexes under FMP 4.1 would be lower than under the existing policy, all else being equal. This aspect of FMP 4.1 was not included in the projection model, meaning that some projected fishing mortality rates may have been overestimated to some extent. For example, some projected rates for fisheries associated with bycatch of stocks belonging to stock complexes may have been overestimated. Because the fisheries for Pacific cod impose bycatch mortality on several stock complexes, it is possible that projected fishing mortality rates for Pacific cod under FMP 4.1 were overestimated. If this is the case, it would also follow that projected biomasses for Pacific cod under FMP 4.1 were underestimated.

Spatial/Temporal Concentration of Fishing Mortality

Certain areas that are currently open to fishing would be closed under FMP 4.1. If these closures had been in place in 2001, it is estimated that the following proportions of the 2001 Pacific cod catch would have been displaced from each sub-region:

Area:	Bering Sea	Aleutian Islands	Western GOA	Central GOA	Eastern GOA
Proportion of catch displaced:	0.451	0.659	0.612	0.627	0.164

Under FMP 4.1, catches of Pacific cod are projected to decrease substantially in both the BSAI and GOA, meaning that the imposition of new closed areas will not necessarily tend to increase the amount of catch taken from the remaining open areas.

Under FMP 4.1, it is likely that fishing for BSAI and GOA Pacific cod would tend, to some extent, to be concentrated in space and time so as to coincide with concentrations of spawning fish. Evaluating the effects of such concentrations of fishing mortality is difficult for two reasons: 1) Such concentrations of fishing mortality have already been in place for many years. Although the stocks currently appear to be healthy despite such concentrations, the absence of a "control" treatment makes it difficult to determine which population characteristics are attributable specifically to the existing spatial/temporal concentrations of fishing mortality. 2) Pacific cod undergo large migrations and a large degree of genetic mixing appears to exist. Compared to a sedentary species with readily identifiable genetic subunits, this means that the effects of spatial/temporal concentrations of fishing effort are probably diluted to some extent, but also that their evaluation involves a larger number of difficult-to-estimate parameters.

Status Determination

Model projections of future catches of BSAI and GOA Pacific cod are below their respective OFLs in all years under FMP 4.1. In every year throughout the period 2003-2007, the BSAI and GOA Pacific cod stocks are projected to be above $B_{40\%}$,which is the MSST for Tier 3 under this FMP (Tables H.4-3 and H.4-24 of Appendix H).

Age and Size Composition

Under FMP 4.1, the projected mean age of the BSAI Pacific cod stock in 2008 is 2.8 years. This compares with a mean age in the equilibrium unfished BSAI stock of 3.2 years.

Under FMP 4.1, the projected mean age of the GOA Pacific cod stock in 2008 is 2.8 years. This compares with a mean age in the equilibrium unfished GOA stock of 3.2 years.

Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of Pacific cod in both the BSAI and GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next 5 years under this FMP.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 on Pacific cod would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under this FMP.

Summary of Effects of FMP 4.1 – Pacific Cod

Relationship to Comparative Baseline

The comparative baselines for BSAI and GOA Pacific cod are identical: Neither stock is overfished, the biomass of both stocks is below $B_{40\%}$ and has been decreasing for the last few years, and all catch and bycatch are accounted for in the management of both stocks. Under FMP 4.1, both stocks are projected to remain above MSST throughout the period 2003-2007, the biomass of both stocks is projected to be above $B_{40\%}$ throughout the period 2003-2007, the biomass of both stocks is expected to show an overall increase during the period 2003-2007 and beyond, and all catch and bycatch would continue to be accounted for in the management of both stocks.

Significance of Direct and Indirect Effects

The criteria used to rate the significance of impacts of FMP 4.1 on the BSAI and GOA stocks of Pacific cod are identical to those used for the other groundfish stocks. The rating of conditionally significant (either beneficial or adverse) is not applicable to any of the direct or indirect effects of FMP 4.1 on BSAI or GOA Pacific cod.

For the BSAI and GOA Pacific cod stocks, the impact of FMP 4.1 on fishing mortality is rated "insignificant," because the projection model indicates that fishing mortality would be less than the OFL throughout the period 2003-2007.

For the GOA Pacific cod stock, the impact of FMP 4.1 on biomass is rated "insignificant," because the projection model indicates that biomass would be above the MSST throughout the period 2003-2007. For the BSAI Pacific cod stock, the impact of FMP 4.1 on biomass is rated "significant (beneficial)," because the projection model indicates not only that biomass would be above the MSST throughout the period 2003-2007, but also that the expected biomass in 2007 is greater than $B_{60\%}$ and the difference between the expected biomass in 2007 and the estimated biomass in 2002 is greater than 15 percent of the equilibrium unexploited biomass.

Because the existing spatial-temporal concentration of the catch does not appear to have led to changes in the genetic structure of the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the impacts of spatial-temporal concentration on genetic structure under FMP 4.1 are expected to be no greater than those of the existing concentration, the magnitude of this effect is rated insignificant for both stocks.

Likewise, because the existing spatial-temporal concentration of the catch does not appear to have led to changes in the reproductive success of the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the impacts of spatial-temporal concentration on reproductive success under FMP 4.1 are expected to be no greater than those of the existing concentration, the magnitude of this effect is rated insignificant for both stocks.

Likewise, because the existing level of groundfish harvest does not appear to have led to changes in prey availability for the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the level of groundfish harvest under FMP 4.1 is expected to be no greater than the existing level, the magnitude of this effect is rated insignificant for both stocks.

Likewise, because the existing level of habitat disturbance does not appear to have led to changes in spawning or rearing success in the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the level of habitat disturbance under FMP 4.1 is expected to be no greater than the existing level, the magnitude of this effect is rated insignificant for both stocks (Table 4.8-1).

Cumulative Effects of FMP 4.1 – BSAI Pacific Cod

For further information regarding persistent past effects listed below in the text and in the tables, please refer to the past/present effects analysis section of Section 3.5.1.2. Cumulative effects for Pacific cod are summarized in Tables 4.5-3 and 4.5-4.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Pacific cod stock is insignificant under FMP 4.1 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries are identified for the BSAI Pacific cod stock. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** While bycatch and removals of Pacific cod are predicted to continue in the IPHC longline fishery, State of Alaska crab fishery and subsistence/personal use fishery in the BSAI, these are not expected to be contributing factors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels for Pacific cod and do not add additional fishing mortality. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI Pacific cod, but the effect is judged to be insignificant. Pacific cod are fished at less than the OFL and all catch and bycatch are accounted for in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis. The stock is presently above MSY and with the reduced or removed fishing pressure it is likely to remain well above MSY.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Pacific cod stock is expected to be significantly beneficial under the FMP (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While past large removals of Pacific cod and other past effects on biomass have been identified (see Section 3.5.1.2), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to bycatch in the IPHC longline and State of Alaska crab fisheries, and bycatch and removals in the subsistence/ personal use fishery in the BSAI. However, these removals are not expected to affect the ability of the stock to maintain MSST. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** Cumulative effects for change in biomass are identified under the FMP; the effects are significantly beneficial since the combination of internal and external factors could to sufficiently increase the Pacific cod biomass such that the ability of the stock to maintain itself at or above MSST is enhanced.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population (see Direct/Indirect Effects discussion in this section). Pacific cod are migratory species and a large degree of genetic mixing appears to exist. This likely means that the spatial/temporal concentration of fishing effort is diluted to some extent.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of Pacific cod and other past effects (see Section 3.5.1.2) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had an adverse effect on Pacific cod recruitment, lingering effects are identified for change in reproductive success. Lingering past effects (either beneficial or adverse depending on the regime) are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline and State of Alaska crab fisheries, and subsistence use in the BSAI, have the potential to cause adverse effects. However, the removals are not expected to be sufficiently concentrated to alter the genetic structure of the population. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 4.1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that the FMP would have insignificant effects on Pacific cod prey availability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic and state fisheries catch and bycatch of Pacific cod prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific cod prey species (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on Pacific cod prey species could be either beneficial or adverse since a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries shown on Table 4.8-1 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the ability of the Pacific cod stock to sustain itself at or above MSST is enhanced.

<u>Change in Habitat Suitability</u>

- **Direct/Indirect Effects.** Under FMP 4.1, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that the FMP would have insignificant effects on Pacific cod habitat suitability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects identified for BSAI Pacific cod stock include past foreign, JV, and domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline, and climate changes and regime shifts (see Section 3.5.1.2). Past fishing for Pacific cod in the past fisheries likely disrupted habitat in areas of the BSAI. It is possible that some of these areas have not recovered (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska fisheries, subsistence, and the IPHC fishery since any of these may impact bottom habitat through the use of fishing gear. As described above for prey availability, impacts on habitat from climate changes and regime shifts on the BSAI Pacific cod stock could be either beneficial or adverse. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability; however, the effect is insignificant since any impacts on habitat suitability are not expected to affect the Pacific cod stock such that its ability to sustain itself at or above MSST is enhanced.

GOA Pacific Cod

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA Pacific cod stock is insignificant under FMP 4.1 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries are identified for the GOA Pacific cod stock. Additionally, the State of Alaska groundfish fishery contributed to past removals in the GOA. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** While bycatch and removals of Pacific cod are predicted to continue in the IPHC longline fishery, State of Alaska crab fishery, subsistence/personal use fishery, and in the State of Alaska groundfish fisheries in the GOA, these are not expected to be contributing factors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels for Pacific cod and do not add additional fishing mortality. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA Pacific cod, but the effect is judged to be insignificant. Pacific cod are fished at less than the OFL and all catch and bycatch are accounted for in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis. The stock is presently above MSY and with the reduced or removed fishing pressure it is likely to remain well above MSY.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA Pacific cod stock is expected to be insignificant under the FMP (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While past large removals of Pacific cod and other past effects on biomass have been identified (see Section 3.5.1.16), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to bycatch in the IPHC longline and State of Alaska crab fisheries, and bycatch and removals in the subsistence/personal use fishery, and in the State of Alaska groundfish fisheries. However, these removals are not expected to affect the ability of the stock to maintain MSST. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified under the FMP; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently reduce the GOA Pacific cod biomass such that the ability of the stock to maintain itself at or above MSST is enhanced.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of Pacific cod and other past effects (see Section 3.5.1.16) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had an adverse effect on Pacific cod recruitment particularly in the GOA where the State of Alaska groundfish fishery is very localized, lingering effects are identified for change in reproductive success. Lingering past effects (either beneficial or adverse depending on the regime) are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline and State of Alaska crab fisheries, subsistence use, and State of Alaska groundfish fisheries, have the potential to cause adverse effects. However, the removals are not expected to be sufficiently concentrated to alter the genetic structure of the population. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration under FMP 4.1; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of the FMP would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that FMP 4.1 would have insignificant effects on Pacific cod prey availability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While lingering population level effects from past foreign, domestic, and State of Alaska fisheries catch and bycatch of Pacific cod prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific cod prey species (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** As described for the Bering Sea, effects of climate changes and regime shifts on Pacific cod prey species could be either beneficial or adverse. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor and the other fisheries shown on Table 4.5-4 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the ability of the GOA Pacific cod stock to sustain itself at or above MSST is enhanced.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that the FMP would have insignificant effects on Pacific cod habitat suitability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects identified for GOA Pacific cod include past foreign, JV, and domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline, and climate changes and regime shifts (see Section 3.5.1.16). Additionally, the State of Alaska groundfish fishery contributed to habitat impacts in the GOA. Fishing for Pacific cod in the past fisheries likely disrupted habitat in areas of the GOA. It is possible that some of these areas have not recovered (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska fisheries, subsistence, and the IPHC fishery since any of these may impact bottom habitat through use of fishing gear. As described for the Bering Sea, impacts on habitat from climate changes and regime shifts on the GOA Pacific cod stock could be either beneficial or adverse. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects is identified for habitat suitability; however, the effect is insignificant since any impacts on habitat suitability are not expected to affect the Pacific cod stock such that its ability to sustain itself at or above MSST is enhanced.

Direct/Indirect Effects of FMP 4.2

Total Biomass

Total (ages 1 through 12+) biomass of BSAI Pacific cod at the start of 2002 is estimated to be 1,933,000 mt. Model projections of future total BSAI biomasses are shown in Table H.4-3 of Appendix H. Under FMP 4.2, model projections indicate that total BSAI biomass is expected to increase steadily to a value of 2,930,000 mt in 2007, with a 2003-2007 average value of 2,528,000 mt.

Total (ages 1 through 12+) biomass of GOA Pacific cod at the start of 2002 is estimated to be 568,000 mt. Model projections of future total GOA biomasses are shown in Table H.4-24 of Appendix H. Under FMP 4.2, model projections indicate that total GOA biomass is expected to increase steadily to a value of 841,000 mt in 2007, with a 2003-2007 average value of 713,000 mt.

Spawning Biomass

Spawning biomass of female BSAI Pacific cod at the start of 2002 was estimated to be 404,500 mt. Model projections of future BSAI spawning biomasses are shown in Table H.4-3 of Appendix H. Under FMP 4.2, model projections indicate that BSAI spawning biomass is expected to increase steadily to a value of 775,000 mt in 2007, with a 2003-2007 average value of 609,000 mt. Projected spawning biomass never decreases below the B_{MSY} proxy value of 361,000 mt for the years 2003-2007.

Spawning biomass of female GOA Pacific cod at the start of 2002 was estimated to be 97,900 mt. Model projections of future GOA spawning biomasses are shown in Table H.4-24 of Appendix H. Under FMP 4.2, model projections indicate that GOA spawning biomass is expected to decrease to a value of 91,800 mt in 2003, then increase to a value of 144,700 mt in 2007, with a 2003-2007 average value of 115,700 mt. Projected spawning biomass never decreases below the B_{MSY} proxy value of 79,000 mt for the years 2003-2007.

Fishing Mortality

The fishing mortality rate imposed on the BSAI Pacific cod stock in 2002 was estimated to be 0.228. Model projections of future BSAI fishing mortality rates are shown in Table H.4-3 of Appendix H. Under FMP 4.2, model projections indicate that BSAI fishing mortality will decrease to a value of 0 in 2003, then remain there through 2007, with a 2003-2007 average of 0. These values are well below the F_{MSY} proxy value of 0.409, which is the rate associated with the OFL for stocks above $B_{40\%}$.

The fishing mortality rate imposed on the GOA Pacific cod stock in 2002 was estimated to be 0.255. Model projections of future GOA fishing mortality rates are shown in Table H.4-24 of Appendix H. Under FMP 4.2, model projections indicate that GOA fishing mortality is expected to decrease to a value of 0 in 2003, then remain there through in 2007, with a 2003-2007 average of 0. These values are well below the F_{MSY} proxy value of 0.421, which is the rate associated with the OFL for stocks above $B_{40\%}$.

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 4.2, if fishing for BSAI or GOA Pacific cod is allowed, it is likely that such fishing would tend, to some extent, to be concentrated in space and time so as to coincide with concentrations of spawning fish. Evaluating the effects of such concentrations of fishing mortality is difficult for two reasons: 1) Such concentrations of fishing mortality have already been in place for many years. Although the stocks currently appear to be healthy despite such concentrations, the absence of a "control" treatment makes it difficult to determine which population characteristics are attributable specifically to the existing spatial/temporal concentrations of fishing mortality. 2) Pacific cod undergo large migrations and a large degree of genetic mixing appears to exist. Compared to a sedentary species with readily identifiable genetic subunits, this means that the effects of spatial/temporal concentrations of fishing effort are probably diluted to some extent, but also that their evaluation involves a larger number of difficult-to-estimate parameters.

Status Determination

Model projections of future catches of BSAI and GOA Pacific cod are below their respective OFLs in all years under FMP 4.2. The BSAI and GOA Pacific cod stocks are projected to be above $B_{35\%}$ and therefore above their respective MSSTs in every year throughout the period 2003-2007 (Tables H.4-3 and H.4-24 of Appendix H).

Age and Size Composition

Under FMP 4.2, the projected mean age of the BSAI Pacific cod stock in 2008 is 2.8 years. This compares with a mean age in the equilibrium unfished BSAI stock of 3.2 years.

Under FMP 4.2, the projected mean age of the GOA Pacific cod stock in 2008 is 2.8 years. This compares with a mean age in the equilibrium unfished GOA stock of 3.2 years.

Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of Pacific cod in both the BSAI and GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next 5 years under this FMP.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.2 on Pacific cod would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under this FMP.

Summary of Effects of FMP 4.2 – Pacific Cod

Relationship to Comparative Baseline

The comparative baselines for BSAI and GOA Pacific cod are identical: Neither stock is overfished, the biomass of both stocks is below $B_{40\%}$ and has been decreasing for the last few years, and all catch and bycatch are accounted for in the management of both stocks. Under FMP 4.2, both stocks are projected to remain above MSST throughout the period 2003-2007, the biomass of both stocks is projected to be above $B_{40\%}$ throughout the period 2003-2007, the biomass of both stocks is expected to show an overall increase during the period 2003-2007 and beyond, and all catch and bycatch would continue to be accounted for in the management of both stocks.

Significance of Direct and Indirect Effects

The criteria used to rate the significance of impacts of FMP 4.2 on the BSAI and GOA stocks of Pacific cod are identical to those used for the other groundfish stocks. The rating of conditionally significant (either beneficial or adverse) is not applicable to any of the direct or indirect effects of FMP 4.2 on BSAI or GOA Pacific cod.

For the BSAI and GOA Pacific cod stocks, the impact of FMP 4.2 on fishing mortality is rated "insignificant," because the projection model indicates that fishing mortality would be less than the OFL throughout the period 2003-2007.

For the BSAI and GOA Pacific cod stocks, the impact of FMP 4.2 on biomass is rated "significant (beneficial)," because the projection model indicates that the expected biomass in 2007 is greater than $B_{60\%}$ and the difference between the expected biomass in 2007 and the estimated biomass in 2002 is greater than 15 percent of the equilibrium unexploited biomass.

Because the existing spatial-temporal concentration of the catch does not appear to have led to changes in the genetic structure of the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the impacts of spatial-temporal concentration on genetic structure under FMP 4.2 are expected to be no greater than those of the existing concentration, the magnitude of this effect is rated insignificant for both stocks.

Likewise, because the existing spatial-temporal concentration of the catch does not appear to have led to changes in the reproductive success of the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the impacts of spatial-temporal concentration on reproductive success under FMP 4.2 are expected to be no greater than those of the existing concentration, the magnitude of this effect is rated insignificant for both stocks.

Likewise, because the existing level of groundfish harvest does not appear to have led to changes in prey availability for the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the level of groundfish harvest under FMP 4.2 is expected to be no greater than the existing level, the magnitude of this effect is rated insignificant for both stocks.

Likewise, because the existing level of habitat disturbance does not appear to have led to changes in spawning or rearing success in the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the level of habitat disturbance under FMP 4.2 is expected to be no greater than the existing level, the magnitude of this effect is rated insignificant for both stocks (Table 4.8-1).

Cumulative Effects FMP 4.2

Cumulative effects for Pacific cod are summarized in Tables 4.5-3 and 4.5-4.

BSAI Pacific Cod

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI and Pacific cod stock is insignificant under FMP 4.2 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries are identified for the BSAI Pacific cod stock. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1 in the BSAI, bycatch and removals of Pacific cod are predicted to continue in the IPHC longline fishery, State of Alaska crab fishery and subsistence/personal use fishery in the BSAI, but these are not expected to be contributing factors to fishing mortality in the cumulative case. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution and climate changes and regime shifts are not identified as being contributors to Pacific cod mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI Pacific cod, but the effect is judged to be insignificant. Pacific cod are fished at less than the OFL and all catch and bycatch are accounted for in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis. The stock is presently above MSY and with the reduced or removed fishing pressure it is likely to remain well above MSY.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Pacific cod stock is expected to be significantly beneficial under the FMP (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While past large removals of Pacific cod and other past effects on biomass have been identified (see Section 3.5.1.2), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, effects on biomass are indicated due to bycatch in the IPHC longline and State of Alaska crab fisheries, and bycatch and removals in the subsistence/personal use fishery in the BSAI. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass and climate changes and regime shifts are not identified as being contributors to Pacific cod mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** Cumulative effects for change in biomass are identified under the FMP; the effects are significantly beneficial since the combination of internal and external factors could sufficiently increase the Pacific cod biomass such that the ability of the stock to maintain itself at or above MSST is enhanced.

Spatial/Temporal Concentration of Catch
- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.2, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of Pacific cod and other past effects (see Section 3.5.1.2) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had an adverse effect on Pacific cod recruitment, lingering effects are identified for change in reproductive success. Lingering past effects (either beneficial or adverse depending on the regime) are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, the IPHC longline and State of Alaska crab fisheries, and subsistence use in the BSAI have the potential to cause adverse effects. Marine pollution could also contribute adversely to genetic changes and reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that the FMP would have insignificant effects on Pacific cod prey availability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic and State of Alaska fisheries catch and bycatch of Pacific cod prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific cod prey species (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, the effects of climate changes and regime shifts on Pacific cod prey species could be either beneficial or adverse. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor and the other fisheries shown on Table 4.8-1 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey is not expected to increase prey availability such that the Pacific cod stock is unable to sustain itself at or above MSST is enhanced.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.2, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, the removal of fishing pressure is determined to have insignificant effects on habitat suitability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects**. Past effects identified for BSAI Pacific cod stock include past foreign, JV, and domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline, and climate changes and regime shifts (see Section 3.5.1.2). Fishing for Pacific cod in the past fisheries likely disrupted habitat in areas of the BSAI. It is possible that some of these areas have not recovered (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, effects are possible from the State of Alaska fisheries, subsistence, and the IPHC fishery since any of these may impact bottom habitat through the use of fishing gear. Impacts on habitat from climate changes and regime shifts on the BSAI Pacific cod stock could be either beneficial or adverse. Marine pollution has been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability. Under FMP 4.2, the significance of the cumulative effect is rated as insignificant.

GOA Pacific Cod

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA Pacific cod stock is insignificant under FMP 4.2 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries are identified for the GOA Pacific cod stock. Additionally, the State of Alaska groundfish fishery contributed to past removals in the GOA. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, bycatch and removals of Pacific cod are predicted to continue in the IPHC longline fishery, State of Alaska crab fishery, subsistence/personal use fishery, and in the State of Alaska groundfish fisheries in the GOA, but these are not expected to be contributing factors to fishing mortality in the cumulative case. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution and climate changes and regime shifts are not identified as being contributors to Pacific cod mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA Pacific cod, but the effect is judged to be insignificant. Pacific cod are fished at less than the OFL and all catch and bycatch are accounted for in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis. The stock is presently above MSY and with the reduced or removed fishing pressure it is likely to remain well above MSY.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA Pacific cod stock is expected to be significantly beneficial under the FMP (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While past large removals of Pacific cod and other past effects on biomass have been identified (see Section 3.5.1.16), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, effects on biomass are indicated due to bycatch in the IPHC longline and State of Alaska crab fisheries, and bycatch and removals in the subsistence/personal use fishery, and in the State of Alaska groundfish fisheries. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass and climate changes and regime shifts are not identified as being contributors to Pacific cod mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified under the FMP; the effect is significantly beneficial. The reduction of the groundfish fisheries is expected to enhance the ability of the stock to maintain itself at or above the MSST.

Spatial/Temporal Concentration of Catch

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.2, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of Pacific cod and other past effects (see Section 3.5.1.16) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had an adverse effect on Pacific cod recruitment particularly in the GOA where the State of Alaska groundfish fishery is very localized, lingering effects are identified for change in reproductive success. Lingering past effects (either beneficial or adverse depending on the regime) are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, the IPHC longline and State of Alaska crab fisheries, subsistence use, State of Alaska groundfish fisheries, and marine pollution all have the potential to cause adverse effects.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration under FMP 4.2; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of the FMP would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that FMP 4.2 would have insignificant effects on Pacific cod prey availability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic and State of Alaska fisheries catch and bycatch of Pacific cod prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific cod prey species (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, the effect of climate changes and regime shifts on Pacific cod prey species could be either beneficial or adverse. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor and the other fisheries shown on Table 4.8-1 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey is not expected to increase prey availability such that the GOA Pacific cod stock is unable to sustain itself at or above MSST is enhanced.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.2, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify however the effect is judged to be insignificant (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects identified for GOA Pacific cod include past foreign, JV, and domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline, and climate changes and regime shifts (see Section 3.5.1.16). Additionally, the State of Alaska groundfish fishery contributed to habitat impacts in the GOA. Fishing for Pacific cod in the past fisheries likely disrupted habitat in areas of the GOA. It is possible that some of these areas have not recovered (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 4.1, effects are possible from the State of Alaska fisheries, subsistence, and the IPHC fishery since any of these may impact bottom habitat through the use of fishing gear. Impacts on habitat from climate changes and regime shifts on the GOA Pacific cod stock could be either beneficial or adverse. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability. Under FMP 4.2, the cumulative effect is insignificant.

4.8.1.3 Sablefish

This section provides the direct, indirect, and cumulative effects analysis for sablefish for each of the bookends under Alternative 4. Sablefish are managed as one stock in the BSAI and GOA; therefore, BSAI and GOA areas are discussed together in this section.

The goal of Alternative 4 is to seek to adopt highly precautionary approaches to managing fisheries under scientific uncertainty. The intention is to minimize the likelihood that fisheries impose any detrimental effects on the environment. For further information regarding persistent past effects identified in this section, see the past/present effects analysis of Sections 3.5.1.3 and 3.5.1.17.

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Catch/ABC

FMP 4.1 is projected to significantly decrease sablefish yield compared to the baseline. In FMP 4.1, a risk-averse adjustment is applied to F_{ABC}. The amount of adjustment is affected by uncertainty in survey abundance estimates. Sablefish abundance is estimated by longline surveys with reasonable certainty, so that the adjustment should not be large. However, projected catch under FMP 4.1 is substantially reduced (500 mt) compared to baseline (Tables H.4-11 and H.4-30 of Appendix H). FMP 4.2 reduces sablefish yield to zero (Tables H.4-11 and H.4-30 of Appendix H).

Total Biomass

FMP 4.1 is projected to significantly increase sablefish total biomass (age 2-31+) compared to the baseline. In FMP 4.1, a substantial risk-averse adjustment is applied to F_{ABC}. As a result, catches significantly decrease thereby significantly increasing under total biomass FMP 4.1 (Tables H.4-11 and H.4-30 of Appendix H).

FMP 4.2 is projected to significantly increase sablefish total biomass (age 2-31+) compared to the baseline because FMP 4.2 closes the fishery (Tables H.4-11 and H.4-30 of Appendix H). However, for the combined stock, the lack of catch out to 2007 is not expected to affect the stock's ability to maintain itself above MSST and the effect is therefore insignificant.

Spawning Biomass

FMP 4.1 is projected to significantly increase sablefish spawning biomass compared to the baseline. In FMP 4.1, a substantial risk-averse adjustment is applied to F_{ABC}. As a result, catches significantly decrease thereby significantly increasing under spawning biomass (500 mt and 30,400 mt, respectively) FMP 4.1 (Tables H.4-11 and H.4-30 of Appendix H).

FMP 4.2 is projected to significantly increase sablefish spawning biomass compared to the baseline because FMP 4.2 closes the fishery (Tables H.4-11and H.4-30 of Appendix H).

Fishing Mortality

Under FMP 4.1, the fishing mortalities imposed on the sablefish stock are well below the F_{MSY} proxy value of 0.14 which is the rate associated with the OFL (Tables H.4-11 and H.4-30 of Appendix H).

No fishery mortality occurs because FMP 4.2 closes the fishery (Tables H.4-11 and H.4-30 of Appendix H). The effect is judged insignificant.

Spatial/Temporal Concentration of Fishing Mortality

Sablefish fishing is concentrated along the upper continental slope and deepwater gullies. FMP 4.1 is projected to significantly increase the spatial/temporal concentration of fishing mortality compared to the baseline. The proposed closed areas in FMP 4.1 cover many of the areas where the sablefish fishery, both longline and trawl, currently operate, thus restricting the fishery to the remaining open areas. Sablefish undergo large migrations (e.g. Heifetz and Fujioka 1991) and substantial genetic mixing is expected for this stock. The degree of spatial/temporal concentration of the fishery is not likely to result in depletion of sub-populations of sablefish if they exist. For this reason, it is not likely that the amount of spatial/temporal concentration of fishing effort would inhibit the stock's ability to remain above the MSST.

Under FMP 4.2, sablefish is not overfished nor approaching an overfished condition.

Status Determination

Under FMP 4.1, sablefish is not overfished nor approaching an overfished condition.

Age and Size Composition

FMP 4.1 and FMP 4.2 are projected to have an insignificant impact on mean age compared to the baseline. The mean ages actually observed in 2008 (as opposed to projections of mean ages) will be driven largely by incoming recruitment strengths during the intervening years.

BSAI mean age likely is overestimated. The model assumes that the lower exploitation rate for the BSAI compared to the GOA will translate into greater mean age for the BSAI. However sablefish migration is substantial enough to erase the effects of differential exploitation rates between the GOA and BSAI. The mean age for the GOA best represents the mean age for the BSAI/GOA because sablefish abundance is much greater for the GOA.

Sex Ratio

The sex ratio of the adult population is 40 males:60 females, based on sex ratio data collected during sablefish longline surveys. These FMPs probably would have no significant effect on the sex ratio compared to the baseline.

Habitat Suitability

FMP 4.1 would decrease exploitation rates overall, but also will significantly increase the spatial/temporal concentration of fishing mortality compared to the baseline. The proposed closed areas in this FMP cover some longline and trawl fishing for sablefish, thus restricting the fishery to the remaining open areas. This would eliminate the local fishing mortality rates on sablefish in the closed areas, but effort also would increase in some areas or times as a result of area closures, thus concentrating the fishery at certain fishing locations and increasing fishing mortality rates on sablefish there. Under FMP 4.1, average catch is projected to decrease by about one-half compared to baseline. As long as at least one-half of the areas remain open, the remaining catch should not decrease habitat suitability in the open areas and the habitat suitability of closed areas should improve, to the extent that fishing affects habitat suitability. This FMP will have an insignificant overall effect.

FMP 4.2 would significantly improve habitat suitability compared to the baseline, to the extent that fishing affects habitat suitability. However, this improvement in habitat suitability is not expected to lead to a detectable change in spawning or rearing success such that the ability of the sablefish stock to sustain itself at or above MSST is enhanced.

Predator-Prey Relationships

FMP 4.1 and FMP 4.2 is projected to significantly increase total biomass (age 2-31+) compared to the baseline, so this FMP should significantly increase the amount of sablefish biomass available to the ecosystem and the amount of predation due to sablefish. However, this improvement in prey availability is not expected to lead to a detectable change in spawning or rearing success such that the ability of the sablefish stock to sustain itself at or above MSST is enhanced (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects on sablefish are summarized in Table 4.5-5.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the sablefish stock is insignificant under FMP 4.1 and FMP 4.2 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska groundfish fisheries are identified for sablefish. Large removals of Sablefish occurred, particularly in the JV and domestic fisheries. Catches that were under-reported during the late 1980s may have contributed to abundance declines in the 1990s. (see Sections 3.5.1.3 and 3.5.1.17).

- **Reasonably Foreseeable Future External Effects.** While bycatch and removals of Sablefish are predicted to continue in the IPHC longline fishery, and the State of Alaska groundfish fishery, these are not expected to be contributing factors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels and do not add additional fishing mortality. Due the highly migratory nature, Canadian fisheries fishing within Canadian waters could be harvesting sablefish considered to be part of the GOA population. These removals are not accounted for in the TAC setting process and can be considered as having a potential adverse contribution to the cumulative case. Likewise, marine pollution is identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to direct Sablefish mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of sablefish, but the effect is judged to be insignificant. Sablefish are fished at less than the OFL and all catch and bycatch are accounted for (with the exception of any fish taken in Canadian waters) in the management of the stock. Under FMP 4.2, the sablefish fisheries would be suspended. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis. The stock is presently above MSY and with the reduced or removed fishing pressure it is likely to remain well above MSY.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the sablefish stock is expected to be significantly beneficial under FMP 4.1 and FMP 4.2 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While past large removals of Sablefish and other past effects on biomass have been identified (see Section 3.5.1.3 and 3.5.1.17), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to catch and bycatch in the IPHC longline, State of Alaska groundfish fisheries, and in the Canadian fisheries. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to Sablefish mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified; and the effect is significantly beneficial since the combination of internal and external factors is expected to sufficiently increase the sablefish biomass such that the ability of the stock to maintain itself at or above MSST is enhanced. The stock is presently above MSST and the reduced fishing and removal of fishing under the FMP will allow it to remain as such.

Spatial/Temporal Concentration of Catch

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure or reproductive success. While spatial/temporal concentration of catch occurred in the State of Alaska directed sablefish fisheries, there are no lingering effects due to the migratory nature of the fish (see Sections 3.5.1.3 and 3.5.1.17).

- **Reasonably Foreseeable Future External Effects**. The IPHC longline, State of Alaska groundfish fisheries, and Canadian fisheries all have the potential to cause adverse effects. However, the removals are not expected to be sufficiently concentrated to alter the genetic structure of the population or affect recruitment. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that these FMPs would have insignificant effects on sablefish prey availability (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While lingering population level effects from past foreign, domestic, and State of Alaska fisheries catch and bycatch of Sablefish prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Sablefish prey species (see Sections 3.5.1.3 and 3.5.1.17).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on Sablefish prey species could be either beneficial or adverse since a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment (see Sections 3.5.1.3 and 3.5.1.17). Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries shown on Table 4.5-5 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey is not expected to increase prey availability such that the ability for the sablefish stock to sustain itself at or above MSST is enhanced.

Change in Habitat Suitability

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 will have an insignificant overall effect on habitat (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects identified for Sablefish include past foreign, JV, domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline, and climate changes and regime shifts (see Sections 3.5.1.3 and 3.5.1.17). Fishing for Sablefish in the past fisheries likely disrupted habitat in areas of the GOA and possibly the BSAI. It is possible that some of these areas have not recovered (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska fisheries, and the IPHC fishery since any of these may impact bottom habitat through the use of fishing gear. As described for prey availability, impacts on habitat from climate changes and regime shifts on the Sablefish stock could be beneficial or adverse depending on water temperatures. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability; however, its effect on the sablefish stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the sablefish stock to sustain itself at or above MSST is enhanced.

4.8.1.4 Atka Mackerel

This section provides the direct, indirect and cumulative effects analysis for Atka mackerel for each of the bookends under Alternative 4. The goal of Alternative 4 is to seek to adopt highly precautionary approaches to managing fisheries under scientific uncertainty. The intention is minimize the likelihood that fisheries impose any detrimental effects on the environment. For further information regarding persistent past effects listed below in the text and in the tables, please refer to the past/present effects analysis of Sections 3.5.1.4 and 3.5.1.18.

External effects and the resultant cumulative effects associated with FMP 4.1 and 4.2 are depicted on Tables 4.8-1 and 4.5-7. For further information regarding persistent past effects identified in this section see past/present effects analysis of Sections 3.5.1.4 and 3.5.1.18.

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Model projections of future BSAI Atka mackerel catch and biomass levels under FMP 4.1 assume a max F_{ABC} of $F_{75\%}$. Furthermore, the max F_{ABC} for BSAI Atka mackerel is adjusted downward based on the lower bound of the confidence interval surrounding the survey biomass estimate.

FMP 4.1 requires that the TAC for a stock complex be determined by applying the appropriate max_{ABC} control rule to each of the component stocks and then setting the TAC equal to the minimum of the resulting values. This component was not implemented in the projection model used to generate the results. If this component of FMP 4.1 were implemented, it is likely that catches of BSAI Atka mackerel would impacted. Setting the TAC of all complexes to the lowest single species ABC would result in very low TACs for all rockfish and flatfish complexes as well as the other species complex. Low rockfish TACs could be quite constraining to the BSAI Atka mackerel fishery. Also, the temporal/spatial management of TAC was not modeled explicitly within the projection model. FMP 4.1 implements extensive spatial closures in the Aleutian Islands which would severely impact the directed fishery for Atka mackerel. As such, the projections of catch and biomass do not reflect actual expected levels under FMP 4.1. Actual catches are likely to be lower, and expected biomass levels likely to be higher.

GOA Atka mackerel are managed in Tier 6 because current estimates of total and spawning biomass are unknown for GOA Atka mackerel. Age structured models were not available for evaluation of impacts for the GOA, therefore model projections of future biomass levels were not produced.

FMP 4.2 suspends all fishing until the fisheries can be shown to have no adverse effect on the resource and the environment. The TAC for all species is set to zero and all areas of the EEZ would be closed to all fishing. The projection model assumes no fishing for FMP 4.2.

Catch and Fishing Mortality

As noted above, the expected catch and fishing mortality values are not reflected in the projections if FMP 4.1 were to be fully implemented (Table H.4-17 of Appendix H). The average fishing mortality imposed on the BSAI Atka mackerel stock in 2002 is 0.251. Model projections show an 81 percent decrease in the average fishing mortality from 2002 to 2007. However, it is expected that fishing mortality would be even lower if FMP 4.1 were fully implemented. The projections show that the fishing mortality rates are well below the MSY proxy ($F_{35\%}$) value of 0.564 which is the rate associated with the OFL. Actual fishing mortality rates are expected to be even lower.

Projections of GOA Atka mackerel under FMP 4.1 indicate that catches will average less than 50 mt through 2007 (Table H.4-38 of Appendix H). Annual changes in the GOA Atka mackerel catches reflect shifts in catches of other species which catch Atka mackerel as bycatch (e.g. Pacific ocean perch, pollock, northern rockfish, and Pacific cod).

As noted above, there is no fishing under FMP 4.2. Model projections show no catch and fishing mortality of zero for 2003-2007 (Table H.4-17 of Appendix H). Fishing mortality rates of zero are well below the F_{MSY} proxy ($F_{35\%}$) value of 0.564 which is the rate associated with the OFL for BSAI Atka mackerel.

Total Biomass

Total (ages 1-15+) biomass of BSAI Atka mackerel at the start of 2002 is estimated to be 480,000 mt. Model projections of future total BSAI total biomasses are shown in Table H.4-17 of Appendix H. As noted previously, the expected biomass levels under FMP 4.1 are not reflected in the projections which should be considered minimal estimates. Under FMP 4.1, model projections indicate a 22 percent increase in total biomass from 2002 to 2007. Actual biomass levels are expected to be even higher if FMP 4.1 were fully implemented.

Under FMP 4.2, model projections indicate a 28.5 percent increase in total biomass from 2002 to 2007 in the absence of fishing.

Spawning Biomass

Female spawning biomass of BSAI Atka mackerel at the start of 2002 is estimated at 118,500 mt. Model projections of future BSAI spawning biomasses are shown in Table H.4-17 of Appendix H. As noted above, the actual expected biomass levels under FMP 4.1 are not reflected in the projections which should be considered minimal estimates. Model projections indicate a 32.5 percent increase in spawning biomass from 2002 to 2007 under FMP 4.1. Actual spawning biomass levels are expected to be even higher if FMP 4.1 were fully implemented. The minimal estimates of projected spawning biomass exceed the B_{MSY} proxy value ($B_{35\%}$) of 77,800 mt for the projection years (2003-2007).

Model projections indicate a 48 percent increase in spawning biomass from 2002 to 2007 in the absence of fishing under FMP 4.2. Estimates of projected spawning biomass exceed the B_{MSY} proxy value ($B_{35\%}$) of 77,800 mt for the projection years (2003-2007).

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 4.1, 20-50 percent of the EEZ is designated as no-take marine reserves. Additionally, Special Management Areas (no trawl areas) are designated in the Aleutian Islands to protect coral and other live bottom habitats. The spatial closures in the Aleutian Islands under FMP 4.1 would close most of the preferred fishing areas of the directed fishery for Atka mackerel. A large proportion of the BSAI Atka mackerel catch (>90 percent) is expected to be displaced to a very few remaining open areas under FMP 4.1. However, in conjunction with the spatial closures, the TACs are significantly reduced under FMP 4.1. As such, it is difficult to predict the net changes in the spatial/temporal concentration of the catch under FMP 4.1. The spatial/temporal concentration of the catch under FMP 4.1 is not expected to adversely affect the sustainability of the stock (at least in the short-term), either through changes in the genetic structure of the population or changes in reproductive success, as measured by the ability of the stock to maintain its MSST. However, because Atka mackerel are a patchily distributed fish and the harvest is concentrated in specific locations, the elimination of the directed Atka mackerel fishery in most of the fishery locations may be expected to lead to significantly beneficial increases in recruitment success in these locations. This may enhance the ability of the BSAI Atka mackerel stock to sustain itself at or above its MSST.

Under FMP 4.2, all areas of the EEZ are closed to all fishing. Catches are zero, therefore there is no spatial/temporal concentration of the catch under FMP 4.2. As such, the spatial/temporal concentration of zero catch assumed under FMP 4.2 is not likely to adversely affect the sustainability of the stock either through changes in the genetic structure of the population or changes in reproductive success, as measured by the ability of the stock to maintain itself above its MSST. However, because Atka mackerel are a patchily distributed fish and the harvest is concentrated in specific locations, the elimination of a directed Atka mackerel fishery may be expected to lead to significantly beneficial increases in recruitment at these locations. Therefore, elimination of the directed fishery for BSAI Atka mackerel may enhance the ability of the stock to sustain itself at or above its MSST.

Status Determination

Model projections of future catches of BSAI Atka mackerel are below the OFL in all years under FMP 4.1 (Table H.4-17 of Appendix H). Actual catches are expected to be even lower. Minimal estimates of female spawning biomass in each of the projection years (2003-2007), are above $B_{35\%}$ (B_{MSY} proxy) and also above $B_{40\%}$ (designated as a limit under FMP 4.1), thus the BSAI Atka mackerel stock is not overfished and is determined to be above its limit and its MSST under FMP 4.1. FMP 4.1 requires that an MSST would be specified for all tiers. However, MSSTs were not implemented in the projection model for stocks in Tiers 4-6 and a status determination for GOA Atka mackerel which are in Tier 6, cannot be made.

Model projections of future catches of BSAI Atka mackerel are below the OFL in all years under FMP 4.2 (Table H.4-17 of Appendix H). Estimates of female spawning biomass in each of the projection years (2003-2007), are above $B_{35\%}$ (B_{MSY} proxy), thus the BSAI Atka mackerel stock is not overfished and is determined to be above its MSST under FMP 4.2.

GOA Atka mackerel are in Tier 6 and its MSST is unknown; therefore a status determination cannot be made.

Age and Size Composition

Under FMP 4.1, the mean age of BSAI Atka mackerel in 2007, as computed in model projections, is 3.4 years. This compares with a mean age in the equilibrium unfished BSAI stock of 3.82 years. Note that the mean ages and sizes actually observed in 2007 (as opposed to the model projections of mean age in 2007) will be driven by the strengths of incoming recruitments during the intervening years. Also, the projection model assumed a level of catch that probably will not be realized under FMP 4.1. The mean age of BSAI Atka mackerel in 2007 should be considered a minimal estimate. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality, and the current composition is also the result of its being a fished population with a greater than 30-year catch history. In the short-term however, the impacts of the current fishing mortality levels on the stock would be overshadowed by the magnitude of incoming year-classes, which in turn, are highly dependent on environmental conditions. The cumulative long-term impacts of the fishing mortality rates could cause a shift in the age and size compositions.

Under FMP 4.2 the mean age of BSAI Atka mackerel in 2007, as computed in model projections, is 3.58 years. This compares with a mean age in the equilibrium unfished BSAI stock of 3.82 years. Note that the mean ages and sizes actually observed in 2007 (as opposed to the model projections of mean age in 2007) will be driven by the strengths of incoming recruitments during the intervening years, which are highly dependent on environmental conditions and unpredictable.

The level of catch of GOA Atka mackerel is so low and projected to remain at a low level, therefore, it is unlikely that the age and size compositions would change in the future under FMP 4.1 or FMP 4.2. Changes in the age and size compositions of GOA Atka mackerel are more likely driven by variation in recruitment than to the effects of fishing.

Sex Ratio

A 50:50 sex ratio is assumed for the BSAI Atka mackerel stock assessment and model projections. It is unknown what the true population sex ratio is, and what change, if any, would occur in the future. The current population sex ratio of GOA Atka mackerel is unknown. The true GOA population sex ratio, and what changes, if any, would occur in the future is unknown.

Habitat Suitability

The spatial closures in the Aleutian Islands under FMP 4.1 would eliminate the directed fishery for Atka mackerel in most of the preferred fishing locations. The level of habitat disturbance would decrease in the closed areas, and may increase in the remaining open areas. The extent to which habitat disturbance would increase in the open areas under FMP 4.1 is unclear given the large TAC reductions. However, FMP 4.1 is not expected to affect the sustainability of the stock (at least in the short-term) as measured by the ability of the stock to maintain itself above its MSST. The removal of directed fishing may lead to habitat improvement, but whether this would translate into improved reproductive success is uncertain.

Under FMP 4.2 all areas of the EEZ are closed to all fishing. Therefore, the level of habitat disturbance caused by the fishery under FMP 4.2 is not likely to adversely affect the sustainability of the stock as measured by the ability of the stock to maintain itself above its MSST. The removal of directed fishing may lead to habitat improvement, but whether this would translate into improved reproductive success is uncertain.

Predator Prey Relationships

The trophic interactions of Atka mackerel are governed by a complex web of indirect interactions which are currently difficult to quantify. Total elimination of the directed fishery for Atka mackerel under FMP 4.2 and elimination in many areas and the reduced TAC under FMP 4.1, could impact the amount of Atka mackerel available to the ecosystem. More commercial-sized Atka mackerel would be available as prey and predators in the ecosystem. In a study conducted by Yang (1996), more than 90 percent of the total stomach contents weight of Atka mackerel in the study was made up of invertebrates, with less than 10 percent made up of fish. Based on the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 4.1 and FMP 4.2 will not impact prey availability for BSAI and GOA Atka mackerel.

Summary of Effects of FMP 4.1 and FMP 4.2 – Atka Mackerel

The criteria used to estimate the significance of impacts of the FMPs on the BSAI and GOA stock of Atka mackerel are outlined in Section 4.1.1.1. The ratings of conditionally significant (either beneficial or adverse) are not applicable in this analysis as the model projections yielded results that were deemed either significant (beneficial or adverse), insignificant, or unknown.

The ratings use the F_{OFL} and the MSST for the fishing mortality effect and the MSST for all other effects, as a basis for the beneficial or adverse impacts of FMP 4.1 and FMP 4.2. The spawning stock biomass of BSAI Atka mackerel in each of the projection years (2003-2007) is above $B_{35\%}$ (B_{MSY} proxy), thus the BSAI Atka mackerel stock is determined to be above its MSST under FMP 4.1 and FMP 4.2. Because the mean projected BSAI Atka mackerel fishing mortality rates are below the overfishing mortality rate for projection years (2003-2007), the overfishing aspect of the fishing mortality effect is insignificant for FMP 4.1 and FMP 4.2. The spawning stock biomass is above its MSST in each of the projection years (2003-2007), and increases to such a level that it is expected to enhance the ability of the stock to sustain itself at or above its MSST, therefore the rating for the change in biomass aspect of the fishing mortality effect is significantly beneficial.

As noted above, the spawning stock biomass of BSAI Atka mackerel in each of the projection years (2003-2007) is above $B_{35\%}$ (B_{MSY} proxy), thus the BSAI Atka mackerel stock is determined to be above its MSST under FMP 4.1 and FMP 4.2. Thus, for all other effects, it was determined that FMP 4.1 and FMP 4.2 did not jeopardize the ability of the BSAI Atka mackerel stock to sustain itself at or above its MSST. However, because BSAI Atka mackerel are a patchily distributed fish and the harvest is concentrated in specific locations, elimination of the directed fishery in many locations under FMP 4.1, or complete elimination under FMP 4.2, may lead to improved reproductive success in these locations, and the rating for that aspect of the spatial/temporal concentration of the catch effect is significantly beneficial. Because there is no current evidence of genetic sub-population structure, that aspect of the spatial/temporal concentration of the catch effect is insignificant. Based on the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 4.1 and FMP 4.2 will not impact prey availability for BSAI Atka mackerel and the impact to that effect is insignificant. The removal of directed fishing in certain areas may lead to habitat improvement, but whether this would translate into reproductive success is uncertain; therefore, this effect is determined to be insignificant.

Relative to the comparative baseline, under FMP 4.1 and FMP 4.2, the BSAI Atka mackerel stock is not overfished. Minimal estimates of projected spawning biomass increase through 2007. Long-term projections (10 and 20-year projections) of spawning biomass show a continued increasing trend.

The fishing mortality rate and the MSST for GOA Atka mackerel is unknown, thus the effect of fishing mortality is unknown under FMP 4.1. As the MSST cannot be estimated for GOA Atka mackerel which are in Tier 6, the significance of the spatial/temporal concentration and habitat suitability effects is also unknown under FMP 4.1. Although the MSST cannot be estimated for GOA Atka mackerel, based on the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 4.1 will not impact prey availability for BSAI Atka mackerel and the impact to the prey availability effect is insignificant.

Relative to the comparative baseline, under FMP 4.1 and FMP 4.2, the GOA Atka mackerel stock is likely to remain at low abundance under continued low exploitation (or no exploitation under FMP 4.2) as a bycatch fishery only (Table 4.8-1).

Cumulative Effects FMP 4.1 and FMP 4.2

Cumulative effects on BSAI Atka mackerel are summarized in Table 4.5-6.

BSAI Atka Mackerel

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Atka mackerel stock is insignificant under FMP 4.1 and FMP 4.2 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects of the foreign, JV, and domestic fisheries are not expected for the BSAI Atka mackerel stock. While large removals of Atka mackerel did occur in the past, there does not appear to be a lingering effect on the BSAI Atka mackerel populations (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as the only external event that could cause effects on the BSAI Atka mackerel population. Acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI Atka mackerel, but the effect is judged to be insignificant. Atka mackerel are fished at less than the OFL and are above the MSST. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis. The stock is presently above MSY and with the reduced or removed fishing pressure it is likely to remain well above MSY.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Atka mackerel stock is expected to be significantly beneficial under FMP 4.1 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While past large removals of Atka mackerel and other past effects on biomass have been identified (see Section 3.5.1.4), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality, and therefore would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified. The effect is determined to be significantly beneficial since the combination of internal and external factors could sufficiently increase the Atka mackerel biomass such that the ability of the stock to maintain itself at or above MSST is enhanced.

Spatial/Temporal Concentration of Catch
- – Change in Genetic Structure of Population
- – Change in Reproductive Success

- **Direct/Indirect Effects.** Because BSAI Atka mackerel are a patchily distributed fish and the harvest is concentrated in specific locations, elimination of the directed fishery in many locations under FMP 4.1 may lead to improved reproductive success in these locations, and the rating for that aspect of the spatial/temporal concentration of the catch effect is significantly beneficial.

- **Persistent Past Effects.** Since the Atka mackerel fishery was highly localized, past foreign, JV, and domestic fisheries are found to have had lingering effects on the spatial/temporal distribution of the fish. However, the effect of this change in distribution on genetic structure is unknown. Past commercial whaling and sealing removed large predators of Atka mackerel adding to the potential for reproductive success of the stock. Lingering past effects are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts could have potential beneficial or potential adverse effects on Atka mackerel reproductive success.

A shift toward colder waters favors recruitment and survival of Atka mackerel. Conversely, warmer waters are potentially adverse.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; the effect is insignificant for change in the genetic structure of the population because there is no evidence of genetic sub-population structure. However, because BSAI Atka mackerel are a patchily distributed fish and the harvest is concentrated in specific locations, reduction of the directed fishery under the FMP may lead to improved reproductive success. The external factors identified above are unlikely to negate the beneficial determination.

Change in Prey Availability

- **Direct/Indirect Effects.** Severe reduction or elimination of fishing levels and distribution of harvest would not impact prey availability such that it affects the sustainability of the stock as measured by the ability of the stock to maintain itself above its MSST and the effect is judged insignificant (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic fisheries catch and bycatch of Atka mackerel prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Atka mackerel prey species (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Climate changes and regime shifts could have potential beneficial or potential adverse effects on Atka mackerel reproductive success. A shift toward colder waters favors recruitment and survival of Atka mackerel. Conversely, warmer waters are potentially adverse. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey species is not expected to increase prey availability such that the ability of the Atka mackerel stock to sustain itself at or above MSST is enhanced.

Change in Habitat Suitability

- **Direct/Indirect Effects.** The effect on the stock's ability to maintain itself above its MSST is judged insignificant (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects identified for BSAI Atka mackerel stocks include past foreign, JV, domestic fisheries, and climate changes and regime shifts (see Section 3.5.1.4). Intense bottom trawling for Atka mackerel in the past fisheries likely disrupted habitat in areas of the BSAI. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6).

- **Reasonably Foreseeable Future External Effects**. Impacts on habitat from the climate changes and regime shifts could be either beneficial or adverse. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability; however, its effect on the BSAI Atka mackerel stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Atka mackerel stock to sustain itself at or above MSST is enhanced.

GOA Atka Mackerel – Cumulative Effects FMP 4.1 and FMP 4.2

GOA Atka mackerel are managed in Tier 6 because current estimates of total and spawning biomass are unknown for GOA Atka mackerel. Age structured models were not available for evaluation of impacts for the GOA, therefore model projections of future biomass levels were not produced. Therefore, the internal effects of the FMP are unknown for all categories. In addition, the external effects and cumulative effects are the same for each FMP. Cumulative effects of GOA Akta mackerel are summarized in Table 4.5-7.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA Atka mackerel stock is unknown under FMP 4.1 and FMP 4.2. The fishing mortality rate and the MSST for GOA Atka mackerel is unknown, thus the effect of fishing mortality is unknown under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects of the past foreign, JV, and domestic fisheries are likely for the GOA Atka mackerel stock. Large, concentrated removals of Atka mackerel occurred in the foreign, domestic, and JV fisheries, and have had a lingering effect on the GOA Atka mackerel population that has not yet recovered (see Section 3.5.1.18).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the population is jeopardized. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA Atka mackerel, but the significance of the effect is unknown. GOA Atka mackerel are in Tier 6 and its MSST is unknown; therefore a status determination cannot be made.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA Atka mackerel stock is unknown for FMP 4.1 and FMP 4.2. Current reliable estimates of total and spawning biomass are unknown for GOA Atka mackerel.

- **Persistent Past Effects.** Past effects of the past foreign, JV, and domestic fisheries are likely for the GOA Atka mackerel stock. Large, concentrated removals of Atka mackerel occurred in the foreign, domestic, and JV fisheries, and have had a lingering effect on the GOA Atka mackerel population that has not yet recovered (see Section 3.5.1.18).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as having a potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the population is affected. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality, therefore, would not directly affect biomass.

- **Cumulative Effects.** A cumulative effects for change in biomass is identified; however, the significance of the effect is unknown.

<u>Spatial/Temporal Concentration of Catch</u>

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** As the MSST cannot be estimated for GOA Atka mackerel which are in Tier 6, the significance of the spatial/temporal concentration effects is also unknown under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Since the Atka mackerel fishery was highly localized, past foreign, JV, and domestic fisheries are found to have had lingering effects on the spatial/temporal distribution of the fish. However, the effect of this change in distribution on genetic structure is unknown. The past highly localized fisheries are found to have had lingering effects on the spatial/temporal distribution of the fish. Also, there are lingering past effects due to Climate Changes and Regime Shifts (see Section 3.5.1.18).

- **Reasonably Foreseeable Future External Effects.** Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Also, climate changes and regime shifts could impact spawning success since a shift toward colder waters favors recruitment and survival of Atka mackerel. Conversely, warmer waters are potentially adverse.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the significance of the effect is unknown.

<u>Change in Prey Availability</u>

- **Direct/Indirect Effects.** Although the MSST cannot be estimated for GOA Atka mackerel, due to the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 4.1 and FMP 4.2 will not impact prey availability for GOA Atka mackerel and the impact to the prey availability effect is determined to be insignificant.

- **Persistent Past Effects.** While lingering population level effects on the invertebrate prey of Atka mackerel from past foreign, state, and domestic fisheries, and the effects of EVOS on these species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Atka mackerel prey species (see Section 3.5.1.18).

- **Reasonably Foreseeable Future External Effects**. Future external effects of climate changes and regime shifts on Atka mackerel prey species could be either beneficial or adverse depending on the direction of change. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, since the direction of the external effects is unknown, the significance of the cumulative effect is unknown.

<u>Change in Habitat Suitability</u>

- **Direct/Indirect Effects.** As the MSST cannot be estimated for GOA Atka mackerel which are in Tier 6, the significance of the habitat suitability effects is also unknown under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects on habitat suitability identified for GOA Atka mackerel stocks include past foreign, JV, domestic fisheries, EVOS, and climate changes and regime shifts (see Section 3.5.1.18). Intense bottom trawling for Atka mackerel in the past fisheries likely disrupted habitat in areas of the GOA. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** Impacts on habitat from climate changes and regime shifts on the GOA Atka mackerel could be either favorable or unfavorable depending on the direction of change. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects**. Cumulative effects are identified for habitat suitability; however, its significance on the GOA Atka mackerel stock is unknown.

4.8.1.5 Yellowfin Sole and Shallow Water Flatfish

Numerous fishery management actions have been implemented that affect the yellowfin sole fisheries in the BSAI. These actions are described in more detail in Section 3.5.1.5 of this Programmatic SEIS. Yellowfin sole is managed as its own stock under the BSAI groundfish FMP under the Tier 3 management category, thus MSSTs are defined for these species.

Eight flatfish species inhabit shallow waters and are managed in the shallow water flatfish assemblage in the GOA. They include: northern and southern rock sole, yellowfin sole, starry flounder, butter sole, English sole, Alaska plaice and sand sole. Survey results from 2001 indicate that over half of the estimated biomass

(54 percent) of this assemblage are northern and southern rock sole. The shallow water group is managed as Tier 4 and Tier 5 species in the GOA (Turnock *et al*. 2001).

External effects associated with FMP 4.1 and FMP 4.2 are depicted on Tables 4.5-8 and 4.8-1. For further information regarding persistent past effects identified see Sections 3.5.1.5 and 3.5.1.19.

BSAI Yellowfin Sole – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total Biomass

The total biomass of yellowfin sole at the start of 2002 is estimated to be 1,552,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-4 of Appendix H. Under FMP 4.1, model projections indicate that the total BSAI biomass is expected to decline slightly more than 5 percent of the 2002 value to 1,471,000 mt by 2007, with a 2003-2007 average value of 1,495,000 mt. Under FMP 4.2, model projections indicate that the total BSAI biomass is expected to increase 12 percent of the 2002 value to 1,806,000 mt by 2007, with a 2003-2007 average value of 1,672,000 mt.

Spawning Biomass

Spawning biomass of female yellowfin sole at the start of 2002 is estimated to be 450,700 mt. Model projections of future yellowfin sole spawning biomass estimates are shown in Table H.4-4 of Appendix H. Under FMP 4.1, model projections indicate that female spawning biomass is expected to decline 14 percent of the 2002 value to 388,000 mt by 2007, with a 2003-2007 average value of 416,600 mt. Under FMP 4.2, model projections indicate that female spawning biomass is expected to increase about 21 percent of the 2002 value to 547,800 mt by 2007, with a 2003-2007 average value of 505,800 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 336,900 mt throughout the 5-year projection.

Fishing Mortality

The average annual fishing mortality imposed on the yellowfin sole stock in 2002 is 0.064. Model projections show this value will increase to 0.94 for all five projection years (Table H.4-4 of Appendix H). These values are well below the F_{MSY} proxy value of 0.138, the rate associated with the OFL. Under FMP 4.2, no fishing would occur, and thus the stock would not be overfished.

Spatial/Temporal Concentration of Fishing Mortality

Fishing which previously occurred in areas which would be closed under FMP 4.1 would presumably be shifted to the remaining open areas where yellowfin sole concentrations are sufficient to support a commercial fishery. It is estimated that 40 percent of the catch under this FMP would be redistributed relative to the 2001 catch distribution. Under FMP 4.2, no fishing would occur for yellowfin sole since 100 percent of the BSAI would be closed.

Status Determination

Model projections of future catches of BSAI yellowfin sole are below the OFLs in all years under FMP 4.1 and FMP 4.2. The yellowfin sole stock is above the MSST for all five projected years as in the baseline year 2002.

Age and Size Composition

Under FMP 4.1, the mean age of the BSAI yellowfin sole stock in 2008, as computed in model projections (Table H.4-4 of Appendix H), is 6.2 years. Under FMP 4.2, the mean age of the BSAI yellowfin sole stock in 2008, as computed in model projections (Table H.4-4 of Appendix H), is 6.9 years. This compares with a mean age in the equilibrium unfished BSAI stock of 8.0 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of yellowfin sole in the BSAI is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 and FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change during the next 5 years under these FMPs.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 on yellowfin sole would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under FMP 4.1 or FMP 4.2.

Summary of Effects of FMP 4.1 and FMP 4.2 – BSAI Yellowfin Sole

Table 4.5-8 summarizes the effects of FMP 4.1 on BSAI yellowfin sole. The rating of conditionally significant (either beneficial or adverse) is not applicable in this analysis as the model projections yielded results that were determined either significant (beneficial or adverse), insignificant, or unknown.

The ratings utilize the F_{OFL} and the MSST as a basis for beneficial or adverse impacts fishing mortality and changes in reproductive success for each FMP. FMP 4.1 redefines the MSST with $B_{40\%}$ as the limit, rather than the target abundance level as found in the National Standard Guidelines 50 CFR Part 600 (Federal Register Vol. 63, No. 84, 24212-24237). Under FMP 4.1 and FMP 4.2, the spawning stock biomass of BSAI yellowfin sole is expected to be above the MSST. Since the fishing mortality rate does not exceed F_{OFL} and the stock is expected to remain above the MSST, the expected changes under these FMPs are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Thus, the indirect and direct effects under these FMPs are considered insignificant (Table 4.8-1).

Relative to the 2002 comparative baseline, the yellowfin sole stock is projected to continue to not be overfished under these FMPs. The 20-year projection indicates that the female spawning stock is expected to decline until 2010 to an abundance level below B_{ABC} , but will increase thereafter to a level above B_{ABC} for the last ten years of the projection.

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects on BSAI yellowfin sole are summarized in Table 4.5-8.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI yellowfin sole is rated as insignificant under FMP 4.1 and FMP 4.2 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI yellowfin sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause yellowfin sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of yellowfin sole.

- **Cumulative Effects.** A cumulative effect is possible for mortality of BSAI yellowfin sole, but is rated as insignificant. Fishing mortality at projected levels is below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 will result in insignificant effects to these stocks (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI yellowfin sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause yellowfin sole mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse contributions on the yellowfin sole biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.5 and 3.10.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI yellowfin sole, but is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock and the spawning biomass is above the B_{MSY} value. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects are not identified for spatial/temporal concentration of BSAI yellowfin sole catch.

- **Reasonably Foreseeable Future External Effects.** As described for biomass, effects on the reproductive success of yellowfin sole due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as having a potential adverse contribution since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI yellowfin sole.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the yellowfin sole catch; these effects are ranked as insignificant. The spatial/temporal distribution of yellowfin sole catch is not expected to change significantly. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the BSAI yellowfin sole is ranked as insignificant (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the BSAI yellowfin sole stock and include climate changes and regime shifts. Crab and shrimp have shown variation in abundance associated with changes in climate and water temperatures. However, studies on most benthic invertebrates have not been conducted. See Sections 3.5.1.5 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** As described for biomass and spatial/temporal concentration, effects of the climate changes and regime shifts on the BSAI yellowfin sole stock are potential beneficial or adverse. Marine pollution has been identified as having a potential adverse contribution.

- **Cumulative Effects.** Cumulative effects are identified for change in prey availability; however, these effects are considered insignificant. The combination of internal and external removals of prey is not expected to enhance the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the BSAI yellowfin sole is ranked as insignificant (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects identified for BSAI yellowfin sole include climate changes and regime shifts. In the past, when the Aleutian Low was strong and water temperatures warm, catch tended to be dominated by flatfish species, implying increased recruitment. In contrast, when the Aleutian Low was weak and water temperatures cooler, catch tended to be dominated by shrimp. Persistent past contributions of the foreign, JV, and domestic fisheries gear impacts are described in Sections 3.5.1.5 and 3.6.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI yellowfin sole stock are potential beneficial or adverse as described for prey availability. Marine pollution has been identified as having a potential adverse contribution since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for BSAI yellowfin sole habitat suitability; however, these effects are considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the yellowfin sole stock to sustain itself at or above the MSST is enhanced.

GOA Shallow Water Flatfish – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total Biomass and Spawning Biomass

Estimated total and spawning biomass is not available for GOA shallow water flatfish species.

Fishing Mortality

The catch of GOA shallow water flatfish in 2002 was estimated to be 6,800 mt. Model projections of future catch are shown in Table H.4-27 of Appendix H. Under FMP 4.1, model projections indicate that the catch is expected to decrease to 3,900 mt each year of the 5-year projection. Under FMP 4.2 no fishing would occur from 2003-2007.

Spatial/Temporal Concentration of Fishing Mortality

Fishing which previously occurred in areas which would be closed under FMP 4.1 would presumably be shifted to the remaining open areas where shallow water flatfish species concentrations are sufficient to support a commercial fishery. It is estimated that under this FMP, the catch of Alaska plaice and butter sole would be mostly displaced from the western and central areas relative to the 2001 catch distribution. No fishing would be allowed for GOA shallow water flatfish under FMP 4.2.

Status Determination

The available information for flatfish species in the shallow water complex requires that they are classified into either the Tier 4 or Tier 5 management category. As a result, no MSSTs are defined for these species. Therefore, it is not possible to determine their status.

Age and Size Composition

Age and size composition projections are not available for GOA shallow water flatfish species.

Sex Ratio

The sex ratio of shallow water flatfish in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next 5 years under these FMPs.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 on shallow water flatfish would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under FMP 4.1 or FMP 4.2.

Summary of Effects of FMP 4.1 and FMP 4.2 – GOA Shallow Water Flatfish

The direct and indirect effects of FMP 4.1 and FMP 4.2 on GOA shallow water flatfish cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of these stocks is over the 5-year projection under these FMPs. The catches predicted under FMP 4.1 and FMP 4.2 are well below the OFL for this stock, therefore, insignificant effects on shallow water flatfish are predicted through mortality (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects on GOA shallow water flatfish are summarized in Table 4.5-9.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA shallow water flatfish is rated as insignificant under FMP 4.1 and FMP 4.2 (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past JV and domestic fisheries have been identified as having lingering past adverse effects on the GOA shallow water flatfish complex (see Section 3.5.1.19).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause shallow water flatfish species mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of shallow water flatfish. The State of Alaska scallop fishery is identified as a non-contributing factor since shallow water flatfish species bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for mortality of GOA shallow water flatfish, but is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass

- **Direct/Indirect Effects.** Although the total and spawning biomass estimates for GOA shallow water species is unavailable, the effects of FMP 4.1 and FMP 4.2 on change in biomass is considered to be insignificant (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** The past JV and domestic fisheries are identified as having past lingering adverse effects on the biomass levels of GOA shallow water flatfish (see Section 3.5.1.19).

- **Reasonably Foreseeable Future External Events.** Future external effects on the change in biomass are indicated due to the potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause shallow water flatfish species mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse contributions on the shallow water flatfish species biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.19 and 3.10. The State of Alaska scallop fishery is identified as a non-contributing factor since bycatch of shallow water flatfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for change in biomass of GOA shallow water flatfish, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effects of internal removals and removals are unlikely to enhance the capacity of the stock to maintain current population levels.

<u>Spatial/Temporal Concentration of Catch</u>
- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, fishing would shift to the remaining open areas where shallow water flatfish species concentration are sufficient to support a commercial fishery. We conclude that the effects of the fishery on GOA shallow water flatfish under FMP 4.1 are insignificant (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects have not been identified for the change in genetic structure or the change in reproductive success of GOA shallow water flatfish.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of shallow water flatfish species due to climate changes and regime shifts are potentially beneficial or adverse as described above for change in biomass. Marine pollution has also been identified as having a potential adverse contribution, and the State of Alaska scallop fishery has been identified as a non-contributing factor to the change in genetic structure and reproductive success since bycatch of shallow water flatfish species is not expected to occur in this fishery.

- **Cumulative Effects.** Cumulative effects are possible for change in genetic structure and reproductive success of GOA shallow water flatfish, and are rated as insignificant. The combined effects of internal and external removals are unlikely to enhance the capacity of the stock to maintain current population levels.

<u>Change in Prey Availability</u>

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the GOA shallow water flatfish is determined to be insignificant (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the GOA shallow water flatfish stock complex and include climate changes and regime shifts. Crab and shrimp have shown variation in abundance associated with changes in climate and water temperatures. However, studies on most benthic invertebrates have not been conducted. See Sections 3.5.1.19 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA shallow water flatfish stock complex are potential beneficial or adverse as described for biomass. Marine pollution has also been identified as having a potential adverse contribution, and the State of Alaska scallop fishery is identified as a non-contributing factor since bycatch of shallow water flatfish prey species is not expected to occur in this fishery.

- **Cumulative Effects**. Cumulative effects for change in prey availability are insignificant. The predation-mediated impacts of FMP 4.1 and FMP 4.2 on shallow water flatfish are governed by a complex web of indirect interactions which are currently difficult to quantify; however, it is unlikely that prey availability would be increased to levels that would enhance the ability of the GOA shallow water flatfish complex to maintain current population levels.

<u>Change in Habitat Suitability</u>

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the GOA shallow water flatfish complex is considered to be insignificant (see Direct/Indirect Effects discussion in this section).

- **Persistent Past Effects**. Past effects identified for GOA shallow water flatfish include climate changes and regime shifts. In the past, when the Aleutian Low was strong and water temperatures warm, catch tended to be dominated by flatfish species, implying increased recruitment. In contrast, when the Aleutian Low was weak and water temperatures cooler, catch tended to be dominated by shrimp. Persistent past effects of the foreign, JV, and domestic fisheries gear impacts are described in Section 3.5.1.19 and Section 3.6.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA shallow water flatfish stock complex are potential beneficial or adverse as described for prey availability. Marine pollution has also been identified as having a potential adverse contribution, and the State of Alaska scallop fishery is also identified as a potential adverse contributor to GOA shallow water flatfish habitat suitability. See Section 3.6 for information of the impacts of fishery gear on EFH.

- **Cumulative Effects.** Cumulative effects are identified for GOA shallow water flatfish habitat suitability, and are rated as insignificant. The combination of internal and external habitat disturbances is unlikely to lead to a detectable change in spawning or rearing success such that the ability of the GOA shallow water flatfish stock to maintain current population levels is enhanced.

4.8.1.6 Rock Sole

Rock sole is described in more detail in Section 3.5.1.6 of this Programmatic SEIS. Rock sole is managed as its own stock under the BSAI groundfish FMP under the Tier 3 management category, thus MSSTs are defined for these species.

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total Biomass

The total biomass of rock sole at the start of 2002 is estimated to be 970,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-7 of Appendix H. Under FMP 4.1, model projections indicate that the total BSAI biomass is expected to decline slightly more than 26 percent of the 2002 value to 717,000 mt by 2007, with a 2003-2007 average value of 785,000 mt. Under FMP 4.2, model projections indicate that the total BSAI biomass is expected to decrease 13 percent of the 2002 value to 844,000 mt by 2007, with a 2003-2007 average value of 853,000 mt.

Spawning Biomass

Spawning biomass of female rock sole at the start of 2002 is estimated to be 331,000 mt. Model projections of future rock sole spawning biomass estimates are shown in Table H.4-7 of Appendix H. Under FMP 4.1, model projections indicate that female spawning biomass is expected to decline 41 percent of the 2002 value to 192,300 mt by 2007, with a 2003-2007 average value of 247,100 mt. Under FMP 4.2, model projections indicate that female spawning biomass is expected to decrease 25 percent of the 2002 value to 247,700 mt by 2007, with a 2003-2007 average value of 277,900 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 136,700 mt throughout the 5-year projection.

Fishing Mortality

The average annual fishing mortality imposed on the rock sole stock in 2002 is 0.055. Model projections show this value will steadily increase to 0.099 by 2007 (Table H.4-7 of Appendix H). These values are well below the F_{MSY} proxy value of 0.21, the rate associated with the OFL. Under FMP 4.2, no fishing would occur, and thus the stock would not be overfished.

Spatial/Temporal Concentration of Fishing Mortality

Fishing which previously occurred in areas which would be closed under FMP 4.1 would presumably be shifted to the remaining open areas where rock sole concentrations are sufficient to support a commercial fishery. It is estimated that 80 percent of the catch would be spatially displaced under this FMP relative to the 2001 catch distribution. Under FMP 4.2, no fishing would occur for rock sole since 100 percent of the BSAI would be closed.

Status Determination

Model projections of future catches of BSAI rock sole are below the OFLs in all years under FMP 4.1 and FMP 4.2 and the female spawning stock is above the MSST. The rock sole stock is above the MSST level in the baseline year 2002.

Age and Size Composition

Under FMP 4.1, the mean age of the BSAI rock sole stock in 2008, as computed in model projections (Table H.4-7 of Appendix H), is 4.9 years. Under FMP 4.2, the mean age of the BSAI rock sole stock in 2008, as computed in model projections (Table H.4-7 of Appendix H), is 5.9 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.9 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of rock sole in the BSAI is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 and FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next 5 years under these FMPs.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 on rock sole would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under FMP 4.1 or FMP 4.2.

Summary of Effects of FMP 4.1 and FMP 4.2 – BSAI Rock Sole

Under FMP 4.1 and FMP 4.2, the spawning stock biomass of BSAI rock sole is expected to be above the MSST. Since the fishing mortality is below the F_{OFL} level and the female spawning stock is currently above the MSST, the expected changes under these FMPs are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime (Table 4.8-1).

Relative to the 2002 comparative baseline, the rock sole stock is projected to continue to not be overfished under this FMP. The 20-year projection indicates that the female spawning stock is expected to decline until 2010 to just above B_{ABC} levels and will increase thereafter through the end of the projection in 2023.

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects on BSAI rock sole are summarized in Table 4.5-10.

Mortality

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of fishing mortality on the BSAI rock sole is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI rock sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause rock sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of rock sole.

- **Cumulative Effects.** A cumulative effect is possible for mortality of BSAI rock sole and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effects of the fisheries on BSAI rock sole biomass is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI rock sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass level are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause rock sole mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the rock sole biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts (see Sections 3.5.1.6 and 3.10).

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI rock sole, and is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of the BSAI rock sole. Climate changes and regime shifts have been identified as having a persistent past effect on the reproductive success of BSAI rock sole. Climate changes and regime shifts and corresponding water temperature variation could affect prey availability and habitat suitability, which in combination could affect the reproductive success of the rock sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of rock sole due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI rock sole.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the rock sole catch, and is ranked as insignificant. The spatial/temporal distribution of rock sole catch is not expected to change significantly. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the change in prey availability for the BSAI rock sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects include climate changes and regime shifts. Climate changes and regime shifts and corresponding water temperature variation do effect the availability of some forage species (i.e. capelin); however studies on benthic invertebrates have not been conducted.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI rock sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect identified for change in prey availability is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the change in habitat suitability for the BSAI rock sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI rock sole include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.6.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI rock sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect identified for BSAI rock sole habitat suitability is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the rock sole stock to sustain itself at or above the MSST is jeopardized.

4.8.1.7 Flathead Sole

BSAI and GOA flathead sole are described in more detail in Sections 3.5.1.7 and 3.5.1.20 of this Programmatic SEIS. Flathead sole is managed as its own stock under the BSAI groundfish FMP under the Tier 3 management category, thus MSSTs are defined for these species. Beginning in 2002, flathead sole were managed independent of the other flatfish complex in the GOA. Until recently, GOA flathead sole were managed under Tier 4; beginning in 2004, GOA flathead sole will be managed under Tier 3. However, for the purposes of this analysis, GOA flathead sole were modeled under the Tier 4 management category.

Direct/Indirect Effects of FMP 4.1 and FMP 4.2 – BSAI Flathead Sole

Total Biomass

Total biomass of BSAI flathead sole at the start of 2003 is estimated to be 513,000 mt. Model projections of future total BSAI flathead sole biomass are shown in Table H.4-8 of Appendix H. Under FMP 4.1, model projections indicate that BSAI flathead sole total biomass is expected to decrease (8 percent) to a value of 501,000 mt in 2005, then increase (4 percent) to a value of 519,000 mt in 2008, with a 2003-2008 average value of 508,000 mt. Under FMP 4.2, model projections indicate that BSAI flathead sole biomass is expected to increase to a value of 546,000 mt in 2008, with a 2003-2008 average value of 522,000 mt.

Spawning Biomass

Spawning biomass of BSAI flathead sole at the start of 2003 is estimated to be 231,900 mt. Model projections of future total BSAI flathead sole biomass are shown in Table H.4-8 of Appendix H. Under FMP 4.1, model projections indicate that BSAI flathead sole spawning biomass is expected to decrease (25 percent) to a value of 186,000 mt in 2008, with a 2003-2008 average value of 209,100 mt. Under FMP 4.2, model projections indicate that BSAI flathead sole biomass is expected to decrease to a value of 198,900 mt in 2008, with a 2003-2008 average value of 214,300 mt.

Fishing Mortality

The projected fishing mortality imposed on the BSAI flathead sole stock is approximately 0.024 in 2003 and increases to 0.049 in 2008. The proportion of spawner biomass per recruit conserved under these fishing mortality rates is 89 percent in 2003 and decreases to 80 percent in 2008, with an average of 85 percent from 2003-2008 (Table H.4-8 of Appendix H). Under FMP 4.2, the projected TAC has been set to zero for all species unless the harvesting of a species has been shown to have no adverse effect on the environment (Table H.4-8 of Appendix H). Thus, there is no fishery for BSAI flathead sole from 2003-2008.

Spatial/Temporal Concentration of Fishing Mortality

The average annual projected harvest of flathead sole under FMP 4.1 was 7,400 mt, with 3,000 mt (40 percent) of the harvest occurring in the EBS shelf yellowfin sole fishery, 2,000 mt (26 percent) in the rock sole fishery, and 1,300 mt (17 percent) in the flathead sole fishery. It is estimated that 40 percent of the catch under this FMP will be displaced relative to the catch distribution in 2001. Under FMP 4.2, there is no projected fishing mortality.

Status Determination

Under FMP 4.1 and FMP 4.2, the ABC is set lower than the OFL, creating a buffer between these two harvest regulations. Model projections of future catches of BSAI flathead sole are below the ABC and OFL levels from 2003 to 2008.

Age and Size Composition

Under FMP 4.1, the mean age of the BSAI flathead sole stock in 2008, as computed in model projections (Table H.4-8 of Appendix H), is 4.66 years. Under FMP 4.2, the mean age of the BSAI flathead sole stock in 2008, as computed in model projections (Table H.4-8 of Appendix H), is 4.84 years. This compares with a mean age in the equilibrium unfished stock of 5.39 years.

Sex Ratio

The sex ratio of BSAI flathead sole is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change under FMP 4.1 or FMP 4.2.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 4.1 or FMP 4.2.

Summary of Effects of FMP 4.1 and FMP 4.2 – BSAI Flathead Sole

Because the BSAI flathead sole are fished at less than the ABC and are above the MSST, the direct and indirect effects under FMP 4.1 and FMP 4.2 are considered insignificant. Fishing rates are below accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity (Table 4.8-1).

Relative to the 2002 comparative baseline, the flathead sole stock is projected to continue to not be overfished under these FMPs. The twenty year projection indicates that the female spawning stock is expected to decrease until 2009 at which time it will be begin to steadily increase throughout the end of the projection. The female spawning stock is estimated to remain above B_{ABC} throughout the projection.

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects on BSAI flathead sole are summarized in Table 4.5-11.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI flathead sole is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI flathead sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of flathead sole.

- **Cumulative Effects.** A cumulative effect is possible for mortality of BSAI flathead sole, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fisheries on BSAI flathead sole is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass in the BSAI flathead sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the flathead sole biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts (see Sections 3.5.1.7 and 3.10).

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI flathead sole, and is rated as insignificant. Model projections indicate that BSAI flathead sole spawning biomass is above the MSST for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for spatial/temporal concentration of BSAI flathead sole catch.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of flathead sole due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI flathead sole.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the flathead sole catch, and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the BSAI flathead sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects are not identified for the change in prey availability of the BSAI flathead sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI flathead sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability, and is considered insignificant. The combination of internal and external removals of prey is not expected to enhance the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the BSAI flathead sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI flathead sole include climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI flathead sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for BSAI flathead sole habitat suitability, and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the flathead sole stock to sustain itself at or above the MSST is enhanced.

GOA Flathead Sole – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass

Estimates of total and spawning biomass are currently unavailable for this species.

Fishing Mortality

The catch of GOA flathead sole in 2002 was estimated to be 2,000 mt. Model projections of future catch are shown in Table H.4-28 of Appendix H. Under FMP 4.1, model projections indicate that the catch is expected to decrease from the 2002 level and will range from 500 mt in 2003 to 700 mt in 2007. The 2003-2007 average catch is 600 mt (35 percent of the 2002 catch). Under FMP 4.2 no fishing would occur from 2003-2007.

Spatial/Temporal Concentration of Fishing Mortality

Fishing which previously occurred in areas which would be closed under FMP 4.1 would presumably be shifted to the remaining open areas where GOA flathead sole concentrations are sufficient to support a commercial fishery. No fishing would occur for GOA flathead sole because fishing would not be allowed under FMP 4.2.

Status Determination

The available information for GOA flathead sole requires that they are classified into the Tier 4 management category. As a result, no MSSTs are defined for this species. Therefore, it is not possible to determine their status.

Age and Size Composition

Age and size composition estimates are currently unavailable for this species.

Sex Ratio

The sex ratio of flathead sole in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 and FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change during the next 5 years under these FMP.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 on flathead sole would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under FMP 4.1 or FMP 4.2.

Summary of Effects of FMP 4.1 and FMP 4.2 – GOA Flathead Sole

The direct and indirect effects of FMP 4.1 and FMP 4.2 on GOA flathead sole cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of this stock is over the 5-year projection under these FMPs. The predicted catches under FMP 4.1 and FMP 4.2 are well below the OFL for this stock, therefore, FMP 4.1 and FMP 4.2 would have insignificant effects on GOA flathead sole through mortality (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects of GOA flathead sole are summarized in Table 4.5-12.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA flathead sole is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects have been identified for fishing mortality in the GOA flathead sole stock and include past JV and domestic fisheries. Removals by these fisheries have had a lingering adverse effect on GOA flathead sole (see Section 3.5.1.20).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of flathead sole. The State of Alaska scallop fishery has also been identified as a non-contributing factor since GOA flathead sole bycatch is not expected in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for mortality of GOA flathead sole, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in biomass level is rated as insignificant due to the significant reduction in the groundfish fisheries and the anticipated low harvest of GOA flathead sole.

- **Persistent Past Effects.** Past effects have been identified for the change in biomass in the GOA flathead sole stock and include past JV and domestic fisheries. Large removals of flathead sole by these fisheries is determined to have had a lingering effect on the GOA flathead sole stock (see Section 3.5.1.20).

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the flathead sole biomass level. For more information on climate changes and regime shifts (see Sections 3.5.1.20 and 3.10). The State of Alaska scallop fishery is identified as a non-contributing factor for change in biomass level since flathead sole bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of GOA flathead sole and is rated as insignificant. The MSST cannot be determined and the total and spawning biomass estimates are currently unavailable. However, due to the anticipated low levels of exploit, the combined effect of internal and external removals is unlikely to enhance the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is insignificant.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of the GOA flathead sole stock. However, climate changes and regime shifts have been identified as having a beneficial or adverse effect on GOA flathead sole reproductive success. See Section 3.5.1.20 for more information on the effects of climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of flathead sole due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of GOA flathead sole. The State of Alaska scallop fishery has been identified as a non-contributing factor to change in genetic structure and change in reproductive success since GOA flathead sole bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the flathead sole catch and is rated as insignificant. The spatial/temporal distribution of flathead sole catch is not expected to change significantly. The predation-mediated is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain current population levels is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the GOA flathead sole is rated as insignificant. Due to the reduction of the groundfish fishery effort, it is unlikely that the groundfish fisheries would significantly impact flathead sole prey availability.

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the GOA flathead sole stock and include climate changes and regime shifts. For more information on the effects of climate changes and regime shifts on the GOA flathead sole stock (see Section 3.5.1.20).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA flathead sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The State of Alaska scallop fishery is identified as a potential adverse contributor to GOA flathead sole prey availability. The State of Alaska scallop fishery gear could impact flathead sole benthic prey availability and/or quality.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability and is rated as insignificant. The combination of internal and external removals of prey is not expected to enhance the ability of the stock to sustain itself at current population levels.

<u>Change in Habitat Suitability</u>

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for GOA flathead sole is insignificant. The reduced groundfish fishery effort is unlikely to significantly impact flathead sole habitat suitability.

- **Persistent Past Effects.** Past effects identified for GOA flathead sole include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.20.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA flathead sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The State of Alaska scallop fishery is identified as a potential adverse contributor to GOA flathead sole habitat suitability. For information on the effects of fishery gear on essential fish habitat (see Section 3.6).

- **Cumulative Effects.** A cumulative effect is identified for GOA flathead sole habitat suitability and is rated as insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the flathead sole stock to sustain itself at current population levels is enhanced.

4.8.1.8 Arrowtooth Flounder

BSAI and GOA arrowtooth flounder are described in more detail in Sections 3.5.1.8 and 3.5.1.21 of this Programmatic SEIS. Arrowtooth flounder is managed as its own stock under the BSAI and GOA groundfish FMPs under the Tier 3 management category, thus MSSTs are defined for this species.

BSAI Arrowtooth Flounder – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total Biomass

The total biomass of BSAI arrowtooth flounder at the start of 2002 is estimated to be 811,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-6 of Appendix H. Under FMP 4.1, model projections indicate that the total BSAI biomass is expected to decline 23 percent of the 2002 value to 621,000 mt by 2007, with a 2003-2007 average value of 687,000 mt. Under FMP 4.2, model projections indicate that the total BSAI biomass is expected to decrease 22 percent of the 2002 value to 633,000 mt by 2007, with a 2003-2007 average value of 694,000 mt.

Spawning Biomass

Spawning biomass of female BSAI arrowtooth flounder at the start of 2002 is estimated to be 475,900 mt. Model projections of future arrowtooth flounder spawning biomass estimates are shown in Table H.4-6 of Appendix H. Under FMP 4.1, model projections indicate that female spawning biomass is expected to decline 27.5 percent of the 2002 value to 345,000 mt by 2007, with a 2003-2007 average value of 396,600 mt. Under FMP 4.2, model projections indicate that female spawning biomass is expected to decrease 26 percent of the 2002 value to 353,100 mt by 2007, with a 2003-2007 average value of 401,000 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 182,900 mt throughout the 5-year projection.

Fishing Mortality

The average annual fishing mortality imposed on the BSAI arrowtooth flounder stock in 2002 is 0.015 (Table H.4-6 of Appendix H). Model projections show that the values between 2003-2007 are below the F_{MSY} proxy value of 0.38, the rate associated with the OFL. Under FMP 4.2, no fishing would occur, and thus the stock would not be overfished.

Spatial/Temporal Concentration of Fishing Mortality

Fishing which previously occurred in areas which would be closed under FMP 4.1 would presumably be shifted to the remaining open areas where BSAI arrowtooth flounder concentrations are sufficient to support a commercial fishery. It is estimated that 60 percent of the Bering Sea catch will be displaced under this FMP relative to the 2001 catch distribution. Under FMP 4.2, no fishing would occur for arrowtooth flounder since 100 percent of the BSAI would be closed.

Status Determination

Model projections of future catches of BSAI arrowtooth flounder are below the OFLs in all years under FMP 4.1 and FMP 4.2. The BSAI arrowtooth flounder stocks are above the MSST level throughout the 5-year projection, as in the 2002 baseline year.

Age and Size Composition

Under FMP 4.1, the mean age of the BSAI arrowtooth flounder stock in 2008, as computed in model projections (Table H.4-6 of Appendix H), is 4.9 years. Under FMP 4.2, the mean age of the BSAI arrowtooth flounder stock in 2008, as computed in model projections (Table H.4-6 of Appendix H), is 5.0 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.4 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

Fishery-independent resource assessment surveys in the BSAI have found that populations of arrowtooth flounder are comprised of a higher percentage of females than males. It is believed that this is a function of a higher natural mortality rate for males than females. No information is available to suggest that this would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change during the next 5 years under these FMPs.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 on BSAI arrowtooth flounder would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under FMP 4.1 or FMP 4.2.

Summary of Effects of FMP 4.1 and FMP 4.2 – BSAI Arrowtooth Flounder

Under FMP 4.1 and FMP 4.2, the spawning stock biomass of BSAI arrowtooth flounder is expected to be above the MSST and $B_{40\%}$. Since the fishing mortality rate does not exceed F_{OFL} and the female spawning stocks are expected to remain above the MSST, the expected changes under these FMPs are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under FMP 4.1 and FMP 4.2. Thus, the indirect and direct effects under these FMPs are considered insignificant (Table 4.8-1).

Relative to the 2002 comparative baseline, the BSAI arrowtooth flounder stocks are projected to continue to not be overfished under these FMPs. The 20-year projection indicates that both female spawning stocks are expected to remain above B_{ABC} levels through the end of the projection in 2023.

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects for BSAI arrowtooth flounder are summarized in Table 4.5-13.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI arrowtooth flounder is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause arrowtooth flounder mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of arrowtooth flounder. The IPHC longline fishery is identified as a potential adverse contributor to BSAI arrowtooth flounder mortality since arrowtooth flounder are caught as bycatch in this fishery. Finally, the state herring fishery is identified as a non-contributing factor to BSAI arrowtooth flounder mortality since bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for mortality of BSAI arrowtooth flounder, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fisheries on biomass is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass in the BSAI arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause arrowtooth flounder mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the arrowtooth flounder biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts (see Sections 3.5.1.8 and 3.10). The IPHC longline fishery has been identified as a potential adverse contributor to BSAI arrowtooth flounder biomass level since bycatch is expected to occur in this fishery. Finally, the State of Alaska herring fishery is identified as a non-contributing factor since arrowtooth flounder bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI arrowtooth flounder, and but is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of BSAI arrowtooth flounder. Climate changes and regime shifts are identified as having had potential adverse or beneficial effects on the reproductive success of BSAI arrowtooth flounder (see Section 3.5.1.8).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of arrowtooth flounder due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI arrowtooth flounder. The IPHC longline fishery is identified as a non-contributing factor to the genetic structure and reproductive success of BSAI arrowtooth flounder since the removals are not expected to be significant. The state herring fishery is also identified as a non-contributing factor to the genetic structure and reproductive success of BSAI arrowtooth flounder since bycatch is not expected in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the arrowtooth flounder catch; however, these effects are ranked as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the BSAI arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified include the past foreign, JV, domestic fisheries, State of Alaska groundfish fisheries, state herring fisheries and climate changes and regime shifts (see Section 3.5.1.8).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI arrowtooth flounder stock are potential beneficial or adverse. Some forage species (i.e. capelin and herring), shrimp and pollock respond to variations in water temperatures which vary with the climate. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The IPHC longline fishery is identified as a non-contributing factor to prey availability since the bycatch of prey species is not expected in this fishery. The state herring fishery is identified as a potential adverse contributor to prey availability by reducing the availability of herring.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability, and is considered insignificant. The combination of internal and external removals of prey is not expected to enhance the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the BSAI arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI arrowtooth flounder include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.8.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI arrowtooth flounder stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fishery and the State of Alaska herring fishery are both identified as non-contributing factors to BSAI arrowtooth flounder habitat suitability. The impacts from the fishery gear are expected to be minimal.

- **Cumulative Effects.** A cumulative effect is identified for BSAI arrowtooth flounder habitat suitability, and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the arrowtooth flounder stock to sustain itself at or above the MSST is enhanced.

GOA Arrowtooth Flounder – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total Biomass

The total biomass of GOA arrowtooth flounder at the start of 2002 is estimated to be 1,816,000 mt. Model projections of future total GOA biomass estimates are shown in Table H.4-29 of Appendix H. Under FMP 4.1, model projections indicate that the total GOA biomass is expected to increase 17 percent of the 2002 value to 2,120,000 mt by 2007, with a 2003-2007 average value of 2,000,000 mt. Under FMP 4.2, model projections indicate that the total GOA biomass is expected to increase 17.5 percent of the 2002 value to 2,134,000 mt by 2007, with a 2003-2007 average value of 2,006,000 mt.

Spawning Biomass

Spawning biomass of female GOA arrowtooth flounder at the start of 2002 is estimated to be 1,113,800 mt. Model projections of future arrowtooth flounder spawning biomass estimates are shown in Table H.4-29 of Appendix H. Under FMP 4.1, model projections indicate that female spawning biomass is expected to increase 6 percent of the 2002 value to 1,182,000 mt by 2007, with a 2003-2007 average value of 1,156,700 mt. Under FMP 4.2, model projections indicate that female spawning biomass is expected to increase 7 percent of the 2002 value to 1,192,500 mt by 2007, with a 2003-2007 average value of 1,161,600 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 432,700 mt throughout the 5-year projection.

Fishing Mortality

The average annual fishing mortality imposed on the GOA arrowtooth flounder stock in 2002 is 0.017 (Table H.4-29 of Appendix H). Model projections indicate that fishing mortality will range from 0.002 to 0.004 from 2003-2007. These values are well below the F_{MSY} proxy value of 0.165, the rate associated with the OFL. Under FMP 4.2, no fishing would occur, and thus the stock would not be overfished.

Spatial/Temporal Concentration of Fishing Mortality

Fishing which previously occurred in areas which would be closed under FMP 4.1 would presumably be shifted to the remaining open areas where GOA arrowtooth flounder concentrations are sufficient to support a commercial fishery. It is estimated that 74 percent and 80 percent of the GOA western region and GOA central region catch, respectively, will be displaced under this FMP relative to the 2001 catch distribution. Under FMP 4.2, no fishing would occur for arrowtooth flounder since 100 percent of the GOA would be closed.

Status Determination

Model projections of future catches of GOA arrowtooth flounder are below the OFLs in all years under FMP 4.1 and FMP 4.2. The GOA arrowtooth flounder stocks are above the MSST level throughout the 5-year projection, as in the 2002 baseline year.

Age and Size Composition

Under FMP 4.1 and FMP 4.2, the mean age of the GOA arrowtooth flounder stock in 2008, as computed in model projections (Table H.4-29 of Appendix H), is 5.1 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.1 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

Fishery-independent resource assessment surveys in the GOA have found that populations of arrowtooth flounder are comprised of a higher percentage of females than males. It is believed that this is a function of a higher natural mortality rate for males than females. No information is available to suggest that this would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change during the next 5 years under these FMPs.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 on GOA arrowtooth flounder would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under FMP 4.1 or FMP 4.2.

Summary of Effects of FMP 4.1 and FMP 4.2 – GOA Arrowtooth flounder

Under FMP 4.1 and FMP 4.2, the spawning stock biomass of GOA arrowtooth flounder is expected to be above the MSST and $B_{40\%}$. Since the fishing mortality rate does not exceed F_{OFL} and the female spawning stocks are expected to remain above the MSST, the expected changes under this FMP are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Thus, the indirect and direct effects under these FMPs are considered insignificant.

Relative to the 2002 comparative baseline, the GOA arrowtooth flounder stocks are projected to continue to not be overfished under these FMPs. The 20-year projection (Table H.4-29 of Appendix H) indicates that both female spawning stocks are expected to remain above B_{ABC} levels through the end of the projection in 2023.

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects for GOA arrowtooth flounder are summarized in Table 4.5-14.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA arrowtooth flounder is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the GOA arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those described for BSAI arrowtooth flounder under these FMPs.

- **Cumulative Effects.** A cumulative effect is possible for mortality of GOA arrowtooth flounder, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated earlier in the direct/indirect effects section, the effect of the fisheries on biomass is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the GOA arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass levels are the same as those described for BSAI arrowtooth flounder under these FMPs.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA arrowtooth flounder, and is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch
- – Change in Genetic Structure of Population
- – Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of GOA arrowtooth flounder. Climate changes and regime shifts are identified as having had potential adverse or beneficial effects on the reproductive success of GOA arrowtooth flounder (see Section 3.5.1.21).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success and genetic structure are the same as those described for BSAI arrowtooth flounder under these FMPs.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the arrowtooth flounder catch, and is rated as insignificant. The spatial/temporal distribution of arrowtooth flounder catch is not expected to change significantly. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the GOA arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects**. Past effects identified include climate changes and regime shifts (see Section 3.5.1.21).

- **Reasonably Foreseeable Future External Effects.** Future external effects on prey availability are the same as those described for BSAI arrowtooth flounder under these FMPs.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability, and is considered insignificant. The combination of internal and external removals of prey is not expected to enhance the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the GOA arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for habitat suitability of GOA arrowtooth flounder are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on habitat suitability are the same as those described for BSAI arrowtooth flounder under these FMPs.

- **Cumulative Effects.** A cumulative effect is identified for GOA arrowtooth flounder habitat suitability, and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the arrowtooth flounder stock to sustain itself at or above the MSST is enhanced.

4.8.1.9 Greenland Turbot and Deepwater Flatfish

BSAI Greenland turbot and GOA deepwater flatfish are described in more detail in Sections 3.5.1.9 and 3.5.1.22 of this Programmatic SEIS. Greenland turbot is managed as its own stock under the BSAI groundfish FMP under the Tier 3 management category, thus MSSTs are defined for these species. The reference fishing mortality rate and ABC for the GOA deepwater flatfish management group are determined by the amount of population information available. ABCs for Dover sole were calculated using Tier 5. Greenland turbot and deepsea sole are in Tier 6 because no reliable biomass estimates exists.

BSAI Greenland Turbot – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total Biomass

The total biomass of Greenland turbot at the start of 2002 is estimated to be 106,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-5 of Appendix H. Under FMP 4.1, model projections indicate that the total BSAI biomass is expected to decline 12 percent of the 2002 value to 93,000 mt by 2007, with a 2003-2007 average value of 96,000 mt. Under FMP 4.2, model projections indicate that the total BSAI biomass is expected to increase 3 percent of the 2002 value to 109,000 mt by 2007, with a 2003-2007 average value of 104,000 mt.

Spawning Biomass

Spawning biomass of female Greenland turbot at the start of 2002 is estimated to be 67,800 mt. Model projections of future Greenland turbot spawning biomass estimates are shown in Table H.4-5 of Appendix H. Under FMP 4.1, model projections indicate that female spawning biomass is expected to decline 22 percent of the 2002 value to 52,800 mt by 2007, with a 2003-2007 average value of 57,100 mt. Under FMP 4.2, model projections indicate that female spawning biomass is expected to decrease three percent of the 2002 value to 65,800 mt by 2007, with a 2003-2007 average value of 64,900 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 47,600 mt throughout the 5-year projection.

Fishing Mortality

The average annual fishing mortality imposed on the Greenland turbot stock in 2002 is 0.052. Model projections show this value will increase to 0.112 in 2003-2006 and then decrease to 0.109 in 2007 (Table H.4-5 of Appendix H). These values are well below the F_{MSY} proxy value of 0.48, the rate associated with the OFL. Under FMP 4.2, no fishing would occur, and thus the stock would not be overfished.

Spatial/Temporal Concentration of Fishing Mortality

Fishing which previously occurred in areas which would be closed under FMP 4.1 would presumably be shifted to the remaining open areas where Greenland turbot concentrations are sufficient to support a commercial fishery. Also, harvesting would be restricted to only longline fishing under this FMP. It is estimated that 62 percent of the catch would be spatially displaced under this FMP relative to the 2001 catch distribution. Under FMP 4.2, no fishing would occur for Greenland turbot since 100 percent of the BSAI would be closed.

Status Determination

Model projections of future catches of BSAI Greenland turbot are below the OFLs in all years under FMP 4.1 and FMP 4.2. The Greenland turbot female spawning stock is above the MSST level throughout the 5-year projection, as in the baseline year 2002.

Age and Size Composition

Under FMP 4.1, the mean age of the BSAI Greenland turbot stock in 2008, as computed in model projections (Table H.4-5 of Appendix H), is 4.7 years. Under FMP 4.2, the mean age of the BSAI Greenland turbot stock in 2008, as computed in model projections (Table H.4-5 of Appendix H), is 4.9 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.9 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of Greenland turbot in the BSAI is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change during the next 5 years under these FMPs.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 on Greenland turbot would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under FMP 4.1 or FMP 4.2.

Summary of Effects of FMP 4.1 and FMP 4.2 – BSAI Greenland Turbot

Under FMP 4.1 and FMP 4.2, the spawning stock biomass of BSAI Greenland turbot is not expected to drop below the MSST. Since the fishing mortality rate does not exceed F_{OFL} and the female spawning stock is not expected to decline below the MSST, the expected changes under these FMPs are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Thus, the indirect and direct effects under these FMPs are considered insignificant. However, the female spawning biomass does decline below the $B_{40\%}$ limit in 2006 and 2007 which would initiate a rebuilding plan that would most likely reduce future harvests (Table 4.8-1).

Relative to the 2002 comparative baseline, the Greenland turbot stock is projected to not be overfished under these FMPs. The 20-year projection indicates that the female spawning stock is expected to decline below B_{ABC} levels in 2006 and 2007 and will increase thereafter above B_{ABC} through the end of the projection in 2023.

Cumulative Effects Analysis FMP 4.1 and FMP 4.2

Cumulative effects for BSAI Greenland turbot are summarized in Table 4.5-15.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Greenland turbot is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI Greenland turbot stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause Greenland turbot mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of Greenland turbot.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI Greenland turbot and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As indicated in the direct/indirect effects section, the effect of the fisheries on the change in biomass level is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass in the BSAI Greenland turbot stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause Greenland turbot mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the Greenland turbot biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts (see Sections 3.5.1.9 and 3.10).

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of BSAI Greenland turbot, but is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock and the female spawning biomass is above the B_{MSY} value from 2003-2006. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as persistent past effects for the spatial/temporal concentration of BSAI Greenland turbot catch. Climate changes and regime shifts are suspected of having an effect on the reproductive success of the Greenland turbot stock (see Section 3.5.1.9).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of Greenland turbot due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI Greenland turbot.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the Greenland turbot catch and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is enhanced.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the BSAI Greenland turbot is ranked as insignificant.

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the BSAI Greenland turbot stock. Past foreign, JV, and domestic fisheries have been identified as having influenced the availability of Greenland turbot prey, mainly pollock which is their main prey item in the BSAI. Climate changes and regime shifts have also been identified as influencing Greenland turbot prey availability (see Section 3.5.1.9).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI Greenland turbot stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability and is considered insignificant. The combination of internal and external removals of prey is not expected to enhance the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the BSAI Greenland turbot is ranked as insignificant.

- **Persistent Past Effects**. Past effects identified for BSAI Greenland turbot include climate changes and regime shifts. The foreign, JV, and domestic fisheries have also influenced the habitat suitability of Greenland turbot, largely through the impacts of fishing gear on benthic habitats. See Section 3.5.1.9 for more information on the persistent past effects on Greenland turbot.

- **Reasonably Foreseeable Future External Effects**. Future external effects of the climate changes and regime shifts on the BSAI Greenland turbot stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for BSAI Greenland turbot habitat suitability and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Greenland turbot stock to sustain itself at or above the MSST is enhanced.

GOA Deepwater Flatfish – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass

Reliable estimates of total and spawning biomass are not available for these species.

Fishing Mortality

The catch of GOA deepwater flatfish in 2002 was estimated to be 600 mt. Model projections of future catch are shown in Table H.4-25 of Appendix H. Under FMP 4.1, model projections indicate that the catch is expected to decrease to 500 mt in 2004-2007 with a 2003-2007 average value of 500 mt. Under FMP 4.2 no fishing would occur from 2003-2007.

Spatial/Temporal Concentration of Fishing Mortality

Fishing which previously occurred in areas which would be closed under FMP 4.1 would presumably be shifted to the remaining open areas where species of the deepwater flatfish complex were in concentrations sufficient to support a commercial fishery. It is estimated that the Dover sole catch would be displaced 87 percent in the western area and 71 percent in the central area under this FMP relative to the 2001 catch distribution. No fishing would be allowed for GOA deepwater flatfish under FMP 4.2.

Status Determination

The available information for flatfish species in the deepwater complex requires that they are classified into either the Tier 5 or Tier 6 management category. As a result, no MSSTs are defined for these species. Therefore, it is not possible to determine their status.

Age and Size Composition

Age and size composition estimates are not available for these species.

Sex Ratio

The sex ratio of deepwater flatfish in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 and FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change during the next 5 years under these FMPs.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 on deepwater flatfish would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under FMP 4.1 or FMP 4.2.

Summary of Effects of FMP 4.1 and FMP 4.2 – GOA Deepwater Flatfish

The direct and indirect effects of FMP 4.1 and FMP 4.2 on GOA deepwater flatfish cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of these stocks is over the 5-year projection. The predicted catch rates under FMP 4.1 and FMP 4.2 are well below the OFL for this stock, therefore, the effects of these FMPs would be insignificant on GOA deepwater flatfish through mortality (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects for GOA deepwater flatfish are summarized in Table 4.5-16.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA deepwater flatfish is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the GOA deepwater flatfish stock.

- **Reasonably Foreseeable Future External Effects**. Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause deepwater flatfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of deepwater flatfish. The State of Alaska scallop fishery is identified as a non-contributing factor since bycatch of deepwater flatfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for mortality of GOA deepwater flatfish, but is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to maintain current population levels.

<u>Change in Biomass Level</u>

- **Direct/Indirect Effects.** Total and spawning biomass estimates are unavailable for the deepwater flatfish species. However, the effects of FMP 4.1 and FMP 4.2 on the change in biomass level are rated as insignificant due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass in the GOA deepwater flatfish stock complex.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause deepwater flatfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the deepwater flatfish species biomass level. For more information on climate changes and regime shifts (see Sections 3.5.1.22 and 3.10). The State of Alaska scallop fishery has been identified as a non-contributing factor for change in biomass level since deepwater flatfish species bycatch is not expected to occur.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of GOA deepwater flatfish and is rated as insignificant. The combined effect of internal and external removals is unlikely to enhance the capacity of the stock to maintain current population levels.

<u>Spatial/Temporal Concentration of Catch</u>
- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is rated as insignificant for the stock.

- **Persistent Past Effects**. Past effects include climate changes and regime shifts which are suspected of having an effect on the reproductive success of the deepwater flatfish stock complex. See Section 3.5.1.22 for more information on the effects of climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of Greenland turbot due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of GOA deepwater flatfish. The State of Alaska scallop fishery is identified as a non-contributing factor to change in genetic structure and reproductive success since bycatch of GOA deepwater flatfish species is not expected to occur.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the GOA deepwater flatfish catch and is rated as insignificant. The combined effect of internal and external removals is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain current population levels is enhanced.

<u>Change in Prey Availability</u>

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the GOA deepwater flatfish complex is insignificant.

- **Persistent Past Effects**. Past effects are identified for the change in prey availability of the GOA deepwater flatfish stock complex and include climate changes and regime shifts (see Section 3.5.1.22).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA deepwater flatfish stock complex are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The state scallop fishery has been identified as a potential adverse contributor to benthic prey availability. See Section 3.6 for information of the impacts of fishery gear on essential fish habitat.

- **Cumulative Effects.** A cumulative effect is identified as insignificant for change in prey availability. The combination of internal and external removals of prey is not expected to enhance the ability of the stock to maintain current populations.

<u>Change in Habitat Suitability</u>

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the GOA deepwater flatfish complex is rated as insignificant.

- **Persistent Past Effects.** Past effects identified for GOA deepwater flatfish include climate changes and regime shifts. The foreign, JV, and domestic fisheries have also influenced the habitat suitability of deepwater flatfish, largely through the impacts of fishing gear on benthic habitats. See Section 3.5.1.22 for more information on the persistent past effects on deepwater flatfish.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA deepwater flatfish stock complex are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The state scallop fishery has been identified as a potential adverse contributor to habitat suitability. See Section 3.6 for more information on the impacts of fishery gear on essential fish habitat.

- **Cumulative Effects.** A cumulative effect is identified as insignificant for GOA deepwater flatfish habitat suitability. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the deepwater flatfish stock complex to maintain current population levels is enhanced.

4.8.1.10 Alaska Plaice, Other Flatfish, and Rex Sole

BSAI Alaska plaice and other flatfish and GOA rex sole are described in more detail in Sections 3.5.1.10 and 3.5.1.23 of this Programmatic SEIS.

BSAI Alaska plaice – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total Biomass

Total biomass of BSAI Alaska plaice at the start of 2003 is estimated to be 1,083,000 mt. Model projections of future total BSAI Alaska plaice biomass are shown in Table H.4-9 of Appendix H. Under FMP 4.1, model projections indicate that BSAI Alaska plaice biomass is expected to increase to a value of 1,112,000 mt in 2008, with a 2003-2008 average value of 1,102,000 mt. Under FMP 4.2, model projections indicate that BSAI Alaska plaice biomass is expected to increase to a value of 1,159,000 mt in 2008, with a 2003-2008 average value of 1,123,000 mt.

Spawning Biomass

Spawning biomass of BSAI Alaska plaice at the start of 2003 is estimated to be 275,700 mt. Model projections of future total BSAI Alaska plaice biomass are shown in Table H.4-9 of Appendix H. Under FMP 4.1, model projections indicate that BSAI Alaska plaice biomass is expected to increase to a value of 283,700 mt in 2008, with a 2003-2008 average value of 278,200 mt. Under FMP 4.2, model projections indicate that BSAI Alaska plaice biomass is expected to increase to a value of 301,200 mt in 2008, with a 2003-2008 average value of 288,800 mt.

Fishing Mortality

The projected fishing mortality imposed on the BSAI Alaska plaice stock is approximately 0.02 in 2003 and decreases to 0.017 in 2008. The proportion of spawner biomass per recruit conserved under these fishing mortality rates is 91 percent in 2003 and increases to 92 percent in 2008, with an average of 91 percent from 2003-2008 (Table H.4-9 of Appendix H). Under FMP 4.2, the projected TAC has been set to zero for all species unless the harvesting of a species has been shown to have no adverse effect on the environment (Table H.4-9 of Appendix H). Thus, there is no fishery for BSAI Alaska plaice from 2003-2008.

Spatial/Temporal Concentration of Fishing Mortality

The average annual projected harvest of Alaska plaice under FMP 4.1 was 10,400 mt, with 8,800 mt (85 percent) of the harvest occurring in the EBS shelf yellowfin sole fishery. It is estimated that 40 percent of the catch under this FMP will be displaced relative to the 2001 catch distribution due to area closures. Under FMP 4.2, there is no projected fishing mortality.

Status Determination

Under FMP 4.1 and FMP 4.2, the ABC is set lower than the OFL, creating a buffer between these two harvest regulations. Model projections of future catches of BSAI Alaska plaice are below the ABC and OFL levels from 2003 to 2008.

Age and Size Composition

Under FMP 4.1, the mean age of the BSAI Alaska plaice stock in 2008, as computed in model projections (Table H.4-9 of Appendix H), is 4.40 years. Under FMP 4.2, the mean age of the BSAI Alaska plaice stock in 2008, as computed in model projections (Table H.4-9 of Appendix H), is 4.47 years. This compares with a mean age in the equilibrium unfished stock of 4.51 years.

Sex Ratio

The sex ratio of BSAI Alaska plaice is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under FMP 4.1 or FMP 4.2. Because the BSAI Alaska plaice are fished at less than the ABC and are above the MSST, the direct and indirect effects under FMP 4.1 and FMP 4.2 through habitat suitability are considered insignificant.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 4.1 or FMP 4.2. Because the BSAI Alaska plaice are fished at less than the ABC and are above the MSST, the direct and indirect effects under FMP 4.1 and FMP 4.2 through prey availability are considered insignificant.

Summary of Direct/Indirect Effects of FMP 4.1 and FMP 4.2 – BSAI Alaska Plaice

Because the BSAI Alaska plaice are fished at less than the ABC and are above the MSST, the direct and indirect effects under FMP 4.1 and FMP 4.2 are considered insignificant. With the removal of fishing for BSAI Alaska plaice, the direct and indirect effects under FMP 4.2 are considered insignificant. Fishing rates are below accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity (Table 4.8-1).

Relative to the 2002 comparative baseline, the Alaska plaice stock is projected to continue to not be overfished under these FMPs. The 20-year projection indicates that the female spawning stock is expected to remain at a high and stable level well above B_{ABC}.

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects for BSAI Alaska plaice are summarized in Table 4.5-17.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Alaska plaice stock is insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** No lingering past effects on BSAI Alaska plaice have been identified.

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as a potential adverse contributor to mortality of BSAI Alaska plaice. Acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as contributors to mortality since a change is not expected to be significant in magnitude to cause mortality.

- **Cumulative Effects.** Under FMP 4.1 and FMP 4.2, a cumulative effect is identified for BSAI Alaska plaice mortality and is considered insignificant. Alaska plaice are fished above the ABC and OFL values. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to enhance the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Alaska plaice stock is expected to be insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** No lingering past effects on BSAI Alaska plaice have been identified.

- **Reasonably Foreseeable Future External Effects.** Marine pollution events are identified as potential adverse contributors to BSAI Alaska plaice change in biomass level. Acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are identified as potential beneficial or adverse contributors to change in biomass level, since recruitment is affected by climate changes and regime shifts through a combination of prey availability and habitat suitability effects.

- **Cumulative Effects.** A cumulative effect is identified for BSAI Alaska plaice change in biomass and is rated as insignificant. The combination of internal and external factors is not expected to increase Alaska plaice biomass such that the ability of the stock to maintain itself at or above the MSST is enhanced.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 is determined to have an insignificant effect on BSAI Alaska plaice spatial/temporal characteristics.

- **Persistent Past Effects.** No persistent past effects have been identified for the genetic structure of the BSAI Alaska plaice population. Although, climate changes and regime shifts have been identified as having a potential beneficial or adverse effect on BSAI Alaska plaice reproductive success. In general, when the Aleutian Low is strong and corresponding water temperatures are high, flatfish recruitment tends to be favored.

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contribution to BSAI Alaska plaice genetic structure and reproductive success. Acute and/or chronic events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and could also result in reduced recruitment. Climate changes and regime shifts have been identified as potential beneficial or adverse contributors to the reproductive success of BSAI Alaska plaice, but as non-contributing factors to the genetic structure of Alaska plaice. The reproductive success is affected through a combination of climate induced changes in prey availability and habitat suitability.

- **Cumulative Effects.** A cumulative effect has been identified for the spatial/temporal concentration of BSAI Alaska plaice and is rated as insignificant. The combined internal and external events are not expected to significantly alter the reproductive success or genetic structure such that it enhances the capacity of the stock to maintain itself above MSST.

Change in Prey Availability

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 is determined to have an insignificant effect on BSAI Alaska plaice prey availability.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having potential adverse or beneficial effects on BSAI Alaska plaice prey availability. Little research has been conducted on benthic invertebrates, the main prey species of Alaska plaice, therefore the magnitude and direction of the effects imposed by climate changes and regime shifts are unknown.

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as a potential adverse contributor to the prey availability of BSAI Alaska plaice. Acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above the MSST. Climate changes and regime shifts are identified as potential beneficial or adverse contributors to BSAI Alaska plaice prey availability. However, as stated above, since little research has been conducted on the effects of climate changes on benthic invertebrates, the magnitude and direction of the changes are unknown.

- **Cumulative Effects.** A cumulative effect has been identified for the BSAI Alaska plaice change in prey availability and is rated as insignificant. The combination of internal and external removals of prey species is not expected to increase prey availability such that the ability of BSAI Alaska plaice stock to maintain itself at or above MSST is enhanced.

<u>Change in Habitat Suitability</u>

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 is determined to have an insignificant effect on Alaska plaice habitat suitability.

- **Persistent Past Effects.** The past foreign, JV, and domestic fisheries have been identified as having adverse effects on BSAI Alaska plaice habitat. See Sections 3.5.1.10 and 3.6 for more information on the effects of fishing gear on flatfish habitat. Climate changes and regime shifts are also identified as having a potential adverse or beneficial effect on Alaska plaice habitat (see Sections 3.5.1.10 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to BSAI Alaska plaice habitat suitability. Acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success of Alaska plaice. Climate changes and regime shifts have also been identified as having potential beneficial or adverse contributions to BSAI Alaska plaice habitat suitability. In general, when the Aleutian Low is strong and corresponding water temperatures are high, flatfish recruitment is favored.

- **Cumulative Effects.** A cumulative effect for BSAI Alaska plaice change in habitat suitability is identified and is rated as insignificant. The combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the BSAI Alaska plaice stock to maintain itself at or above the MSST is enhanced.

BSAI Other Flatfish – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass

Estimates of total and spawning biomass are not available for these species.

Fishing Mortality

The catch of BSAI other flatfish in 2002 was estimated to be 2,600 mt. Model projections of future catch are shown in Table H.4-10 of Appendix H. Under FMP 4.1, model projections indicate that the catch is expected to decrease from the 2002 value to 1,900 mt in 2003 and then further decrease to 1,800 mt in 2007 (31 percent decrease from 2002). The 2003-2007 average catch is 1,900 mt. Under FMP 4.2, catch in all five projected years would be zero.

Spatial/Temporal Concentration of Fishing Mortality

Fishing which previously occurred in areas which would be closed under FMP 4.1 would presumably be shifted to the remaining open areas where other flatfish concentrations are sufficient to support a commercial fishery. No fishing would occur for other flatfish since 100 percent of the BSAI would be closed.

Status Determination

The available information for flatfish species in the deepwater complex requires that they are classified into either the Tier 4 or Tier 5 management category. As a result, no MSSTs are defined for these species. Therefore, it is not possible to determine their status.

Age and Size Composition

Age and size composition estimates are not available for these species.

Sex Ratio

The sex ratios of the species of the BSAI other flatfish category are assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo a significant qualitative change during the next 5 years under these FMPs.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 on other flatfish would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under FMP 4.1 or FMP 4.2.

Summary of Direct/Indirect Effects of FMP 4.1 and FMP 4.2 – BSAI Other Flatfish

The direct and indirect effects of FMP 4.1 and FMP 4.2 on BSAI other flatfish cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of these stocks is over the 5-year projection under these FMPs. The predicted catches under these FMPs are well below the OFL for this stock, therefore, FMP 4.1 and FMP 4.2 would have insignificant effects on BSAI other flatfish through mortality (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects for BSAI other flatfish are summarized in Table 4.5-18.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI other flatfish is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects have not been identified for BSAI other flatfish mortality.

- **Reasonably Foreseeable Future External Effects**. Future external effects on mortality are the same as those described for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI other flatfish and is rated as insignificant. Fishing mortality rates for projected years are well below the other flatfish OFL. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of changes in biomass level is rated as insignificant.

- **Persistent Past Effects.** Past effects have not been identified for the BSAI other flatfish change in biomass level effect indicator.

- **Reasonably Foreseeable Future External Effects**. Future external effects on change in biomass level are the same as those indicated for BSAI Alaska plaice under these FMPs.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of BSAI other rockfish and is rated as insignificant. Fishing mortality at projected levels is below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is insignificant.

- **Persistent Past Effects.** Past effects identified for the genetic structure and reproductive success of BSAI other flatfish are the same as those described for BSAI Alaska plaice under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the genetic structure and reproductive success of other flatfish are the same as those described for BSAI Alaska plaice under these FMPs.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the other flatfish catch and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to maintain current population levels.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the BSAI other flatfish is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for the change in prey availability of the BSAI other flatfish are the same as those indicated for BSAI Alaska plaice under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects identified for the change in prey availability are the same as those described for BSAI Alaska plaice under these FMPs.

- **Cumulative Effects.** A cumulative effect is identified for the change in prey availability and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the BSAI other flatfish is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for the change in habitat suitability of BSAI other flatfish are the same as those indicated for BSAI Alaska plaice under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects identified for the change in habitat suitability of BSAI other flatfish are the same as those indicated for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for BSAI other flatfish habitat suitability and is rated as insignificant. The establishment of MPAs may be beneficial to other flatfish species habitat. The combined effect of internal habitat disturbances and reasonably foreseeable external habitat disturbances is unlikely to be sufficient to enhance the stock's ability to maintain current population levels.

GOA Rex Sole – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass

Estimates of total and spawning biomass are not available for this species.

Fishing Mortality

The catch of GOA rex sole in 2002 was estimated to be 3,000 mt. Model projections of future catch are shown in Table H.4-26 of Appendix H. Under FMP 4.1, model projections indicate that the catch is expected to increase from 150 mt in 2003 to 1,700 mt in 2007. The 2003-2007 average catch is 900 mt. Under FMP 4.2 no fishing would occur from 2003-2007.

Spatial/Temporal Concentration of Fishing Mortality

Fishing which previously occurred in areas which would be closed under FMP 4.1 would presumably be shifted to the remaining open areas where rex sole concentrations are sufficient to support a commercial fishery. It is estimated that 48 percent of the catch in the western area would be displaced under this FMP and 67 percent in the central area relative to the 2001 catch distribution. No fishing would be allowed in the GOA under FMP 4.2.

Status Determination

The available information for GOA rex sole requires that they are classified into the Tier 5 management category. As a result, no MSSTs are defined for this species. Therefore, it is not possible to determine their status.

Age and Size Composition

Age and size composition estimates are not available for this species.

Sex Ratio

The sex ratio of rex sole in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change during the next 5 years under these FMPs.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 on rex sole would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under FMP 4.1 or FMP 4.2.

Summary of Direct/Indirect Effects of FMP 4.1 and FMP 4.2 – GOA Rex Sole

The direct and indirect effects of FMP 4.1 and FMP 4.2 on GOA rex sole cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of this stock is over the 5-year projection under these FMPs. The predicted catches under these FMPs are well below the OFL for this stock, therefore, FMP 4.1 and FMP 4.2 would have insignificant effects on GOA rex sole through mortality (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects for GOA rex sole are summarized in Table 4.5-19.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA rex sole is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Large removals of rex sole by the past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA rex sole stocks (see Section 3.5.1.23).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause rex sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of rex sole. The state scallop fishery has also been identified as a non-contributing factor since it is not expected to contribute to direct mortality of rex sole.

- **Cumulative Effects.** A cumulative effect is possible for mortality of GOA rex sole and is rated as insignificant. Fishing mortality rates for projected years are well below the rex sole OFL. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of changes in biomass level is rated as insignificant.

- **Persistent Past Effects.** Large removals of rex sole by past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA rex sole stocks (see Section 3.5.1.23).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause rex sole mortality. Climate changes and regime shifts have also been identified as having an indirect potential beneficial or adverse effect on the rex sole biomass level. When the Aleutian Low is strong and water temperatures warm, flatfish recruitment is favored, likewise when the Aleutian Low is weak and the temperatures cooler, recruitment tends to be weak. The state scallop fishery is identified as a non-contributing factor since it is not expected to contribute to direct mortality of rex sole. For more information on climate changes and regime shifts (see Sections 3.5.1.23 and 3.10).

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of GOA rex sole and is rated as insignificant. Fishing mortality at projected levels is below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch
  – Change in Genetic Structure of Population
  – Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is ranked as insignificant.

- **Persistent Past Effects.** Past effects are not identified for genetic structure of the population; however, climate changes and regime shifts are identified as having persistent past effects on the reproductive success of the GOA rex sole stock. See Sections 3.5.1.23 and 3.10 for more information of climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the genetic structure of rex sole include the potential adverse effects of marine pollution since an acute and/or chronic pollution event could alter the genetic structure of the population by causing localized mortality. The state scallop fishery and climate changes and regime shifts have both been identified as non-contributing factors to the change in genetic structure of rex sole stocks. These events are not expected to cause localized depletions that would alter the genetic sub-population structure of rex sole stock. Change in reproductive success of rex sole due to climate changes and regime shifts is identified as having a potential beneficial or adverse effect. Marine pollution has been identified as a potential adverse effect since acute and/or chronic pollution events could also the reproductive success of GOA rex sole. Again, the state scallop fishery has been identified as a non-contributing factor since the scallop fishery is not expected to contribute to rex sole removals.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the rex sole catch and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to maintain current population levels.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the GOA rex sole is ranked as insignificant.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had effected the prey availability of the GOA rex sole stock. The actual effect of climate changes and regime shifts on rex sole prey availability is unknown, but could have had a potential beneficial or adverse effect. See Sections 3.5.1.23 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA rex sole stock are potential beneficial or adverse. When the Aleutian Low is strong and water temperatures warm, flatfish recruitment is favored, likewise when the Aleutian Low is weak and water temperatures cooler, flatfish recruitment is reduced. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels. The state scallop fishery has been identified as having a potential adverse effect on rex sole prey availability since the habitat disturbances caused by dredging could influence the availability of benthic prey.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to enhance the capacity of the stock to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the GOA rex sole is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for GOA rex sole include climate changes and regime shifts. The actual effects of climate changes and regime shifts on habitat suitability are unknown, but could have a potential beneficial or adverse effect. Habitat disturbances caused by the past foreign, JV, and domestic fisheries have also been identified as having persistent past effects on the GOA rex sole stock. See Sections 3.5.1.23 and 3.10 for more information regarding the past fisheries and climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA rex sole stock are potential beneficial or adverse. When the Aleutian Low is strong and water temperatures warm, flatfish recruitment is favored, likewise when the Aleutian Low is weak and water temperatures cooler, flatfish recruitment is reduced. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The state scallop fishery is identified as having potential adverse effects on rex sole habitat suitability that may cause changes in the spawning or rearing success of the stock.

- **Cumulative Effects.** A cumulative effect is identified for GOA rex sole habitat suitability and is considered to be insignificant. The establishment of MPAs may be beneficial to rex sole habitat. The combined effect of internal habitat disturbances and reasonably foreseeable external habitat disturbances is unlikely to be sufficient to enhance the stock's ability to maintain current population levels.

4.8.1.11 Pacific Ocean Perch

Pacific ocean perch (*Sebastes alutus*) are managed under Tier 3 in both the BSAI and GOA.

BSAI Pacific Ocean Perch – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total Biomass

Total biomass of BSAI Pacific ocean perch at the start of 2003 is estimated to be 374,000 mt. Model projections of future total BSAI Pacific ocean perch biomass are shown in Table H.4-12 of Appendix H. Under FMP 4.1, model projections indicate that BSAI biomass is expected to increase to a value of 443,000 mt in 2008, with a 2003-2008 average value of 409,000 mt. Under FMP 4.2, model projections indicate that BSAI Pacific ocean perch biomass is expected to increase to a value of 448,000 mt in 2008, with a 2003-2008 average value of 411,000 mt.

Spawning Biomass

Spawning biomass of BSAI Pacific ocean perch at the start of 2003 is estimated to be 136,500 mt. Model projections of future total BSAI Pacific ocean perch biomass are shown in Table H.4-12 and Figure H.4-15 of Appendix H. Under FMP 4.1, model projections indicate that BSAI Pacific ocean perch biomass is expected to increase to a value of 160,800 mt in 2008, with a 2003-2008 average value of 147,800 mt. Under FMP 4.2, model projections indicate that BSAI Pacific ocean perch biomass is expected to increase to a value of 162,700 mt in 2008, with a 2003-2008 average value of 148,800 mt.

Fishing Mortality

The projected fishing mortality imposed on the BSAI Pacific ocean perch stock is approximately 0.002 in each year from 2003 to 2008. This fishing mortality corresponds to an implied spawner-per-recruit fishing mortality rate of 94 percent from 2004-2008 (Table H.4-12 of Appendix H). Under FMP 4.2, the projected TAC has been set to zero for all species unless the harvesting of a species has been shown to have no adverse effect on the environment (Table H.4-12 of Appendix H). Thus, there is no fishery for BSAI Pacific ocean perch from 2003-2008.

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 4.1, the average annual projected harvest of BSAI Pacific ocean perch is 850 mt, of which 660 mt (80 percent) is taken in the eastern Aleutian Islands. This harvest is taken as bycatch in the Atka mackerel fishery (620 mt), with very little taken in the directed Pacific ocean perch fishery in this region (40 mt). The dramatic reduction of catch under FMP 4.1 is consistent with the establishment of no-take reserves in the Aleutian Islands, which nearly completely covers the fishing grounds for the Pacific ocean perch fishery. Under FMP 4.2, there is no projected fishing mortality.

Status Determination

Under FMP 4.1 and FMP 4.2, the ABC is set lower than the OFL, creating a buffer between these two harvest regulations. Model projections of future catches of BSAI Pacific ocean perch are below the ABC and OFL levels from 2003 to 2008. The projected spawning stock biomass is projected to be greater than the B_{MSY} ($B_{35\%}$) level of 120,200 mt in each year of the projection, so BSAI Pacific ocean perch are above the MSST level under FMP 4.1 and FMP 4.2.

Age and Size Composition

Under FMP 4.1, the mean age of the BSAI Pacific ocean perch stock in 2008, as computed in model projections (Table H.4-12 of Appendix H), is 10.90 years. Under FMP 4.2, the mean age of the BSAI Pacific ocean perch stock in 2008, as computed in model projections (Table H.4-12 of Appendix H), is 10.95 years. This compares with a mean age in the equilibrium unfished stock of 14.01 years.

Sex Ratio

The sex ratio of BSAI Pacific ocean perch is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change under FMP 4.1 or FMP 4.2.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 4.1 and FMP 4.2.

Summary of Effects of FMP 4.1 and FMP 4.2 – BSAI Pacific Ocean Perch

A significant feature of FMP 4.1 is the use of the $F_{75\%}$ fishing rate as a maximum for BSAI Pacific ocean perch, and the projected fishing mortality rates are lowered from the $F_{75\%}$ level. An additional feature is establishment of extensive no-take reserves that would prevent targeting of Pacific ocean perch on currently used fishing grounds, essentially eliminating the Pacific ocean perch directed fishery in the BSAI. These two factors would be expected to lead to a significantly beneficial enhancement of the ability of BSAI Pacific ocean perch to sustain itself above the MSST. Because the Pacific ocean perch are patchily distributed fish and the harvest is concentrated in specific locations, the removal of directed Pacific ocean perch harvesting would also be expected to lead to significantly beneficial increases in recruitment success in these locations. The removal of directed fishing may also lead to habitat improvement, but whether this would translate into reproductive success is uncertain, therefore this effect is considered insignificant. Because the BSAI Pacific ocean perch are fished at less or equal to the ABC and are above the MSST, all other effects under FMP 4.1 are considered insignificant. Fishing rates are more conservative than accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment.

Under FMP 4.2, the removal of fishing would be expected to lead to significantly beneficial enhancement of the ability of the BSAI Pacific ocean perch to sustain itself above the MSST. Because Pacific ocean perch are patchily distributed fish and the harvest is concentrated in specific locations, the removal of directed Pacific ocean perch harvesting would also be expected to lead to significantly beneficial increases in recruitment success in these locations. The removal of directed fishing may also lead to habitat improvement, but whether this would translate into reproductive success is uncertain; therefore, this effect is considered insignificant. Because the BSAI Pacific ocean perch are not fished and are above the MSST, all other effects under FMP 4.2 are considered insignificant (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects for BSAI Pacific ocean perch are summarized in Table 4.5-20.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Pacific ocean perch stock is insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** The past foreign, JV, and domestic fisheries are identified as having had adverse effects on the BSAI Pacific ocean perch stock. Large removals of Pacific ocean perch occurred in the past and there appears to be a lingering effect on the BSAI populations (see Section 3.5.1.11).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery is not expected to contribute to BSAI Pacific ocean perch mortality since bycatch in this fishery is not expected. Marine pollution is identified as making a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Pacific ocean perch mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI Pacific ocean perch and is rated as insignificant. Pacific ocean perch are fished at less than the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Pacific ocean perch stock is expected to be significantly beneficial under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** The past foreign, JV, and domestic fisheries are identified as having had adverse effects on the BSAI Pacific ocean perch stock. Large removals of Pacific ocean perch occurred in the past and there appears to be a lingering effect on the BSAI populations (see Section 3.5.1.11).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery is not expected to contribute significantly to BSAI Pacific ocean perch mortality since bycatch is not expected in this fishery. Therefore, the IPHC longline fishery is also not expected to cause significant changes in biomass levels. Marine pollution is identified as making a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are identified as making beneficial or adverse contributions to Pacific ocean perch change in biomass levels as a function of reproductive success.

- **Cumulative Effects.** A cumulative effect for the change in biomass is identified as significantly beneficial. The combination of internal and external factors is expected to increase the biomass toward levels that will enhance the ability of the stock to maintain itself at or above MSST.

Spatial/Temporal Concentration of Catch

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** Due to the reduction in the groundfish fishery effort and the establishment of no-take zones, FMP 4.1 and FMP 4.2 is found to have a significantly beneficial effect on the reproductive success and insignificant effects on the genetic structure of BSAI Pacific ocean perch.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure . However, there are lingering past effects due to climate changes and regime shifts (see Section 3.5.1.11) for change in reproductive success.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery is not expected to contribute to changes in genetic structure or reproductive success of BSAI Pacific ocean perch since bycatch of BSAI Pacific ocean perch is not expected to occur. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are identified as potential beneficial or adverse contributor to reproductive success since changes in climate can effect prey availability and/or habitat suitability which in turn can effect recruitment. Generally, changes in climate that lead to increased advection of the Alaska current are believed to increase euphausiid production, a major prey item of BSAI Pacific ocean perch. Climate changes and regime shifts are not considered to contribute to changes in genetic structure.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of BSAI Pacific ocean perch and is rated as significantly beneficial. The genetic structure of BSAI Pacific ocean perch is not expected to be effected significantly; however, the reproductive success of the BSAI Pacific ocean perch is expected to increase, mainly due to the reduction of the groundfish fishery effort.

Change in Prey Availability

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 would have an insignificant effect on Pacific ocean perch prey availability.

- **Persistent Past Effects.** Past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific ocean perch prey species (see Section 3.5.1.11).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on Pacific ocean perch prey species are identified as potential beneficial or adverse contributors. In general, it is believed that climate changes and regime shifts that lead to the increased advection of the Alaska current also increase production of euphausiids, a major prey item of BSAI Pacific ocean perch. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for prey availability and is rated as insignificant. The combination of internal and external removals of prey is not expected to increase prey availability such that the ability of Pacific ocean perch stock to sustain itself at or above MSST is enhanced.

Change in Habitat Suitability

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 would have an insignificant effect on Pacific ocean perch habitat suitability.

- **Persistent Past Effects.** Past effects on habitat suitability identified for BSAI Pacific ocean perch stocks include past foreign, JV, and domestic fisheries, IPHC longline fisheries and climate changes and regime shifts (see Section 3.5.1.11). Intense bottom trawling on Pacific ocean perch habitat in the past fisheries likely disrupted spawning and/or rearing habitats in areas of the BSAI. It is possible that some of these areas have not recovered from the intense efforts. The IPHC longline fisheries are also identified as having adverse effects on Pacific ocean perch habitat, although these fishing gear impacts are considered to be less significant than those associated with trawl gear (see Section 3.6). Climate changes and regime shifts have had both beneficial and adverse effects on Pacific ocean perch habitat.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery is identified as making adverse contributions to Pacific ocean perch habitat through fishing gear impacts. As stated above, these impacts are expected to be of lesser magnitude than those effects associated with trawl gear. Impacts on habitat from climate changes and regime shifts on the BSAI Pacific ocean perch stock are identified as potential beneficial or adverse contributors, although the magnitude and direction of the change in relation to strong and weak Aleutian Low systems are unknown. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability and is rated as insignificant. The combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Pacific ocean perch stock to sustain itself at or above MSST is enhanced.

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass and Fishing Mortality

FMP 4.1 would reduce catch of GOA Pacific ocean perch because it changes the biological reference point for determining rockfish F_{ABC} from $F_{40\%}$ to $F_{75\%}$ and further adjusts F_{ABC} downward as a function of the coefficient of variation of the mean survey biomass. FMP 4.1 also eliminates fisheries with more than 33 percent bycatch, which might redistribute the Pacific ocean perch fishery if it has a high bycatch rate. Average fishing mortality during the years 2003 - 2008 is expected to be less than F_{OFL} (0.060) (Table H.4-36 and Figure H.4-15 of Appendix H).

FMP 4.2 would eliminate catch of GOA Pacific ocean perch until it could be proven that fishing for GOA Pacific ocean perch would have no adverse effect on the environment. Consequently, average fishing mortality during the years 2003 - 2008 is expected to be less than F_{OFL} (0.060) (Table H.4-36 and Figure H.4-15 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

FMP 4.1 may potentially have a large impact on the spatial concentration of Pacific ocean perch catch if 20 percent to 50 percent of the GOA is set aside as no-take reserves or as MPAs. The Pacific ocean perch fishery is concentrated in slope areas which cover a small geographic area in the GOA. The proposed MPAs cover large portions of Portlock, Albatross, and Shumagin Banks and the "W" grounds west of Yakutat, all of which are major fishing grounds for Pacific ocean perch. Much of the past fishing effort concentrated on these proposed closure areas. If the proposed MPAs are closed to all bottom trawling, then the effects of FMP 4.1 would likely displace fishing effort to other localities. Whether this displacement would result in spreading out the fishing effort over a wider area, or would merely concentrate the effort in new localities depends on the decisions made by the NPFMC. If effort based management and the reduced fishing mortality proposed under FMP 4.1 are adopted then adoption of the MPAs is not likely to result in localized depletions.

FMP 4.1 would also have large effects on the temporal concentration of Pacific ocean perch catch. If the fishery remained a relatively short open-access type fishery, then the closure of major fishing areas may alter catch rates enough that more time is necessary to catch the ABC. If effort-based management is adopted under FMP 4.1, then the Pacific ocean perch trawl fishery would change from a short open-access fishery. This would likely allow directed Pacific ocean perch fishing to continue over a longer time period, which may allow better management oversight of the fishery and reduce the risk of overharvesting.

Under FMP 4.1, fisheries with more than 33 percent bycatch would be eliminated which could also change the distribution of fishing effort for GOA Pacific ocean perch if the bottom trawl fishery for Pacific ocean perch has high bycatch rates.

Fishing mortality for FMP 4.2 is zero, so there is no spatial or temporal concentration of fishing.

Status Determination

Under FMP 4.1, the projected 2003 biomass of 113,800 mt is greater than $B_{35\%}$ and consequently the stock is projected to be above its MSST and not projected to be in an overfished condition. The projected 2005 biomass of 119,200 mt is greater than $B_{35\%}$ and consequently the stock is not projected to be approaching an overfished condition.

Under FMP 4.2, the projected 2003 biomass of 114,100 mt is greater than $B_{35\%}$ and consequently the stock is projected to be above its MSST and not projected to be in an overfished condition. The projected 2005 biomass of 121,600 mt is greater than $B_{35\%}$ and consequently the stock is not projected to be approaching an overfished condition.

Age and Size Composition

Under FMP 4.1 and FMP 4.2, the age composition of GOA Pacific ocean perch may be affected by fishing mortality as in FMP 1. Size composition of GOA Pacific ocean perch might change in proportion to the change in age composition. Age and size composition could also change if the elimination of fisheries with high bycatch rates substantially change the distribution of Pacific ocean perch fishing effort.

Sex Ratio

No information is available to suggest that the sex ratio would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Under FMP 4.1, damage to epifauna by bottom trawls would likely be reduced under less fishing pressure and result in less impact on juvenile Pacific ocean perch habitat. FMP 4.1 may also have a beneficial effect on the habitat of GOA Pacific ocean perch because it proposes to set aside 20 percent to 50 percent of the GOA as no-take reserves or as MPAs. If these MPAs are closed to all bottom trawling, then they may serve as additional refuge for Pacific ocean perch allowing for increased survival of larger and older fish that produce significantly more eggs and larvae to replenish the GOA population. If these MPAs are closed to all bottom trawling, then they would also provide protection from the potential effects of trawling on juvenile rockfish habitat in these areas.

Under FMP 4.2 further damage to epifauna by bottom trawls would be eliminated and result in no impact on juvenile Pacific ocean perch habitat. FMP 4.2 also provides a de facto no-take zone or refuge for GOA Pacific ocean perch in the stock's entire range.

Predation-Mediated Impacts

There is insufficient information to conclude that existing trophic interactions would undergo significant qualitative change under FMP 4.1 or FMP 4.2.

Summary of Direct/Indirect Effects of FMP 4.1 – GOA Pacific Ocean Perch

Under FMP 4.1 and FMP 4.2, average fishing mortality during the years 2003 - 2008 is expected to be less than or equal to F_{OFL}. Consequently fishing mortality is believed to have an insignificant impact on stock sustainability. Under FMP 4.1 and FMP 4.2, the stock is projected to sustain itself at or above MSST. Consequently change in biomass is believed to have an insignificant impact on stock sustainability. Additionally, because the stock is projected to sustain itself at or above MSST, the direct effects of spatial/temporal concentration of catch on change in genetic integrity and reproductive success, as well as the indirect effects of both the change in prey availability and the change in habitat suitability are believed to have an insignificant impact on stock sustainability (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects of GOA Pacific ocean perch are summarized in Table 4.5-21.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA Pacific ocean perch stock is insignificant under FMP 4.1 and FMP 4.2 (Section 3.5.1.24).

- **Persistent Past Effects.** Past effects on mortality are the same as those described for BSAI Pacific ocean perch under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those described for BSAI Pacific ocean perch under these FMPs.

- **Cumulative Effects.** A cumulative effect under FMP 4.1 and FMP 4.2 is identified for mortality of GOA Pacific ocean perch and is rated as insignificant. Pacific ocean perch are fished below the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA Pacific ocean perch stock is expected to be insignificant under FMP 4.1 and FMP 4.2 (Section 3.5.1.24).

- **Persistent Past Effects.** Past effects on the change in biomass are the same as those described for BSAI Pacific ocean perch under these FMPs.

- **Reasonably Foreseeable Future External Effects**. Future external effects on the change in biomass are the same as those described for BSAI Pacific ocean perch under these FMPs.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified as insignificant. The combination of internal and external factors is not expected to sufficiently reduce the Pacific ocean perch biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Impacts of the spatial/temporal changes should have an insignificant effect on the genetic structure and reproductive success of the population.

- **Persistent Past Effects.** Past effects on the spatial/temporal characteristics of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the spatial/temporal characteristics of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under these FMPs.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration and is rated as insignificant. The combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 would have an insignificant effect on Pacific ocean perch prey availability.

- **Persistent Past Effects.** Past effects on the change in prey availability of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in prey availability of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under these FMPs.

- **Cumulative Effects.** A cumulative effect is identified for prey availability and is rated as insignificant. The combination of internal and external removals of prey is not expected to decrease prey availability such that the Pacific ocean perch stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 would have an insignificant effect on Pacific ocean perch habitat suitability.

- **Persistent Past Effects.** Past effects on the change in habitat suitability of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in habitat suitability of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under these FMPs.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability and is rated as insignificant. The combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Pacific ocean perch stock to sustain itself at or above MSST is jeopardized.

4.8.1.12 Thornyhead Rockfish

GOA thornyhead rockfish are described in more detail in Section 3.5.1.23 of this Programmatic SEIS. Until recently, thornyhead rockfish were managed as its own stock under the GOA groundfish FMP under the Tier 3 management category, thus MSSTs are defined for these species. Beginning in 2004, thornyhead rockfish will be managed under Tier 5, however, for the purposes of this analysis, thornyhead rockfish were modeled under Tier 3.

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total Biomass

Total (ages 5 through 55+) biomass of GOA thornyheads at the start of 2002 is estimated to be 54,000 mt. Model projections of future total GOA biomasses are shown in Table H.4-37 of Appendix H. Under FMP 4.1, model projections indicate that total GOA biomass is expected to remain at 54,000 mt by 2003, then increase to a value of 59,000 mt by 2007, with a 2003-2007 average value of 56,000 mt. Under FMP 4.2, model projections indicate that total GOA biomass is expected to remain at 54,000 mt by 2003, then increase to a value of 60,000 mt by 2007, with a 2003-2007 average value of 57,000 mt.

Spawning Biomass

Spawning biomass of female GOA thornyheads at the start of 2002 is estimated to be 23,500 mt. Model projections of future GOA spawning biomasses are shown in Table H.4-37 of Appendix H. Under FMP 4.1, model projections indicate that GOA spawning biomass is expected to increase to a value of 23,600 mt by 2003, and increasing to 25,800 mt by 2007, with a 2002-2007 average value of 24,700 mt. Under FMP 4.2, model projections indicate that GOA spawning biomass is expected to increase to a value of 23,600 mt by 2003, and increasing to 26,400 mt by 2007, with a 2002-2007 average value of 25,000 mt.

Fishing Mortality

The average fishing mortality imposed on the GOA thornyhead stock in 2002 is projected to be 0.032 under current management. Under FMP 4.1, fishing mortality is projected to decrease to 0.006 in 2003 and remain at 0.066 throughout the projection period until 2007 (Table H.4-37 of Appendix H). Under FMP 4.2, fishing mortality is projected to decrease to 0.0 beginning in 2003 and continuing for all projection years through 2007 (Table H.4-37 of Appendix H). These values are well below the F_{MSY} proxy value of 0.102 which is the rate associated with the OFL.

Spatial/Temporal Concentration of Fishing Mortality

Thornyhead catch is divided approximately evenly between longliners and trawlers under status quo management. Under FMP 4.1, there would be no more trawling for thornyheads because it is possible to catch them on longlines, and some portions of thornyhead habitat would be set aside as no-take marine reserves. At present, longline catches are spatially dispersed along the continental shelf break throughout the GOA (Figure 4.5-1), and temporally dispersed due to the nature of the IFQ sablefish fishery. For example, longline thornyhead catches in 2000 occurred year-round, with peaks in April and September which did not exceed 60 mt per week. Trawler catch (which is eliminated under this FMP) has been more concentrated in time, with some catches of 20-40 mt per week happening in late spring and a single large peak of 160 mt per week in 2000 during July, coincident with the rockfish trawl fishery. Between 1997 and 1999, trawl thornyhead catches appear to have become more concentrated in space (Figure 4.5-2). The distribution of thornyheads from surveys did not appear to change over the same time period (Figure 4.5-3). This apparent concentration may be the indirect result of changes in the trawl fisheries for deepwater flatfish and rockfish since thornyheads are not a primary target of trawl fisheries. However, it should be noted that the overall catch of thornyheads is low relative to both the estimated biomass and the ABC, such that this apparent concentration of catch is unlikely to have any adverse population effects. By the same token, the alleviation of this apparent concentration provided under FMP 4.1 is unlikely to have any beneficial population effects. Since thornyheads are taken as bycatch in sablefish longline fisheries, the additional no-take marine reserves implemented under FMP 4.1 are expected to result in the same level of concentration of catch as predicted for sablefish (see Section 4.8.1.3).

Since the fisheries are suspended under FMP 4.2, the spatial/temporal concentration of fishing mortality is not considered.

Status Determination

The GOA thornyhead stock is not overfished. At 23,500 mt, spawning stock biomass is expected to be well above both $B_{35\%}$ level (14,681 mt) as well as the $B_{40\%}$ level (16,045 mt) in the year 2002 and will remain above $B_{40\%}$ in all projection years under FMP 4.1 and FMP 4.2.

Age and Size Composition

Under FMP 4.1, the mean age of the GOA thornyhead stock in 2007, as computed in model projections (Table H.4-37 of Appendix H), is 10.50 years. Under FMP 4.2, the mean age of the GOA thornyhead stock in 2007, as computed in model projections (Table H.4-37 of Appendix H), is 10.63 years. This compares with a mean age in the equilibrium unfished GOA stock of 12.67 years.

Sex Ratio

The sex ratio of GOA thornyheads is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 and FMP 4.2.

Habitat-Mediated Impacts

Under FMP 4.1, all current management measures would be maintained, and more closures would be added. Under FMP 4.2, the groundfish fisheries would be suspended. The level of habitat disturbance under FMP 1 does not appear to affect the sustainability of thornyheads either through changes in the genetic structure of the population or changes in reproductive success, as measured by the ability of the stock to maintain itself above its MSST, so the similar to lower level of habitat disturbance under FMP 4.1 and FMP 4.2 may not result in any perceptible population effects. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next 5 years under these FMPs.

Predation-Mediated Impacts

In the GOA shortspine thornyheads prey on benthic invertebrates; according to the AFSC food habits database, much of their diet in the 1990s has been composed of shrimp. Thornyheads are rare in the diets of other groundfish, birds, or marine mammals in the GOA according to the present limited information. Therefore, the effects of status quo federal groundfish fisheries on trophic interactions involving GOA thornyheads are expected to be minor. The current levels and distribution of groundfish harvest do not appear to impact prey availability for thornyheads such that it affects the sustainability of the stock as measured by the ability of the stock to maintain itself above its MSST. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next 5 years under FMP 4.1 and FMP 4.2.

Summary of Effects of FMP 4.1 and FMP 4.2 – GOA Thornyhead Rockfish

The GOA thornyhead stock appears to be healthy and stable under current management, and catches have generally been below the estimated ABCs because thornyheads are taken as bycatch in other directed fisheries. Thornyheads are thought to be widely distributed in the deeper habitats of the GOA, where fishing impacts have historically been low. As long as catches remain at or near the currently observed low levels, as predicted under FMP 4.1 and FMP 4.2, no significant population effects are expected to thornyheads (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects of GOA thornyhead rockfish are summarized in Table 4.5-22.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA thornyhead rockfish is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects include past foreign, JV, and domestic groundfish fisheries. The removals of thornyhead rockfish that occurred in these fisheries have had a lingering adverse effect on the populations (see Section 3.5.1.23).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause thornyhead rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of thornyhead rockfish. The IPHC longline fishery is identified as a potential adverse contributor to thornyhead rockfish mortality since they are caught as bycatch in this fishery. However, the state shrimp fishery is identified as a non-contributing factor since thornyhead rockfish bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA thornyhead rockfish and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

<u>Change in Biomass Level</u>

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 is expected to result in insignificant effects to these stocks.

- **Persistent Past Effects.** Past effects include past foreign, JV, and domestic groundfish fisheries. Past removals by these fisheries have had a lingering adverse effect on the GOA thornyhead rockfish populations (see Section 3.5.1.23).

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass levels are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause thornyhead rockfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the thornyhead rockfish biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts (see Sections 3.5.1.23 and 3.10). The IPHC longline fishery is identified as a potential adverse contributor to the thornyhead rockfish biomass level since they are caught as bycatch in this fishery. The State of Alaska shrimp fishery is identified as a non-contributing factor since thornyhead rockfish bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of GOA thornyhead rockfish and is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of the GOA thornyhead rockfish. Climate changes and regime shifts have been identified as having a persistent past effect on the reproductive success of GOA thornyhead rockfish. Climate changes and regime shifts and corresponding water temperature variation could affect prey availability and habitat suitability, which in combination could affect the reproductive success of the thornyhead rockfish stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of thornyhead rockfish due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of GOA thornyhead rockfish. The IPHC longline fishery removals could be sufficiently concentrated as to alter the genetic structure and reproductive success of GOA thornyhead rockfish populations and is therefore identified as a potential adverse contributor. The state shrimp fishery is identified as a non-contributing factor since bycatch of thornyhead rockfish is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the thornyhead rockfish catch and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the GOA thornyhead rockfish is ranked as insignificant.

- **Persistent Past Effects.** Past effects include climate changes and regime shifts. Climate changes and regime shifts and corresponding water temperature variation do effect the availability of some prey species (i.e. shrimp); however, studies on benthic invertebrates have not been conducted.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA thornyhead rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The IPHC longline fishery is identified as a non-contributing factor since bycatch of GOA thornyhead rockfish prey species is not expected to occur in this fishery. The state shrimp fishery is identified as a potential adverse contributor to prey availability since removal of shrimp, the main prey species of GOA thornyhead rockfish, occurs in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the GOA thornyhead rockfish is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for GOA thornyhead rockfish include climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA thornyhead rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fishery has been identified as a potential adverse contributor to GOA thornyhead rockfish habitat suitability. See Section 3.6 for information on the impacts of fishery gear on essential fish habitat. The state shrimp fishery is identified as a non-contributing factor since habitat degradation by the shrimp fishery gear is not expected to occur.

- **Cumulative Effects.** A cumulative effect is identified for GOA thornyhead rockfish habitat suitability and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the thornyhead rockfish stock to sustain itself at or above the MSST is jeopardized.

4.8.1.13 Rockfish

Rockfish are described in more detail in Sections 3.5.1.12 through 3.5.1.14 and 3.5.1.24.

BSAI Northern Rockfish – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass

Reliable estimates of total and spawning biomass are not available for this species.

Fishing Mortality

The catch of BSAI northern rockfish in 2003 was estimated as 1,200 mt. Projected catches from 2003-2008 are shown in Table H.4-15 of Appendix H. Under FMP 4.1, model projections indicate that the catch is expected to decrease to 2,600 mt in 2006, and remain at this level through 2008. The 2003-2008 average catch is 1,500 mt.

Under FMP 4.2, the projected TAC has been set to zero for all species unless the harvesting of a species has been shown to have no adverse effect on the environment. Thus, there is no harvest of BSAI northern rockfish from 2003-2008 (Table H.4-15 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

Model projections indicate that the average harvest of 1,500 mt from 2003-2008 occurs largely in the eastern Aleutian Islands (1,300 mt, 87 percent), and the harvest in this area occurs largely in the Atka mackerel fishery. Under FMP 4.2, there is no projected fishing mortality.

Status Determination

The catch rates are below the ABC and OFL values for all years. The MSST cannot be determined.

Age and Size Composition and Sex Ratio

Age and size composition estimates are not available for this species. The sex ratio of BSAI northern rockfish is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change under FMP 4.1 or FMP 4.2. Given the low level of exploitation by the groundfish fisheries under these FMPs, the effects of FMP 4.1 and FMP 4.2 on BSAI northern rockfish through habitat suitability are considered insignificant.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 4.1 or FMP 4.2. Given the low level of exploitation by the groundfish fisheries under these FMPs, the effects of FMP 4.1 and FMP 4.2 on BSAI northern rockfish through prey availability are considered insignificant.

Summary of Effects of FMP 4.1 and FMP 4.2 – BSAI Northern Rockfish

A significant feature of FMP 4.1 is the lowering of ABC levels for rockfish. For northern rockfish, the ABC was assumed to be 1,600 mt, a decrease from the baseline value of 9,500 mt in 2002. Because the BSAI northern rockfish are fished at less or equal to the ABC, the direct and indirect effects under FMP 4.1 are considered insignificant. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity.

With the removal of harvesting of BSAI northern rockfish, the direct and indirect effects under FMP 4.2 are considered insignificant (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects of BSAI northern rockfish are summarized in Table 4.5-23.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI northern rockfish is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on BSAI northern rockfish (see Section 3.5.1.12).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause northern rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of northern rockfish. The IPHC longline fishery is identified as a non-contributing factor since bycatch of BSAI northern rockfish is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI northern rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of changes in biomass level is rated as insignificant due to the significant reduction in groundfish fishery effort.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on BSAI northern rockfish (see Section 3.5.1.12).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause northern rockfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the northern rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts see Sections 3.5.1.12 and 3.10. The IPHC longline fishery is identified as a non-contributing factor since bycatch of BSAI northern rockfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of BSAI northern rockfish and is determined to be insignificant. The combined effect of internal and external removals is unlikely to jeopardize the capacity of the stock to maintain current population levels.

<u>Spatial/Temporal Concentration of Catch</u>
- – Change in Genetic Structure of Population
- – Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is determined to be insignificant due to the significant reduction in groundfish fishery effort.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of BSAI northern rockfish. Climate changes and regime shifts are identified as having a potential beneficial or adverse effect on BSAI northern rockfish (see Sections 3.5.1.12 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of northern rockfish due to climate changes and regime shifts are potential beneficial or adverse. However, climate changes and regime shifts are not expected to be sufficient to alter the genetic sub-population structure of northern rockfish. Marine pollution has been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic sub-population structure and/or the reproductive success of BSAI northern rockfish. The IPHC longline fishery has been identified as a non-contributing factor to the genetic structure and reproductive success of the other rockfish species since bycatch of this species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the northern rockfish catch and is rated as insignificant. The combined effect of internal and external removals is not expected to be of a concentration that would change the reproductive success or genetic diversity such that it jeopardizes the ability of the BSAI northern rockfish stock to sustain current population levels.

<u>Change in Prey Availability</u>

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the BSAI northern rockfish is determined to be insignificant due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Climate changes and regimes shifts have been identified as having had effected the prey availability of the BSAI northern rockfish stock. The actual effect of climate changes and regime shifts on northern rockfish prey availability is unknown, but could have had a potential beneficial or adverse effect. See Sections 3.5.1.12 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI northern rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels. The IPHC longline fishery has been identified as a non-contributing factor since it is unlikely that bycatch of northern rockfish prey species occurs in this fishery. See Section 3.5.1.12 for more information on the trophic interactions of BSAI northern rockfish species.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability and is rated as insignificant. The combined effect of internal and external removals of prey species is not expected to jeopardize the ability of the BSAI northern rockfish stock to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the BSAI northern rockfish is insignificant due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past effects identified for BSAI northern rockfish include climate changes and regime shifts. The actual effects of climate changes and regime shifts on habitat suitability are unknown, but could have a potential beneficial or adverse effect. The past foreign, JV, and domestic groundfish fisheries are identified as having a past adverse effect on habitat suitability, largely due to the intense bottom trawling that has occurred in northern rockfish species habitat. The IPHC longline fishery has also been identified as having had an adverse effect on northern rockfish species habitat suitability, possibly having disrupted northern rockfish species spawning and/or rearing habitats. See Section 3.5.1.12 for more information on the past events that have effected northern rockfish habitat suitability.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI northern rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fisheries have also been identified as having a potential adverse effect on the northern rockfish habitat suitability. These fisheries are expected to continue into the future and could disrupt northern rockfish species spawning and/or rearing habitats.

- **Cumulative Effects.** A cumulative effect is identified for the change in habitat suitability. The combined internal and external effects are unlikely to make the BSAI northern rockfish stock vulnerable to spawning and rearing habitat disturbances due to fishing gear.

BSAI Shortraker/Rougheye Rockfish – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass

Reliable estimates of total and spawning biomass are not available for these stocks.

Fishing Mortality

The projected catch of BSAI shortraker/rougheye rockfish was 100 mt in each year from 2003 to 2008. Projected catches from 2003-2008 are shown in Table H.4-16 of Appendix H. Under FMP 4.2, the projected TAC has been set to zero for all species unless the harvesting of a species has been shown to have no adverse effect on the environment. Thus, there is no harvest of BSAI shortraker/rougheye rockfish from 2003-2008 (Table H.4-16 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

Model projections indicate that the average harvest of 100 mt from 2003-2008 occurs largely in the EBS, with 90 mt (70 percent) of the harvest. Within this area, most of the shortraker/rougheye harvest is taken in the sablefish longline fishery. Under FMP 4.2, there is no projected fishing mortality.

Status Determination

The catch rates are below the ABC and OFL values for all years. The MSST for these stocks is unable to be determined.

Age and Size Composition and Sex Ratio

Age and size composition estimates are not available for these species. The sex ratio of BSAI shortraker/rougheye rockfish is assumed to be 50:50. No information is available to suggest that this would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Any habitat-mediated impacts of FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under FMP 4.1 or FMP 4.2. Given the low level of exploitation by the groundfish fisheries under these FMPs, the effects of FMP 4.1 and FMP 4.2 on BSAI shortraker/rougheye rockfish through habitat suitability are considered insignificant.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 4.1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 4.1. Given the low level of exploitation by the groundfish fisheries under these FMPs, the effects of FMP 4.1 and FMP 4.2 on BSAI shortraker/rougheye rockfish through prey availability are considered insignificant.

Summary of Effects of FMP 4.1 – BSAI Shortraker/Rougheye Rockfish

A significant feature of FMP 4.1 is the lowering of ABC levels for rockfish. For shortraker/rougheye rockfish, the ABC was assumed to be 100 mt. Because the BSAI shortraker/rougheye rockfish are fished at this low ABC level, the direct and indirect effects under FMP 4.1 are considered insignificant. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity.

With the removal of harvesting of BSAI shortraker/rougheye rockfish, the direct and indirect effects under FMP 4.2 are considered insignificant (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects of BSAI shortraker/rougheye rockfish are summarized in Table 4.5-24.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI shortraker/rougheye rockfish is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on BSAI shortraker/rougheye rockfish (see Section 3.5.1.13).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of shortraker/rougheye rockfish. The IPHC longline fishery and the state shrimp fishery are identified as non-contributing factors since bycatch of BSAI shortraker/rougheye rockfish is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI shortraker/rougheye rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of changes in biomass level is rated as insignificant due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on BSAI shortraker/rougheye rockfish (see Section 3.5.1.13).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the shortraker/rougheye rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts (see Sections 3.5.1.13 and 3.10). The IPHC longline fishery and the state shrimp fishery are identified as a non-contributing factors since bycatch of BSAI shortraker/rougheye rockfish species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of BSAI shortraker/rougheye rockfish and is rated as insignificant. The combined effect of internal and external removals is unlikely to jeopardize the capacity of the stock to maintain current population levels.

<u>Spatial/Temporal Concentration of Catch</u>

- *Change in Genetic Structure of Population*
- *Change in Reproductive Success*

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the spatial/temporal concentration of catch is insignificant due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of BSAI shortraker/rougheye rockfish. Climate changes and regime shifts are identified as having a potential beneficial/adverse effect on BSAI shortraker/rougheye rockfish (see Sections 3.5.1.13 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of shortraker/rougheye rockfish due to climate changes and regime shifts are potential beneficial or adverse. However, climate changes and regime shifts are not expected to be sufficient to alter the genetic sub-population structure of shortraker/rougheye rockfish. Marine pollution has been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic sub-population structure and/or the reproductive success of BSAI shortraker/rougheye rockfish. The IPHC longline fishery and state shrimp fishery have been identified as non-contributing factors to the genetic structure and reproductive success of the other rockfish species since bycatch of this species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal characteristics of shortraker/rougheye rockfish and is determined to be insignificant. The combined effect of internal and external removal is unlikely to be of a concentration that would lead to change in the genetic diversity or genetic structure of the stocks such that it jeopardizes the ability of the stocks to maintain current population levels.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the BSAI shortraker/rougheye rockfish is insignificant due to the reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as persistent past effects for the change in prey availability of the BSAI shortraker/rougheye rockfish stock. The actual effect of climate changes and regime shifts on shortraker/rougheye rockfish prey availability is unknown, but could have had a potential beneficial or adverse effect. See Sections 3.5.1.13 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI shortraker/rougheye rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels. The IPHC longline fishery has been identified as a non-contributing factor since it is unlikely that bycatch of shortraker/rougheye rockfish prey species occurs in this fishery. The state shrimp fishery is identified as a potential adverse contributor to BSAI shortraker/rougheye prey availability since shrimp is one of the main prey species of rougheye rockfish. See Section 3.5.1.13 for more information on the trophic interactions of BSAI shortraker/rougheye rockfish species.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability and is rated as insignificant. The combined effect of internal and external removals is unlikely to change prey availability such that it jeopardizes the ability of the stock to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the BSAI shortraker/rougheye rockfish is insignificant due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past effects identified for BSAI shortraker/rougheye rockfish include climate changes and regime shifts. The actual effects of climate changes and regime shifts on habitat suitability are unknown, but could have a potential beneficial or adverse effect. The past foreign, JV, and domestic groundfish fisheries are identified as having a past adverse effect on habitat suitability, largely due to the intense bottom trawling that has occurred in shortraker/rougheye rockfish species habitat. The IPHC longline fishery has also been identified as having had an adverse effect on shortraker/ rougheye rockfish species habitat suitability, possibly having disrupted shortraker/rougheye rockfish species spawning and/or rearing habitats. The state shrimp fishery is identified as a non-contributing factor to shortraker/rougheye rockfish habitat suitability since habitat degradation by shrimp fishery gear is not expected to occur. See Section 3.5.1.13 for more information on the past events that have effected shortraker/rougheye rockfish habitat suitability.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI shortraker/rougheye rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fisheries have also been identified as having a potential adverse effect on the shortraker/rougheye rockfish habitat suitability. These fisheries are expected to continue into the future and could disrupt shortraker/rougheye rockfish species spawning and/or rearing habitats.

- **Cumulative Effects.** A cumulative effect for habitat suitability is identified as insignificant. The combined effect of external and internal habitat disturbances are unlikely to lead to a change in spawning or rearing success such that it materially impacts the ability of the stock to maintain current population levels.

BSAI Other Rockfish – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass

Reliable estimates of total and spawning biomass are not available for these species.

Fishing Mortality

The projected catch of other rockfish species was 100 mt in each year from 2003 to 2008 in each of the Aleutian Islands and EBS subareas. Projected catches from 2003-2008 are shown in Tables H.4-13 and H.4-14 of Appendix H. This example FMP would require that these species be split out if possible and assigned species-specific ABCs. Until then, the other rockfish TAC would be based on the least abundant member of the assemblage. In addition, this FMP would require that a $F_{75\%}$ exploitation rate be used in determining ABCs.

The 2003 OFL for this species complex is 846 mt and 1,280 mt in the Aleutian Islands and EBS, respectively (Reuter and Spencer 2002). Fishing mortality at projected levels under FMP 4.1 is well below the OFL for other rockfish, so FMP 4.1 is not likely to result in any significantly adverse impacts to these stocks. Reduced mortality of other rockfish species would likely benefit the population over time but determining such benefits cannot be made at this time due to insufficient information. A reduced TAC would eliminate any directed fishery for other rockfish species in the BSAI. All other rockfish would be placed on "bycatch-only" status and could significantly constrain other groundfish and the halibut fishery if managers were to strictly limit the bycatch of other rockfish.

Under FMP 4.2, the projected TAC would be temporarily set to zero for all BSAI other rockfish species unless the harvesting of a species can be shown to have no adverse effect on the environment. Other rockfish species are long lived, slow growing fishes. Temporary suspension of fishing would provide only marginal benefits to these stocks assuming the suspension is within two years. Thus, we assume there is no fishing mortality of BSAI other rockfish from 2003-2008, in our analysis (Tables H.4-13 and H.4-14 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

In the Aleutian Islands, 93 percent of the average harvest of 100 mt occurs in the eastern Aleutian Islands, taken largely in the sablefish longline fishery. The sablefish longline fishery also accounts for most of the catch of EBS other rockfish. Bycatch of other rockfish species would be reduced under FMP 4.1 due to reductions in sablefish TAC. Therefore, we conclude that the spatial/temporal effects of groundfish fishing under FMP 4.1 will be insignificant to the current population status of the other rockfish category.

Under FMP 4.2, there is no projected fishing mortality, so there would be no concentration of harvest and no significant impact to other rockfish stocks.

Status Determination

The fishing mortality rates are below the ABC and OFL values for all years. The MSST is unable to be determined.

Age and Size Composition and Sex Ratio

Age and size composition estimates are not available for these species. Estimated sex ratios are not available for these species.

Habitat-Mediated Impacts

Any habitat suitability impacts of FMP 4.1, such as adverse effects to spawning habitat, nursery grounds, benthic structures, as a result of fishing would be governed by a complex web of direct and indirect interactions which are difficult to quantify. FMP 4.1 includes establishing a network of MPAs along the continental shelf and slope of Alaska. It is unclear what benefits other rockfish species may receive from the illustrated closures. Regardless, at the low level of harvest authorized by this FMP, it can be concluded that there would be no significant effects on other rockfish habitat suitability indexes as a result of FMP 4.1.

Under FMP 4.2, the groundfish fisheries would be suspended. As with FMP 4.1, it is unclear what benefits other rockfish species may receive from the fishery closures, however, it can be concluded that there would be no significant effects on other rockfish habitat suitability under FMP 4.2.

Predation-Mediated Impacts

As with habitat suitability impacts, any effect of FMP 4.1 and FMP 4.2 on predator-prey relationships would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude whether trophic interactions would undergo any significant change under the FMP 4.1 or FMP 4.2. Given the low level of exploitation by the groundfish fisheries under these FMPs, the effects of FMP 4.1 and FMP 4.2 on BSAI other rockfish species through prey availability are considered insignificant.

Summary of Effects of FMP 4.1 – BSAI Other Rockfish

A significant feature of FMP 4.1 is the lowering of ABC levels for rockfish. For other rockfish, the Aleutian Islands and EBS ABCs were assumed at 100 mt and 200 mt, respectively. The model projections indicate that the other rockfish are fished at such a low level, and well below the OFL. An additional feature of FMP 4.1 is the specification of MSST levels for all stocks. With the MSST specification, two outcomes are possible regarding stock biomass: 1) the stock biomass may be determined to be above the MSST level, in which case the MSST specification may not change management practices, or 2) the stock biomass may be determined to be below the MSST level, in which case a rebuilding plan would be enacted in order to enhance the ability of the stock to move above the MSST level. Thus, the effect of FMP 4.1 on stock biomass is considered as either insignificant or significantly beneficial. Because the other rockfish species would be managed under FMP 4.1 to be above the MSST level, the remaining direct and indirect effects of fishing under FMP 4.1 are considered insignificant.

Under FMP 4.2, all directed fishing would be prohibited unless it could be shown that fishing activity would not adversely affect the environment. Under this scenario, fishing for other rockfish would not be allowed unless it is clear that the direct and effects would be insignificant. For stocks below the MSST, the suspension of fishing activities may have a significantly beneficial effect by enhancing the ability of the stock to rebuild to levels above the MSST (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects of BSAI other rockfish are summarized in Table 4.5-25.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI other rockfish is rated as insignificant under FMP 4.1 and FMP 4.2.
- **Persistent Past Effects.** Past effects on mortality are the same as those described for BSAI shortraker/rougheye rockfish under these FMPs.
- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those described for BSAI shortraker/rougheye rockfish under these FMPs.
- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI other rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of changes in biomass level is determined to be insignificant due to the reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past effects on the change in biomass are the same as those described for BSAI shortraker/rougheye rockfish under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are the same as those described for BSAI shortraker/rougheye rockfish under these FMPs.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of BSAI other rockfish and is determined to be insignificant. The combined effect of internal and external removals is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

– Change in Genetic Structure of Population
– Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the fisheries on the spatial/temporal characteristics of BSAI other rockfish is rated as insignificant due to the reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past effects are not identified for spatial/temporal concentration of BSAI other rockfish catch.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success and genetic structure are the same as those described for BSAI shortraker/rougheye rockfish under these FMPs.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal characteristics of other rockfish and is rated as insignificant. Bycatch under FMP 4.1 would be reduced due to reduction in sablefish TAC. Under FMP 4.2, the groundfish fisheries would be suspended. The combined effect of internal removals and removals due to reasonable foreseeable external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in prey availability for the BSAI other rockfish is determined to be insignificant due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past effects on the change in prey availability are the same as those described for BSAI shortraker/rougheye rockfish under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in prey availability are the same as those described for BSAI shortraker/rougheye rockfish under these FMPs.

- **Cumulative Effects.** A cumulative effect for change in prey availability and is identified as insignificant. Future harvest levels are unlikely to lead to a change in prey availability such that it jeopardizes that ability of the stock to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the change in habitat suitability for the BSAI other rockfish is ranked as insignificant due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past effects on the change in habitat suitability are the same as those described for BSAI shortraker/rougheye rockfish under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in habitat suitability are the same as those described for BSAI shortraker/rougheye rockfish under these FMPs.

- **Cumulative Effects.** A cumulative effect is identified for the change in habitat suitability and is rated as insignificant. The reduced groundfish fishing effort and associated gear impacts and the establishment of MPAs proposed by this FMP, in combination with the past persistent and reasonably foreseeable future effects are not expected to produce levels of habitat disturbance that would lead to a detectable change in spawning or rearing success such that it jeopardizes the capacity of the stocks to maintain current population levels.

GOA Northern Rockfish – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass and Fishing Mortality

FMP 4.1 would reduce catch of GOA northern rockfish because it changes the biological reference point for determining rockfish F_{ABC} from $F_{40\%}$ to $F_{75\%}$ and further adjusts F_{ABC} downward as a function of the coefficient of variation of the mean survey biomass. FMP 4.1 also eliminates fisheries with more than 33 percent bycatch, which might redistribute or reduce the bycatch of northern rockfish in the Pacific ocean perch fishery. Average fishing mortality during the years 2003 to 2008 is expected to be less than F_{OFL} (0.066) (Table H.4-35 of Appendix H).

FMP 4.2 would eliminate catch of GOA northern rockfish until it could be proven that fishing for GOA northern rockfish would have no adverse effect on the environment. Consequently, average fishing mortality during the years 2003 to 2008 is expected to be less than F_{OFL} (0.066) (Table H.4-35 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

FMP 4.1 may potentially have a large effect on the spatial concentration of northern rockfish catch if 20 percent to 50 percent of the GOA is set aside as no-take reserves or as MPAs. The proposed MPAs cover large portions of Portlock Bank, Albatross Bank, and Shumagin Bank, all of which are major fishing grounds for northern rockfish. Much of the past fishing effort concentrated on these proposed closure areas. In particular, one area known as the Snakehead accounted for 45.8 percent of all GOA northern rockfish catches from 1990 to 1998 (Clausen and Heifetz in preparation.). The proposed closure areas appear to substantially overlap the Snakehead. Assuming that catches from 1990 to 1998 are representative of the true distribution of GOA northern rockfish and that this distribution is stable, the closure area could effectively reduce the size of the GOA northern rockfish population available to fishing pressure by at least 45.8 percent relative to no closures. If the proposed MPAs are closed to all bottom trawling, then fishing effort would likely be displaced to other localities. Whether this displacement would result in spreading out the fishing effort over a wider area, or would merely concentrate the effort in new localities depends on the decisions made by the NPFMC. If effort-based management and the reduced fishing mortality proposed under FMP 4.1 are adopted, then adoption of the MPAs is not likely to result in localized depletions.

FMP 4.1 would also have a substantial effect on the temporal concentration of northern rockfish catch. If the fishery remained a relatively short open-access type fishery, then the closure of major fishing areas may alter catch rates enough that more time is necessary to catch the ABC. If effort-based management is adopted under FMP 4.1, then the northern rockfish trawl fishery would change from a short open-access fishery. This would likely allow directed northern rockfish fishing to continue over a longer time-period, which may allow better management oversight of the fishery and reduce the risk of overharvesting.

Under FMP 4.1, fisheries with more than 33 percent bycatch would be eliminated, which could also change the distribution of fishing effort for GOA northern rockfish.

Fishing mortality for FMP 4.2 is zero, so there is no spatial or temporal concentration of fishing.

Status Determination

Under FMP 4.1, the projected 2003 biomass of 42,700 mt is greater than $B_{35\%}$ and consequently the stock is projected to be above its MSST and not projected to be in an overfished condition. The projected 2005 biomass of 41,200 mt for FMP 4.1, and 40,800 mt for FMP 4.2, are greater than $B_{35\%}$ and consequently the stock is not projected to be approaching an overfished condition.

Age and Size Composition and Sex Ratio

Under FMP 4.1 and FMP 4.2, the age composition of GOA northern rockfish may be affected by fishing mortality as in FMP 1. Size composition of GOA northern rockfish might change in proportion to the change in age composition. Age and size composition could also change if the elimination of fisheries with high bycatch rates substantially change the distribution of fishing effort. No information is available to suggest that sex ratio would change under FMP 4.1 or FMP 4.2.

Habitat-Mediated Impacts

Under FMP 4.1 damage to epifauna by bottom trawls would likely be reduced under less fishing pressure and result in less impact on juvenile northern rockfish habitat. FMP 4.1 may also have a beneficial effect on the habitat of GOA northern rockfish because it proposes to set aside 20 percent to 50 percent of the GOA as no-take reserves or as MPAs. If these MPAs are closed to all bottom trawling, then they may serve as refuge for northern rockfish allowing for increased survival of larger and older fish that produce significantly more eggs and larvae to replenish the GOA population. If these MPAs are closed to all bottom trawling, then they would also provide protection from the potential effects of trawling on juvenile rockfish habitat in these areas.

Under FMP 4.2 further damage to epifauna by bottom trawls would be eliminated and result in no impact on juvenile northern rockfish habitat. FMP 4.2 would also provide a de facto no-take zone or refuge for GOA northern rockfish in their entire range.

Given the low level of exploitation by the groundfish fisheries under these FMPs, the effects of FMP 4.1 and FMP 4.2 on GOA northern rockfish through habitat suitability are considered insignificant.

Predation-Mediated Impacts

There is insufficient information to conclude that existing trophic interactions would undergo significant qualitative change under FMP 4.1 or FMP 4.2. Given the low level of exploitation by the groundfish fisheries under these FMPs, the effects of FMP 4.1 and FMP 4.2 on GOA northern rockfish through prey availability are considered insignificant.

Summary of Effects of FMP 4.1 and FMP 4.2 – GOA Northern Rockfish

Under FMP 4.1 and FMP 4.2, average fishing mortality during the years 2003 - 2008 is expected to be less than or equal to F_{OFL}. Consequently fishing mortality is believed to have an insignificant impact on stock sustainability. Under FMP 4.1 and FMP 4.2, the stock is projected to sustain itself at or above MSST. Consequently change in biomass is believed to have an insignificant impact on stock sustainability. Additionally, because the stock is projected to sustain itself at or above MSST, the direct effects of spatial/temporal concentration of catch on change in genetic integrity and reproductive success, as well as the indirect effects of both the change in prey availability and the change in habitat suitability are believed to have an insignificant impact on stock sustainability (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects of GOA northern rockfish are summarized in Table 4.5-26.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA northern rockfish stock is insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past effects of the past foreign fisheries is identified for the GOA northern rockfish stock. Large removals of northern rockfish occurred in the past and there appears to be a lingering effect on the GOA northern rockfish populations (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since bycatch is this fishery has already been accounted for by domestic groundfish management. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to northern rockfish mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA northern rockfish and is rated as insignificant. Northern rockfish are fished at less than the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA northern rockfish stock is expected to be insignificant under FMP 4.1 and FMP 4.2 due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past effects of the past foreign fisheries is identified for the GOA northern rockfish stock. Large removals of northern rockfish occurred in the past and there appears to be a lingering effect on the GOA northern rockfish populations (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since bycatch is this fishery has already been accounted for by domestic groundfish management. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are identified as making beneficial or adverse contributions to northern rockfish change in biomass levels as a function of change in reproductive success.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified as insignificant. The combination of internal and external factors is not expected to sufficiently reduce the northern rockfish biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch
  – Change in Genetic Structure of Population
  – Change in Reproductive Success

- **Direct/Indirect Effects.** The fisheries should have an insignificant effect on the genetic structure and reproductive success of the population.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure. However, there are lingering past effects due to climate changes and regime shifts (see Section 3.5.1.24) for change in reproductive success.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since bycatch is this fishery has already been accounted for by domestic groundfish management and is not expected to contribute to changes in genetic structure or reproductive success of northern rockfish. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are identified as potential beneficial or adverse contributor to reproductive success since changes in climate can effect prey availability and/or habitat suitability which in turn can effect recruitment. The magnitude and direction of the change in reproductive success with water temperatures is currently unknown. Climate changes and regime shifts are not considered to be contributors to change in genetic structure.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal characteristics of GOA northern rockfish and is rated as insignificant. The combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 would have insignificant effects on northern rockfish prey availability.

- **Persistent Past Effects.** Past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on northern rockfish prey species (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since northern rockfish prey species bycatch is not expected to occur. Climate changes and regime shifts are identified as making potential beneficial or adverse contributions on prey availability, although the magnitude and the direction of change in relation to strong and weak Aleutian Low systems are unknown. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for prey availability and is rated as insignificant. The combination of internal and external removals of prey is not expected to decrease prey availability such that the northern rockfish stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** FMP 4.1 and FMP 4.2 would have insignificant effects on northern rockfish habitat suitability.

- **Persistent Past Effects.** Past effects on habitat suitability identified for GOA northern rockfish stocks include past foreign, JV, and domestic fisheries, IPHC longline fishery, and climate changes and regime shifts (see Section 3.5.1.24). Intense bottom trawling on northern rockfish habitat in the past fisheries likely disrupted spawning and/or rearing habitats in areas of the GOA. It is possible that some of these areas have not recovered from the intense efforts. The IPHC longline fisheries have also been identified as having adverse effects on northern rockfish habitat, although these effects are not expected to have been as intense as those effects associated with trawl gear (see Section 3.6). Climate changes and regime shifts have had both beneficial and adverse effects on northern rockfish habitat.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has been identified as an adverse contributing factor since the fishery gear could disrupt spawning and/or rearing habitats. Although, as stated above, the impacts associated with longline gear are not as significant as those associated with trawl gear. Impacts on habitat from climate changes and regime shifts on the GOA northern rockfish stock are identified as potential beneficial or adverse contributors, although the magnitude and direction of the change in relation to strong and weak Aleutian Low systems are unknown. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability and is rated as insignificant. The combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the northern rockfish stock to sustain itself at or above MSST is jeopardized.

GOA Shortraker/Rougheye Rockfish – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass

No projections are possible for these two parameters, as shortraker/rougheye are classified as Tier 4 or Tier 5 species, with insufficient information to compute either parameter.

Fishing Mortality

This bookend is much more precautionary in its approach than the baseline situation or any of the other FMPs, with the exception of FMP 4.2. FMP 4.1 would have a significant impact on catch of shortraker/ rougheye because it includes a measure that changes the biological reference point for determining rockfish ABCs from the $F_{40\%}$ baseline to the much more conservative value of $F_{75\%}$. Using $F_{75\%}$ would substantially reduce the ABC value for shortraker/rougheye, which in turn would result in a large decrease in catch. Therefore, FMP 4.1 would greatly minimize the risk of overfishing shortraker/rougheye. One other measure in FMP 4.1 that would affect catch of shortraker/rougheye is that procedures to account for uncertainty would be incorporated into ABC determinations. These uncertainty corrections would also act to reduce ABC and result in a further decrease in catches of shortraker/rougheye, thereby providing even greater protection against overfishing. The bycatch model projections for FMP 4.1 show shortraker/rougheye catch reductions of 70 percent compared to FMP 1 (the present management regime), and the projected catches are approximately 80 percent less than has been taken by the fishery in recent years. The projections appear reasonable given the stringent precautionary measures of this bookend (Table H.4-34 of Appendix H).

FMP 4.2 sets ABC equal to zero for all species in the GOA, so catch projections for shortraker/rougheye also become zero for all years (Table H.4-34 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

FMP 4.1 would have a great effect on the spatial/temporal concentration of shortraker/rougheye catch compared to what has occurred in past years and what is proposed in FMP 1, FMP 2.1, FMP 2.2, FMP 3.1, and FMP 3.2. The spatial distribution of the catch would change substantially because FMP 4.1 sets aside between 20 percent and 50 percent of the GOA as no-take reserves or as MPAs. No-take reserves in this bookend cover large portions of the GOAs continental slope inhabited by shortraker and rougheye rockfish, including many important fishing grounds. Much of the past catch of shortraker/rougheye has been taken from the areas of the proposed reserves, so FMP 4.1 would displace this catch to other localities. This displacement would concentrate the catch in new localities, and it would likely be necessary to proportionately reduce TACs in the areas that remained open in order to prevent localized depletion of the resource.

Another important aspect of FMP 4.1 is that overcapacity problems in all fisheries would be addressed by adopting measures such as trip limits and LLPs. Such measures would especially affect trawl fisheries, and these fisheries would become less intense and more spread out in time. This would allow better management oversight of trawl fisheries and reduce of the risk of over-harvesting shortraker/rougheye.

Fishing mortality for FMP 4.2 is zero, so there is no spatial or temporal concentration of fishing.

Status Determination

The catch rates are below the ABC and OFL values. The MSST cannot be calculated for this stock.

Age and Size Composition and Sex Ratio

No projections are possible for these two parameters, as shortraker/rougheye are classified as Tier 4 or Tier 5 species, with insufficient information to compute either parameter. There is no information on the sex ratio of shortraker/rougheye, although sex ratio for many other species of *Sebastes* has been reported to be approximately 50:50. How the sex ratio may be affected by FMP 4.1 or FMP 4.2 is unknown.

Habitat-Mediated Impacts

Because FMP 4.1 creates a series of large no-take reserves across the GOA, it would likely provide substantial habitat benefits to shortraker/rougheye. No-take reserves in this bookend cover large portions of the GOAs continental slope inhabited by shortraker and rougheye rockfish, including many important fishing grounds where these species appear to be especially abundant. The reserves may protect a significant portion of the shortraker/rougheye population and therefore be especially helpful as a habitat conservation measure compared to the baseline or to FMP 1, FMP 2.1, FMP 2.2, FMP 3.1, and FMP 3.2.

FMP 4.2 changes the entire GOA into one large no-take reserve. Such a large closed area would allow increased survival of larger and older shortraker and rougheye rockfish that may produce significantly more eggs and larvae to replenish the stocks. Damage to the benthic environment by fishing gear would be prevented throughout the GOA.

Predation-Mediated Impacts

Pacific cod and to a lesser extent walleye pollock are also species that are known to prey on shrimp, a major prey item of rougheye rockfish, so any changes in the abundance of these two fish as a result of FMP 4.1 hypothetically could affect the food supply of shortraker/rougheye. FMP 4.1 would change the biological reference point for determining ABC of Pacific cod and walleye pollock to the highly precautionary value of $F_{75\%}$, which results in greatly reduced catch projections for these two fish in this bookend compared to the baseline and FMP 1, FMP 2.1, FMP 2.2, FMP 3.1, and FMP 3.2. However, the model projections show that these reduced catches translate into only a modest increase in abundance (i.e., biomass) for Pacific cod and walleye pollock compared to the baseline situation and FMP 1. FMP 4.2 would prevent any fishing for Pacific cod or walleye pollock, but the model projections show that these zero catches translate into only a modest increase in abundance (i.e., biomass) for Pacific cod and walleye pollock compared to the baseline situation and FMP 1. Whether this relatively small increase in abundance of Pacific cod and walleye pollock would actually affect the food supply for shortraker/rougheye is unknown, as there is no quantitative information on trophic interactions between all these species. Moreover, shortraker and rougheye rockfish reside in deeper depths than Pacific cod or walleye pollock, so they may not be competing for the same spatial aggregations of food.

Summary of Effects of FMP 4.1 and FMP 4.2 – GOA Shortraker/Rougheye Rockfish

The effects of FMP 4.1 and FMP 4.2 on shortraker/rougheye in the GOA are summarized in Table 4.8-1. The direct/indirect effects of mortality, change in biomass, change in the spatial/temporal characteristics, change in prey availability, and change in habitat suitability are all rated insignificant under FMP 4.1 and FMP 4.2.

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects of GOA shortraker/rougheye rockfish are summarized in Table 4.5-27.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA shortraker/rougheye rockfish is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA shortraker/rougheye rockfish stocks (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of shortraker/rougheye rockfish. The IPHC longline fishery and State of Alaska shrimp fishery are identified as non-contributing factors since bycatch of rockfish species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA shortraker/rougheye rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of changes in biomass level is insignificant due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA shortraker/rougheye rockfish stocks (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the shortraker/rougheye rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts (see Sections 3.5.1.24 and 3.10). The IPHC longline fishery and State of Alaska shrimp fishery are identified as non-contributing factors to GOA slope rockfish biomass level since bycatch is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of GOA shortraker/rougheye rockfish and is rated as insignificant. The combined effect of internal and external removals is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch
  – Change in Genetic Structure of Population
  – Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the fisheries are determined to have an insignificant effect on the spatial/temporal characteristics of GOA shortraker/rougheye rockfish due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA shortraker/rougheye rockfish; however, climate changes and regime shifts have been identified as having had potential beneficial or adverse effects on shortraker/rougheye rockfish reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability which in combination effect reproductive success (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to GOA shortraker/rougheye rockfish genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts are identified as non-contributing factors to genetic structure; however, they could affect reproductive success by driving changes in prey availability and habitat suitability. The IPHC longline fishery and the State of Alaska shrimp fishery are identified as non-contributing factors to the change in genetic structure and reproductive success of GOA shortraker/rougheye rockfish since bycatch in these fisheries is unlikely to occur.

- **Cumulative Effects.** A cumulative effect of the spatial/temporal characteristics of the GOA shortraker/rougheye rockfish complex is identified and is rated as insignificant. The combined effect of internal and external removals is unlikely to occur in a localized manner such that it will lead to a detectable reduction in genetic diversity and reproductive success of the GOA shortraker/rougheye rockfish complex.

Change in Prey Availability

- **Direct/Indirect Effects.** The effect of the fisheries on the change in prey availability are insignificant due to the significant reduction in the groundfish fishery effort under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on shortraker/rougheye rockfish prey availability (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to shortraker/rougheye rockfish prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regime shifts are identified as potential beneficial or adverse contributors to prey availability (see Sections 3.5.1.24 and 3.10). The IPHC longline fishery is identified as a non-contributing factor to shortraker/rougheye rockfish prey availability since bycatch of shortraker/rougheye rockfish prey species is not expected to occur in this fishery. The State of Alaska shrimp fishery is identified as a potential adverse contributor to shortraker/rougheye rockfish prey availability since shrimp is a main prey item of rougheye rockfish.

- **Cumulative Effects.** A cumulative effect is identified for the change in prey availability of the GOA shortraker/rougheye rockfish and is rated as insignificant. The combined effect of internal and external removals of GOA shortraker/rougheye rockfish prey species is unlikely to jeopardize the ability of the stock to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** The effect of the fisheries on the change in habitat suitability are insignificant due to the significant reduction in the groundfish fishery effort under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Past foreign, JV, domestic groundfish fisheries, and the IPHC longline fisheries have been identified as having past persistent adverse effects on GOA shortraker/rougheye rockfish habitat due to the impacts caused by fishering gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA shortraker/rougheye rockfish habitat suitability (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime shifts could make a potential beneficial or adverse contribution to shortraker/rougheye rockfish habitat suitability. See Sections 3.5.1.24 and 3.10 for more information on climate changes and regime shifts. The IPHC longline fishery has been identified as a potential adverse contributor to shortraker/rougheye rockfish habitat suitability due to impacts from fishing gear. The State of Alaska shrimp fishery is a non-contributing factor since habitat degradation from shrimp fishing gear is not expected to occur. See Section 3.6 for more information on the impacts of fishery gear on essential fish habitat.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability of GOA shortraker/rougheye rockfish and is rated as insignificant. The combination of internal and external habitat disturbances is unlikely to lead to a detectable change in the spawning or rearing success such that it jeopardizes the ability of the stock to maintain current population levels.

GOA Slope Rockfish – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass

No projections are possible for these two parameters, as slope rockfish species are classified as Tier 4 or Tier 5 fish, with insufficient information to compute either parameter.

Fishing Mortality

This bookend is much more precautionary in its approach than the baseline situation or any of the other FMPs, with the exception of FMP 4.2. FMP 4.1 primarily affects catch of slope rockfish in two ways: 1) it retains the eastern GOA trawl closure and also includes various areas located throughout the GOA as “no-take” reserves, in which no fishing of any gear type can take place; and 2) it includes a measure that changes the biological reference point for determining rockfish ABCs from the $F_{40\%}$ baseline to a much more conservative value, $F_{75\%}$. Both of these effects from FMP 4.1 would result in a decreased catch for slope rockfish and greatly reduce any risk of overfishing these species. As in FMP 1, FMP 2.2, FMP 3.1, and FMP 3.2, the eastern GOA trawl closure protects most of the GOA biomass of slope rockfish from any significant fishing pressure. The no-take reserves cover substantial areas of the GOA and would serve to increase this protection even further. At present, changing the biological reference point for slope rockfish species to $F_{75\%}$ would affect just sharpchin rockfish, because the latter is the only slope rockfish species that is in Tier 4 and has the age data required to calculate $F_{75\%}$. Sharpchin rockfish; however, comprise almost 40 percent of the current exploitable biomass for slope rockfish; therefore, using $F_{75\%}$ for sharpchin rockfish would still result in a considerably lower overall ABC for slope rockfish. The model projections for FMP 4.1 show very low slope rockfish catches of only 200 mt per year, which seem plausible given the very stringent precautionary measures of this bookend (Table H.4-31 of Appendix H).

FMP 4.2 sets ABC equal to zero for all species in the GOA, so catch projections for slope rockfish also become zero for all years (Table H.4-31 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

The main spatial effect of FMP 4.1 on slope rockfish would be caused by the bookend's retention of the eastern GOA trawl closure, which would mean most of the GOA population of slope rockfish, which is found primarily in the eastern GOA, would not be vulnerable to fishing. No-take reserves located throughout the GOA, in which no fishing of any kind would be permitted, are also part of this bookend and would serve to increase protection of slope rockfish even further. For example, the bookend includes a large no-take reserve off Cape Ommaney in southeast Alaska, and this would prevent any catch of slope rockfish by longlines in this productive fishing area. There have been no studies to determine stock structure for any species of slope rockfish, and it is unknown if subpopulations exist. However, because most of the biomass of slope rockfish occurs in the eastern GOA, and much of the biomass outside this region is found within the no-take reserves, localized depletion is unlikely under this FMP.

Another important aspect of FMP 4.1 is that overcapacity problems in all fisheries would be addressed by adopting measures such as trip limits and LLPs. Such measures would especially affect trawl fisheries, and these fisheries would become less intense and more spread out in time. This would allow better management oversight of trawl fisheries and reduce of the risk of over-harvesting slope rockfish.

Fishing mortality for FMP 4.2 is zero, so there is no spatial or temporal concentration of fishing.

Status Determination

No projections are possible for the fishing mortality rate or MSST, as slope rockfish species are classified as Tier 4 or Tier 5 fish, with insufficient information to compute either parameter.

Age and Size Composition and Sex Ratio

Age and size composition estimates are not available for these species. There is no information on the sex ratio of slope rockfish, although sex ratio for many other species of *Sebastes* has been reported to be approximately 50:50. How the sex ratio may be affected by FMP 4.1 or FMP 4.2 is unknown.

Habitat-Mediated Impacts

Similar to FMP 1 and the baseline situation in past years, FMP 4.1 impacts habitat for slope rockfish mainly because it closes the eastern GOA to trawling. This creates a de facto no-take zone or refuge for slope rockfish in this area, as trawls are generally the only effective gear for capturing most of these species. Nearly all the biomass of slope rockfish is found in the eastern GOA, which means the trawl closure in this region protects most of the GOA population from any fishing pressure. FMP 4.1 also creates a series of no-take reserves across the GOA, which establishes daily refuge for all species, including slope rockfish.

FMP 4.2 changes the entire GOA into one large no-take reserve. Such a large closed area would allow increased survival of larger and older fish that may produce significantly more eggs and larvae to replenish the stocks. Damage to the benthic environment by fishing gear would be prevented throughout the GOA.

Given the low level of exploitation by the groundfish fisheries under these FMPs, the effects of FMP 4.1 and FMP 4.2 on GOA slope rockfish species through habitat suitability are considered insignificant.

Predation-Mediated Impacts

No studies have been done in Alaska to determine the food habits for any of the slope rockfish species. Many of the abundant species, such as sharpchin, harlequin, and redstripe rockfish, are relatively small in size and may be plankton-feeders, but this is conjecture. There is also no documentation of predation on slope rockfish, although larger fishes such as Pacific halibut that are known to prey on other rockfish presumably also prey on slope rockfish. Because of this lack of information, the effect of FMP 4.1 and FMP 4.2 on predator-prey relationships for slope rockfish is unknown.

Summary of Effects of FMP 4.1 and FMP 4.2 – GOA Slope Rockfish

Internal effects on mortality, spatial/temporal characteristics, change in biomass, and change in habitat suitability are identified as insignificant. Change in prey availability are identified as unknown (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects of GOA slope rockfish are summarized in Table 4.5-28.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA other slope rockfish is rated as insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, domestic fisheries, and State of Alaska groundfish fisheries have been identified as having had a adverse persistent past effect on GOA other slope rockfish stocks (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause other slope rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of other slope rockfish. The State of Alaska groundfish fisheries is identified as a non-contributing factor since catch and bycatch of slope rockfish species is already accounted for by the domestic groundfish fishery model projections. The IPHC longline fishery is also identified as a non-contributing factor since bycatch of slope rockfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA other slope rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of changes in biomass level is determined to be insignificant due to the substantial reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA other slope rockfish stocks (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause other slope rockfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the other slope rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts (see Sections 3.5.1.24 and 3.10). The State of Alaska groundfish fisheries are identified as non-contributing factors to GOA slope rockfish biomass level. Although catch and bycatch do occur in these fisheries, the removals are already accounted for by the domestic groundfish fishery model projections.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of GOA other slope rockfish and is rated as insignificant. The combined effect of internal and external removals is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch
- – Change in Genetic Structure of Population
- – Change in Reproductive Success

- **Direct/Indirect Effects.** The effect of the fisheries on the spatial/temporal characteristics of GOA slope rockfish under FMP 4.1 and FMP 4.2 is insignificant.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA slope rockfish; however, climate changes and regime shifts have been identified as having had potential beneficial or adverse effects on slope rockfish reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability which in combination effect reproductive success (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to GOA slope rockfish genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts are identified as non-contributing factors to genetic structure; however, they could affect reproductive success by driving changes in prey availability and habitat suitability. The State of Alaska groundfish fishery is identified as a non-contributing factor to the change in genetic structure and reproductive success of GOA slope rockfish. Although catch and bycatch of slope rockfish species occurs in these fisheries, they are not expected to contribute to localized depletion such that it leads to a detectable reduction in genetic diversity or reproductive success. The IPHC longline fishery is also identified as a non-contributing factor since bycatch of slope rockfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect for the spatial/temporal characteristics of the GOA slope rockfish complex is identified as insignificant. The combined effect of internal and external removals is unlikely to occur in a localized manner such that it will lead to a detectable reduction in genetic diversity and reproductive success of the GOA slope rockfish complex.

Change in Prey Availability

- **Direct/Indirect Effects.** The change in prey availability under FMP 4.1 and FMP 4.2 is identified as unknown due to the limited scientific information.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on slope rockfish prey availability (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to slope rockfish prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regime shifts are identified as potential beneficial or adverse contributors to prey availability (see Sections 3.5.1.24 and 3.10). The State of Alaska groundfish fishery and the IPHC longline fishery are identified as non-contributing factors to slope rockfish prey availability since bycatch of slope rockfish prey species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is identified for the change in prey availability of the GOA slope rockfish but is unknown. It is unknown whether future harvest levels are would lead to a change in prey availability such that it jeopardizes the ability of the stock to sustain itself at or above current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the effect of the fisheries on the change in habitat suitability is insignificant due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past foreign, JV, domestic groundfish fisheries, State of Alaska groundfish fisheries, and the IPHC longline fisheries have been identified as having past persistent adverse effects on GOA slope rockfish habitat due to the impacts caused by fishery gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA slope rockfish habitat suitability (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime shifts could make a potential beneficial or adverse contribution to slope rockfish habitat suitability. See Sections 3.5.1.24 and 3.10 for more information on climate changes and regime shifts. The State of Alaska groundfish fishery and the IPHC longline fishery have been identified as potential adverse contributors to slope rockfish habitat suitability due to impacts from fishery gear. See Section 3.6 for more information on the impacts of fishery gear on essential fish habitat.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability of GOA slope rockfish and is rated as insignificant. The combined effect of internal and external habitat disturbances are unlikely to lead to a detectable change in spawning or rearing success such that it jeopardizes the ability of the stock to sustain itself at or above current population levels.

GOA Pelagic Shelf Rockfish – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass

No projections are possible for these two parameters, as PSR species are classified as Tier 4 or Tier 5 fish. Until recently, an age-structured model had not been finalized for dusky rockfish. Beginning in 2004, dusky rockfish will be managed under Tier 3; however, for the purposes of this analysis, dusky rockfish have been modeled under Tier 4.

Fishing Mortality

This bookend is much more precautionary in its approach than the baseline situation or any of the other FMPs, with the exception of FMP 4.2. FMP 4.1 would have a substantial impact on catch of PSR because it includes a measure that changes the biological reference point for determining rockfish ABCs from the $F_{40\%}$ baseline to the much more conservative value of $F_{75\%}$. Using $F_{75\%}$ would substantially reduce the ABC value for PSR, which in turn would result in a large decrease in catch. Therefore, FMP 4.1 would greatly minimize the risk of overfishing PSR. The model projections for FMP 4.1 show PSR catch reductions of about 80 percent compared to FMP 1 (the present management regime), and the projected catches are around 90 percent less than has been taken by the fishery in recent years. The projections appear reasonable given the stringent precautionary measures of this bookend (Table H.4-32 of Appendix H).

FMP 4.2 sets ABC equal to zero for all species in the GOA, so catch projections for PSR also become zero for all years (Table H.4-32 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

FMP 4.1 would have a large effect on the spatial/temporal concentration of PSR catch compared to what has occurred in past years and what is proposed in FMP 1, FMP 2.1, FMP 2.2, FMP 3.1, and FMP 3.2. The spatial distribution of the catch would change substantially because FMP 4.1 sets aside between 20 percent and 50 percent of the GOA as no-take reserves or as MPAs. No-take reserves in the proposed area cover large portions of Portlock, Albatross, and Shumagin Banks and the "W" grounds west of Yakutat, all of which are major fishing grounds for dusky rockfish (Reuter 1999). Much of the past fishing effort for dusky rockfish has been concentrated on these banks, so FMP 4.1 would likely displace this effort to other localities. Whether this displacement would result in spreading out the fishing effort over a wider area, or would merely concentrate the effort in new localities, is unknown. As in the other FMPs, ABCs would still be geographically apportioned amongst management areas, which would continue to provide some protection against localized depletion of the resource.

Another important aspect of FMP 4.1 is that overcapacity problems in all fisheries would be addressed by adopting measures such as trip limits and LLPs. Such measures would especially affect trawl fisheries, and these fisheries would become less intense and more spread out in time. This would allow better management oversight of trawl fisheries and reduce of the risk of over-harvesting PSR.

Fishing mortality for FMP 4.2 is zero, so there is no spatial or temporal concentration of fishing.

Status Determination

The catch rates are below the ABC and OFL values. The MSST cannot be determined for these stocks.

Age and Size Composition and Sex Ratio

No projections are possible for these two parameters, as PSR species are classified as Tier 4 or Tier 5 fish and an age-structured model has not been finalized for dusky rockfish. There is no information on the sex ratio of PSR, although sex ratio for many other species of *Sebastes* has been reported to be approximately 50:50. How the sex ratio may be affected by FMP 4.1 or FMP 4.2 is unknown.

Habitat-Mediated Impacts

Because FMP 4.1 creates a series of large no-take reserves across the GOA, it may provide substantial habitat benefits to PSR. At present, the only de facto no-take reserve affecting PSR is the eastern GOA region that has been closed to trawling for the past several years. FMP 4.1 retains the eastern GOA trawl closure, and it also adds many no-take reserves elsewhere in the GOA.

FMP 4.2 changes the entire GOA into one large no-take reserve. Such a large closed area would allow increased survival of larger and older fish that may produce significantly more eggs and larvae to replenish the stocks. Damage to the benthic environment by fishing gear would be prevented throughout the GOA.

Given the low level of exploitation by the groundfish fisheries under these FMPs, the effects of FMP 4.1 and FMP 4.2 on GOA PSR species through habitat suitability are considered insignificant.

Predation-Mediated Impacts

The major prey of dusky rockfish appears to be euphausiids, based on the limited food information available for this species (Yang 1993). Euphausiids are also the major prey of walleye pollock, which means dusky rockfish and walleye pollock may be competing for the same food resource. Thus, any measures in FMP 4.1 that affect the commercial catch of walleye pollock could have a subsequent indirect effect on dusky rockfish by increasing or decreasing the amount of euphausiids available to dusky rockfish. FMP 4.1 would change the biological reference point for determining ABC of walleye pollock to the highly precautionary value of $F_{75\%}$, which results in greatly reduced catch projections for walleye pollock in this bookend compared to the baseline and FMP 1, FMP 2.1, FMP 2.2, FMP 3.1, and FMP 3.2. This would lead to an obvious increase in abundance of walleye pollock and possibly have an adverse effect on the food supply for dusky rockfish. FMP 4.2 would prevent any fishing for walleye pollock, but the model projections show that these zero catches translate into only a modest increase in abundance (i.e., biomass) of walleye pollock compared to the baseline situation and FMP 1. How adverse this effect would really be, however, is unknown, as there is little or no quantitative information on trophic interactions between dusky rockfish and walleye pollock or data on whether they even feed on the same spatial aggregations of euphausiids.

Summary of Effects of FMP 4.1 and FMP 4.2 – GOA Pelagic Shelf Rockfish

The effects of FMP 4.1 and FMP 4.2 on PSR in the GOA are summarized in Table 4.8-1.

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects of the GOA PSR complex are summarized in Table 4.5-29.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA PSR complex is insignificant under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA PSR population (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a non-contributing factor to GOA PSR mortality since bycatch in this fishery is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA PSR mortality since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock complex to maintain current population levels is jeopardized. Climate changes and regime shifts are not identified as being contributors to PSR mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA PSR, and is rated as insignificant. PSR are expected to be fished at levels below the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to maintain current population levels.

<u>Change in Biomass</u>

- **Direct/Indirect Effects.** Under FMP 4.1 and FMP 4.2, the groundfish fishery would have no significant effect on the GOA PSR biomass levels due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA DSR population (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a non-contributing factor to GOA PSR biomass levels since bycatch in this fishery is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA PSR mortality since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the capacity of the stock complex to maintain current population levels is jeopardized. Climate changes and regime shifts are not identified as being contributors to PSR mortality.

- **Cumulative Effects.** A cumulative effect is identified for change in biomass and is rated as insignificant. The combined effect of internal and external removals is unlikely to push biomass towards levels that jeopardize the ability of the stock to maintain current population levels.

<u>Spatial/Temporal Concentration of Catch</u>
- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The effect of the fisheries on the change in genetic structure and reproductive success is insignificant under FMP 4.1 and FMP 4.2 due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA PSR; however, climate changes and regime shifts have been identified as having had potential beneficial or adverse effects on PSR reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability which in combination effect reproductive success (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a non-contributing factor to GOA PSR genetic structure and reproductive success since bycatch in this fishery is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA PSR genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts are identified as non-contributing factors to genetic structure; however, they could affect reproductive success by driving changes in prey availability and habitat suitability.

- **Cumulative Effects.** The cumulative effect is identified for the spatial/temporal concentration of catch as insignificant. The combined effect of internal and external removals is not expected to be of a localized manner such that it leads to changes in the genetic diversity or reproductive success of GOA PSR and jeopardizes the ability of the stock to maintain current population levels.

Change in Prey Availability

- **Direct/Indirect Effects.** The effect of the fisheries on the change in prey availability is unknown under FMP 4.1 and FMP 4.2 due to limited scientific information.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on PSR prey availability (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a potential adverse contributor to GOA PSR prey availability. The catch of shrimp in the shrimp fishery is expected to continue in the future. Marine pollution is identified as a potential adverse contributor to PSR prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regimes shifts are identified as potential beneficial or adverse contributors to prey availability (see Sections 3.5.1.24 and 3.10).

- **Cumulative Effects.** A cumulative effect is identified for the change in prey availability of the GOA PSR, but is unknown. It is unknown whether the combination of internal and external removals of prey species is likely to jeopardize the ability of the GOA PSR stock to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** The effect of the fisheries on the change in habitat suitability is insignificant under FMP 4.1 and FMP 4.2 due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past foreign, JV, and domestic groundfish fisheries have been identified as having past persisting adverse effects on GOA PSR habitat due to the impacts caused by fishery gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA PSR habitat suitability (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a non-contributing factor to GOA PSR habitat suitability since the gear associated with this fishery is not expected to cause a significant impact to the benthic habitat (see Sections 3.5.1.24 and 3.6 for more information on the effects of fishing gear on EFH. Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime shifts could make a potential beneficial or adverse contribution to DSR habitat suitability. See Sections 3.5.1.24 and 3.10 for more information on climate changes and regime shifts.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability of GOA PSR, and is rated as insignificant. The combination of internal and external habitat disturbances is unlikely to lead to detectable change in spawning or rearing success such that it jeopardizes the ability of the stock to maintain current population levels.

GOA Demersal Shelf Rockfish – Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Total and Spawning Biomass

Reliable total and spawning biomass statistics are not available for demersal shelf rockfish species.

Fishing Mortality

The projected TAC of DSR species would be reduced to 100 mt or less, under FMP 4.1. Where currently DSR species are managed as a discrete assemblage, based on their strong association with particular rock habitat, this FMP would require that these species be split out if possible and assigned species-specific ABCs. Until then the DSR TAC would be based on the least abundant member of the assemblage. In addition, this FMP would require that a $F_{75\%}$ exploitation rate be used in determining ABCs. Reduced mortality of DSR would likely benefit the population over time but determining such benefits cannot be made at this time due to insufficient information. However, FMP 4.1 would not result in any significantly adverse effects on the ability of DSR to sustain itself at current population levels. A reduced TAC would eliminate the directed fishery for DSR in the eastern GOA. All DSR would be placed on "bycatch-only" status and could significantly constrain the halibut fishery if managers were to strictly limit the bycatch of DSR (Table H.4-33 of Appendix H).

Under FMP 4.2, the projected TAC would be temporarily set to zero for all DSR species unless the harvesting of a species can be shown to have no adverse effect on the environment. DSR species are long lived, slow growing fishes. Temporary suspension of fishing would provide only marginal benefits to DSR assuming the suspension is within two years. In addition, since the GOA FMP controls only groundfish fishing, some mortality is predicted regardless due to bycatch of DSR in the halibut fishery. For this analysis, we presume that the current bycatch limit for DSR species would remain in the halibut fishery to prevent unlimited mortality. Mortality levels will remain at current levels. Therefore, unless the halibut fishery were restricted further, (a scenario not contemplated now) there would be no significant effect (benefit) of a zero TAC on DSR species (Table H.4-33 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

FMP 4.1 would significantly reduce DSR TAC from present levels. DSR species would be taken only as bycatch in the halibut fishery. As such, the catch of DSR would be associated with areas where halibut fishing is best. Therefore, we conclude that the spatial/temporal effects of fishing DSR under FMP 4.1 will be insignificant to the current DSR stock condition.

Under FMP 4.2, there is no projected fishing mortality, so there would be no concentration of harvest and no significant impact to DSR stocks.

Status Determination

The MSST cannot be determined for this stock complex.

Age and Size Composition and Sex Ratio

Age and size composition data is not available for GOA DSR species. The sex ratio of GOA DSR species is unknown.

Habitat-Mediated Impacts

Any habitat suitability impacts of FMP 4.1 and FMP 4.2, such as spawning habitat, nursery grounds, benthic structures, etc.) would be governed by a complex web of direct and indirect interactions which are difficult to quantify at the present time. The example FMP 4.1 includes establishing a network of MPAs along the continental shelf and slope of Alaska. It is unclear what benefits DSR species may receive from the illustrated closures since they only pertain to groundfish fisheries and not the halibut fishery. Regardless, at the low level of harvest authorized by these FMPs, it can be concluded that there would be no significant effects on DSR habitat suitability indexes as a result of FMP 4.1 or FMP 4.2.

Predation-Mediated Impacts

As with habitat impacts, any effects on predator-prey interactions as a result of fishing under FMP 4.1 and FMP 4.2 would be governed by a complex web of direct and indirect interactions which are difficult to quantify at the present time. Information is insufficient to conclude that existing trophic interactions would undergo any significant change under FMP 4.1 or FMP 4.2. However, due to the significant reduction of the groundfish fishery effort, we conclude that the effects on prey availability would be insignificant.

Summary of Effects of FMP 4.1 and FMP 4.2 – GOA Demersal Shelf Rockfish

A significant feature of FMP 4.1 is the lowering of ABC levels for DSR. For DSR species, the eastern GOA ABC and TAC would be less than 100 mt. Because DSR would now be fished at, or below, this low ABC level, the direct and indirect effects of FMP 4.1 on DSR stocks and their habitat are considered either insignificant. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity.

With the temporary suspension of all direct fishing of DSR species, the direct and indirect effects under FMP 4.2 are considered insignificant (Table 4.8-1).

Cumulative Effects of FMP 4.1 and FMP 4.2

Cumulative effects of the GOA DSR complex are summarized in Table 4.5-30.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA DSR complex is insignificant under FMP 4.1 and FMP 4.2. The TAC and reported landings are expected to remain well below the OFL.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA DSR population (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring, shrimp and groundfish fisheries and the IPHC longline fishery have been identified as non-contributing factors to GOA DSR mortality since catch/bycatch in these fisheries is already accounted for by the domestic fishery management levels or bycatch is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA DSR mortality since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock complex to maintain current population levels is jeopardized. Climate changes and regime shifts are not identified as being contributors to DSR mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA DSR and is rated as insignificant. DSR are expected to be fished at levels below the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass

- **Direct/Indirect Effects.** The effect of the fisheries on the change in biomass levels is insignificant under FMP 4.1 and FMP 4.2 due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA DSR population (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring, shrimp and groundfish fisheries and the IPHC longline fishery have been identified as non-contributing factors to GOA DSR biomass levels since catch/bycatch in these fisheries is already accounted for by the domestic fishery management levels or bycatch is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA DSR mortality since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the capacity of the stock complex to maintain current population levels is jeopardized. Climate changes and regime shifts are not identified as being contributors to DSR mortality.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified and is rated as insignificant. The combined internal and external removals are not expected to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- – Change in Genetic Structure of Population
- – Change in Reproductive Success

- **Direct/Indirect Effects.** The effect of the fisheries on the spatial/temporal characteristics of GOA DSR is insignificant under FMP 4.1 and FMP 4.2 due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA DSR; however, climate changes and regime shifts have been identified as having had potential beneficial or adverse effects on DSR reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability which in combination effect reproductive success (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring, shrimp and groundfish fisheries and IPHC longline fisheries have been identified as non-contributing factors to GOA DSR genetic structure and reproductive success. Catch/bycatch of these fisheries is already accounted for by the domestic groundfish management or is not expected to occur (as in the case of the State of Alaska herring and shrimp fisheries). Marine pollution is identified as a potential adverse contributor to GOA DSR genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts are identified as non-contributing factors to genetic structure; however, they could effect reproductive success by driving changes in prey availability and habitat suitability.

- **Cumulative Effects.** A cumulative effect for the spatial/temporal characteristics of the GOA DSR complex is identified and is rated as insignificant. The combined internal and external removals are not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain current population levels is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** The effect of the fisheries on the change in prey availability is insignificant under FMP 4.1 and FMP 4.2 due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on DSR prey availability (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring and shrimp fisheries have been identified as potential adverse contributors to GOA DSR prey availability. Catch of herring in the herring fishery and the catch of shrimp in the shrimp fishery are expected to continue in the future. The State of Alaska groundfish fishery and the IPHC longline fishery are identified as non-contributing factors to GOA DSR prey availability since bycatch of DSR prey species is not expected to occur. Marine pollution is identified as a potential adverse contributor to DSR prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regimes shifts are identified as potential beneficial or adverse contributors to prey availability (see Sections 3.5.1.24 and 3.10).

- **Cumulative Effects.** The cumulative effect for the change in prey availability of the GOA DSR is identified and is rated as insignificant. The combined external and internal factors effecting prey availability are not expected to jeopardize the populations ability to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** The effect of the fisheries on the change in habitat suitability is insignificant under FMP 4.1 and FMP 4.2 due to the significant reduction in the groundfish fishery effort.

- **Persistent Past Effects.** Past foreign, JV, domestic groundfish fisheries, and the IPHC longline fisheries have been identified as having past persisting adverse effects on GOA DSR habitat due to the impacts caused by fishery gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA DSR habitat suitability (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring and shrimp fisheries have been identified as non-contributing factors to GOA DSR habitat suitability since the gear associated with these fisheries are not expected to cause a significant impact to the benthic habitat. The State of Alaska groundfish fisheries and the IPHC longline fisheries are identified as potential adverse contributors to DSR habitat suitability. See Sections 3.5.1.24 and 3.6 for more information on the effects of fishery gear on EFH. Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime shifts could make a potential beneficial or adverse contribution to DSR habitat suitability. See Sections 3.5.1.24 and 3.10 for more information on climate changes and regime shifts.

- **Cumulative Effects.** The cumulative effect for habitat suitability of GOA DSR is identified and is rated as insignificant. The combined internal and external factors are not expected to lead to a detectable change in spawning or rearing success such that the ability of the DSR complex to maintain current population levels is jeopardized.

4.8.2 Prohibited Species Alternative 4 Analysis

4.8.2.1 Pacific Halibut

Pacific halibut are managed by the IPHC. Halibut bycatch in federal groundfish fisheries is controlled by the use of PSC limits. IPHC provides for all removals of halibut, including bycatch in other fisheries, when setting quotas for the directed longline fishery. Thus, changes in bycatch (increase or decrease) are reflected in changes to quotas set for the directed fishery.

FMP 4.1 and 4.2 – Direct/Indirect Effects

Direct and indirect effects for Pacific halibut include mortality, changes in reproductive success, and prey availability. These effects, which are associated with changes in catch, are considered insignificant because annual quota setting processes implemented by IPHC account for all removals of halibut, including bycatch in other fisheries. Thus, if changes to the baseline condition of the stock occur, they are reflected in the quotas set for the directed fishery. Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. Halibut are opportunistic predators with a wide range of prey species, and no significant change to prey structure is expected as a result of these FMPs. No evidence of fishery impact to habitat of halibut has been shown, so this effect will not be considered in the cumulative effects analysis that follows.

Under FMP 4.1, halibut PSC caps would be reduced by 50 percent. Halibut bycatch mortality attributed to the combined BSAI and GOA groundfish fisheries would decrease from 6,800 mt to 3,400 mt. This would allow a corresponding increase in halibut catches by the directed fishery. Total removals would continue to be limited by IPHC to protect the halibut resource.

As proposed in FMP 4.2, every groundfish fishery in the U.S. EEZ would be suspended until the fisheries are shown to have no adverse effect on the resource or its environment. For this FMP scenario, it is presumed that all other fisheries not governed by the BSAI or GOA groundfish FMPs would be authorized to fish in the EEZ under their respective FMPs or international treaties. Therefore, the Alaska halibut fishery would continue under its current management framework.

In the short-term, no directed groundfish fishery would exist, resulting in no incidental take of halibut. This mortality could be transferred by the IPHC to increase quotas for the commercial halibut fishery. However, once fishing recommences in the groundfish fisheries, it is presumed that these fisheries would be managed under strict regulations and that a halibut PSC limit would again be assigned to each groundfish fishery. The IPHC would estimate the mortality for these groundfish fisheries and would follow the current policy of withdrawing this amount from the level available for harvest. The recreational and subsistence fisheries would most likely continue under any scenario in state waters, as would the small Metlakatla treaty fishery in southeast Alaska. In the long-term, total removals would depend on the definition of adverse effects that emerged for the groundfish fisheries.

FMP 4.1 – Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with FMP 4.1 is shown in Table 4.5-31. For further information on persistent past effects included in this analysis, see Section 3.5.2.1 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects**. The potential effect of fishing mortality on BSAI and GOA Pacific halibut is insignificant under FMP 4.1 because current management of halibut by IPHC accounts for all removals of halibut including bycatch in other fisheries when setting quotas for the directed fishery. Thus, if changes to the baseline condition of the stock occur, quotas set by the IPHC for the directed fishery will be adjusted accordingly.

- **Persistent Past Effects**. No persistent past effects of mortality on Pacific halibut have been identified. It is inferred that halibut bycatch in the past fisheries was accounted for under the IPHC management process that is still in effect today.

- **Reasonably Foreseeable Future External Effects**. The directed longline fishery for Pacific halibut remains in effect, but is closely managed by IPHC. Although state-managed fisheries may incidentally catch halibut, IPHC provides for all removals, including bycatch in other fisheries, when setting quotas for the directed longline fishery. Thus, increases or decreases in halibut bycatch are reflected in changes to quotas set for the directed fishery. The directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in halibut mortality. Long-term climate change and regime shifts are not considered contributing factors as they are not expected to result in direct mortality.

- **Cumulative Effects.** The combined effects of mortality on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events, both human controlled and natural, are considered insignificant for FMP 4.1.

Change in Reproductive Success

- **Direct/Indirect Effects**. The potential effect of changes in reproductive success on BSAI and GOA Pacific halibut is insignificant under FMP 4.1. Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. No significant change from the baseline condition is expected as a result of FMP 4.1.

- **Persistent Past Effects**. No persistent past effects of changes in reproductive success on Pacific halibut have been identified. Currently, halibut stocks are considered healthy and stable.

- **Reasonably Foreseeable Future External Effects**. Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. The directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in reproductive success for halibut, since there is no significant spatial/temporal overlap between these fisheries and halibut spawning areas. Long-term climate change and regime shifts could have impacts to the reproductive success of Pacific halibut depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species. However, the effects of this type of large scale event on halibut cannot be determined at this time.

- **Cumulative Effects.** The combined effects of changes in reproductive success on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events, both human controlled and natural, are considered insignificant for FMP 4.1.

Change in Prey Availability

- **Direct/Indirect Effects**. The potential effect of changes in prey availability on BSAI and GOA Pacific halibut is insignificant under FMP 4.1. Halibut are opportunistic predators with a wide range of prey species and no significant change to prey structure is expected as a result of FMP 4.1.

- **Persistent Past Effects**. No persistent past effects impacting prey availability of halibut have been identified.

- **Reasonably Foreseeable Future External Effects**. Halibut are opportunistic predators with a wide range of prey species. Increase in prey competition between Pacific halibut and fisheries catch is not expected. Thus, the directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in prey availability for halibut. Long-term climate change and regime shifts could have impacts on certain prey species of Pacific halibut depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species. However, the effects of this type of large scale event on the prey structure of halibut cannot be determined at this time.

- **Cumulative Effects.** The combined effects of changes in prey availability on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events, both human controlled and natural, are considered insignificant for FMP 4.1.

Cumulative Effects Analysis FMP 4.2

A summary of the cumulative effects analysis associated with FMP 4.2 is shown in Table 4.5-31. For further information on persistent past effects included in this analysis, see Section 3.5.2.1 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects**. The potential effect of fishing mortality on BSAI and GOA Pacific halibut is insignificant under FMP 4.2 because current management of halibut by IPHC accounts for all removals of halibut including bycatch in other fisheries when setting quotas for the directed fishery. Thus, if changes to the baseline condition of the stock occur, quotas set by the IPHC for the directed fishery will be adjusted accordingly.

- **Persistent Past Effects**. No persistent past effects of mortality on Pacific halibut have been identified. It is inferred that halibut bycatch in the past fisheries was accounted for under the IPHC management process that is still in effect today.

- **Reasonably Foreseeable Future External Effects**. The directed longline fishery for Pacific halibut remains in effect, but is closely managed by IPHC. Although state-managed fisheries may incidentally catch halibut, IPHC provides for all removals, including bycatch in other fisheries, when setting quotas for the directed longline fishery. Thus, increases or decreases in halibut bycatch are reflected in changes to quotas set for the directed fishery. The directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in halibut mortality. Long-term climate change and regime shifts are not considered contributing factors as they are not expected to result in direct mortality.

- **Cumulative Effects.** The combined effects of mortality on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events, both human controlled and natural, are considered insignificant for FMP 4.2.

<u>Change in Reproductive Success</u>

- **Direct/Indirect Effects**. The potential effect of changes in reproductive success on BSAI and GOA Pacific halibut is insignificant under FMP 4.2. Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. No significant change from the baseline condition is expected as a result of FMP 4.2.

- **Persistent Past Effects**. No persistent past effects of changes in reproductive success on Pacific halibut have been identified. Currently, halibut stocks are considered healthy and stable.

- **Reasonably Foreseeable Future External Effects**. Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. The directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in reproductive success for halibut, since there is no significant spatial/temporal overlap between these fisheries and halibut spawning areas. Long-term climate change and regime shifts could have impacts to the reproductive success of Pacific halibut depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species. However, the effects of this type of large scale event on halibut cannot be determined at this time.

- **Cumulative Effects.** The combined effects of changes in reproductive success on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events, both human controlled and natural, are considered insignificant for FMP 4.2.

Change in Prey Availability

- **Direct/Indirect Effects**. The potential effect of changes in prey availability on BSAI and GOA Pacific halibut is insignificant under FMP 4.2. Halibut are opportunistic predators with a wide range of prey species, and no significant change to prey structure is expected as a result of FMP 4.2.

- **Persistent Past Effects**. No persistent past effects impacting prey availability of halibut have been identified.

- **Reasonably Foreseeable Future External Effects**. Halibut are opportunistic predators with a wide range of prey species. Increase in prey competition between Pacific halibut and fisheries catch is not expected. Thus, the directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in prey availability for halibut. Long-term climate change and regime shifts could have impacts on certain prey species of Pacific halibut depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species. However, the effects of this type of large scale event on the prey structure of halibut cannot be determined at this time.

- **Cumulative Effects.** The combined effects of changes in prey availability on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events, both human controlled and natural, are considered insignificant for FMP 4.2.

4.8.2.2 Pacific Salmon or Steelhead Trout

Pacific salmon are managed by the ADF&G, which also manages the salmon sport fisheries and permitted subsistence harvesting, to ensure that escapement goals are met for the spawning population in order to maintain sustained yields from the stock as a whole. Annual harvest levels are responsive to fluctuations in run sizes.

For reasons discussed in Section 4.5.2.2, ESA-listed Pacific Northwest chinook salmon and steelhead trout were not specifically considered in this cumulative effects analysis.

Management of Alaskan salmon stocks is challenging due to the lack of precise information on total return and the inability to predict future returns to most rivers or tributaries with any degree of certainty. In most cases, total return and escapement are not known. Due to this lack of information, estimates of significant impacts of bycatch on various runs are unreliable. Another factor to consider in salmon management is the Alaska Subsistence Preference Law. This law requires that commercial, recreational, and personal use fisheries be restricted prior to the restriction of subsistence fisheries. Therefore, management of all fisheries for these stocks in state waters incorporates conservative measures.

A summary of assumptions included in the impact analysis of the FMPs is presented in Section 4.5.2.2.

The cumulative effects analyses were based on two groupings of Alaska salmon in BSAI and GOA: chinook salmon and other salmon.

Direct/Indirect Effects FMP 4.1 and 4.2

Direct and indirect effects for chinook salmon and other salmon in BSAI and GOA include mortality along with changes in prey availability, genetic structure of population, and reproductive success.

BSAI – Chinook Salmon

Under FMP 4.1, chinook salmon bycatch in the BSAI varies from approximately 7,000 in 2008 to 6,000 in 2003. Assuming that 58 to 70 percent of BSAI chinook salmon bycatch is of western Alaska origin, the bycatch of western Alaska chinook salmon stocks could range from 3,000 to 5,000 fish during the next six years. This harvest represents approximately 1.0 to 1.7 percent of the average western Alaska commercial and subsistence harvest of approximately 300,000 chinook salmon from 1998 through 2000. This FMP results in a significant reduction (>25 percent) in western Alaska chinook salmon catches of approximately 10,000 to 13,000 fish per year. These bycatch levels are not detectable in natal streams and would have no detectable effects on commercial or subsistence harvests or escapement. However, given the recent stock status, this FMP could have a conditionally significant beneficial impact due to uncertainty regarding a gain in population sustainability resulting from this FMP.

Under FMP 4.2, chinook salmon bycatch in the BSAI would be eliminated in the years 2003 through 2008, eliminating all western Alaska chinook salmon bycatch during those years. This FMP results in a significant reduction (>25 percent) in western Alaska chum salmon catches of approximately 13,000 to 18,000 fish per year resulting in a bycatch of zero. When considered across all chinook salmon runs in western Alaska, the reduction in bycatch levels are probably not detectable in natal streams, and would have no detectable effect on commercial or subsistence harvests or escapement. Therefore, no significant impacts on the sustainability of the stock are expected. However, if combined with FMP 4.2 for the GOA, the result would be a significant reduction (>25 percent) in western Alaska chinook salmon bycatch of 21,000 to 34,000 fish. When considered across all chum salmon runs in western Alaska, the combined reduction in bycatch levels is probably not detectable in natal streams, but could have beneficial effects on commercial and subsistence harvests and escapement. Given the recent stock status, this FMP could have a conditionally significant beneficial impact resulting in a gain in population sustainability especially to depressed stocks, although the magnitude of this change in population is not known.

BSAI – Other Salmon

Under FMP 4.1, bycatch of other salmon in BSAI varies from approximately 22,000 in 2008 to 17,000 in 2003. Assuming 96 percent of this other salmon bycatch is chum salmon and 19 percent may be of western Alaska origin, the bycatch of western Alaska chum salmon stocks could range from 3,000 to 4,000 fish during the next six years. This harvest represents approximately 0.3 to 0.4 percent of the average western Alaska commercial and subsistence harvest of approximately 1,100,000 chum salmon from 1998 through 2000. This FMP results in a significant reduction (>25 percent) in western Alaska chum salmon catches of approximately 8,000 to 9,000 fish per year. These bycatch levels are not likely to be detectable in natal streams, would have no detectable effects on commercial or subsistence harvests or escapement, and are not expected to significantly impact sustainability of the stock. The combined decrease in bycatch for BSAI and GOA may provide a conditionally significant beneficial effect on mortality of certain salmon stocks that have been depressed in this region.

Under FMP 4.2, other salmon bycatch in BSAI would be eliminated in the years 2003 through 2008, eliminating all western Alaska chum salmon bycatch during those years. This FMP results in a significant reduction (>25 percent) in western Alaska chum salmon catches of approximately 11,000 to 13,000 fish per year. When considered across all chum salmon runs in western Alaska, the reduction in bycatch levels are not detectable in natal streams and would have no detectable effect on commercial or subsistence harvests or escapement. However, given the recent stock status, this FMP could have a conditionally significant beneficial impact resulting in a gain in population sustainability especially to depressed stocks, although the magnitude of this change in population is not known.

GOA – Chinook Salmon

Under FMP 4.1, chinook salmon bycatch in the BSAI varies from approximately 2,000 in 2003 to 7,000 in 2008. Assuming 58 percent of GOA chinook salmon bycatch may be of western Alaska origin, the bycatch of western Alaska chinook salmon stocks could range from 1,000 to 4,000 fish during the next six years. This harvest represents approximately 0.3 to 1.3 percent of the average western Alaska commercial and subsistence harvest of approximately 300,000 chinook salmon from 1998 through 2000. This FMP results in a significant reduction (>25 percent) in western Alaska chinook salmon catches of approximately 7,000 to 12,000 fish per year. These bycatch levels are not detectable in natal streams, nor would they have any detectable effect on commercial or subsistence harvests or escapement. Given the recent stock status, this FMP would have a conditionally significant beneficial impact resulting in a gain in population sustainability due to uncertainty in the population's response to less catch.

Under FMP 4.2, chinook salmon bycatch in GOA would be eliminated in the years 2003 through 2008, eliminating all western Alaska chinook salmon bycatch during those years. This FMP results in a significant reduction (>25 percent) in western Alaska chinook salmon catches of approximately 8,000 to 16,000 fish per year. These bycatch savings are not detectable in natal streams, but could have beneficial effects on commercial or subsistence harvests or escapement. If combined with FMP 4.2 for the BSAI, the result would be a significant reduction (>25 percent) in western Alaska chinook salmon bycatch of 21,000 to 34,000 fish. When considered across all chum salmon runs in western Alaska, the combined reduction in bycatch levels would not be detectable in natal streams, but could have a beneficial effect on commercial and subsistence harvests and escapement. Given the recent stock status, this FMP could have a conditionally significant beneficial impact resulting in a gain in population sustainability especially to depressed stocks, although the magnitude of this change in population is not known.

GOA – Other Salmon

Under FMP 4.1, bycatch of other salmon in the BSAI varies from approximately 1,000 in 2003 up to 3,000 in 2008. Assuming 56 percent of this other salmon bycatch is chum salmon, the bycatch could range from 1,000 to 2,000 fish during the next six years. The proportion of these fish that are of western Alaska origin is unknown. Assuming that all of these fish originate in western Alaska, this harvest represents approximately 0.1 to 0.2 percent of the average western Alaska commercial and subsistence harvest of approximately 1,100,000 chum salmon from 1998 through 2000. This FMP results in a significant reduction (>25 percent) in western Alaska chum salmon catches of approximately 2,000 to 4,000 fish per year when compared to FMP 1. Although these bycatch levels are not likely to be detectable in natal streams, would have no detectable effects on commercial or subsistence harvests or escapement, and are not expected to significantly impact sustainability of the stock, the combined decrease in bycatch for BSAI and GOA may provide a conditionally significant beneficial effect on mortality of certain salmon stocks that have been depressed in this region.

Under FMP 4.2, other salmon bycatch in the GOA would be eliminated in the years 2003 through 2008, eliminating all western Alaska chum salmon bycatch during those years. This FMP results in a significant reduction (>25 percent) in western Alaska chum salmon catches of approximately 3,000 to 6,000 fish per year. These levels of bycatch are not detectable in natal streams, and would have no detectable effect on commercial or subsistence harvests or escapement. However, given the recent stock status, this FMP could have a conditionally significant beneficial impact resulting in a gain in population sustainability especially to depressed stocks, although the magnitude of this change in population is not known.

Cumulative Effects Analysis FMP 4.1

A summary of the cumulative effects analysis associated with FMP 4.1 is shown in Table 4.8-2. For further information on persistent past effects included in this analysis, see Section 3.5.2.2 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of FMP 4.1 on fishing mortality of BSAI and GOA chinook and other salmon is considered conditionally significant beneficial. When considered across all salmon runs in western Alaska, the combined reduction in bycatch levels is probably not detectable in natal streams, but could have beneficial effects on commercial and subsistence harvests and escapement. Given the depressed western Alaska stock status, this FMP could have a conditionally significant beneficial impact resulting in a gain in population sustainability

- **Persistent Past Effects.** Past foreign fisheries in Japan and Russia are associated with direct catch and bycatch of salmon in BSAI and GOA. U.S. bilateral agreements with these countries attempted to reduce gear conflicts between State of Alaska salmon fisheries and foreign fisheries while allocating salmon resources to the state fisheries. These bilateral agreements were considered marginal management measures for protection of salmon stocks. Before 1959, salmon fisheries in Alaska were managed federally. The state took over salmon management after statehood in 1959. However, the domestic fleet continued to grow during the following years and by the 1970s, the state initiated a limited entry system upon the realization that salmon stocks were being overfished. Persistent past effects of mortality on Alaskan salmon stocks exist and are associated with past foreign, JV, and domestic groundfish fisheries.

- **Reasonably Foreseeable Future External Effects.** External effects on Alaskan salmon populations differ between BSAI and GOA and will be discussed independently for each region.

  In BSAI, state commercial and subsistence fisheries exert effects on mortality of chinook and other salmon populations. The magnitude of this effect cannot be determined; however, the current stock status indicates that salmon runs in western Alaska are depressed. In considering this stock condition, impacts of catch and bycatch by state fisheries could hinder recovery of depressed stocks and are considered a potential adverse contribution to the population as a whole. State commercial, subsistence, and sport fisheries are not considered contributing factors in the mortality of GOA other salmon stocks, since these stocks are considered stable. Land management practices heavily influence the condition of watersheds used by spawning salmon, but are not considered contributing factors in the direct mortality of salmon. State of Alaska hatchery enhancement programs were initiated in GOA and have a potential beneficial contribution to the effect of mortality on salmon stocks. In addition, long-term climate change and regime shift are not expected to result in the direct mortality of salmon.

In GOA, state commercial, subsistence, and sport fisheries exert effects on mortality of chinook and other salmon populations, but they are not considered contributing factors in the mortality of salmon stocks as a whole. As mentioned in BSAI above, land management practices are an important factor influencing spawning habitat of salmon, but are not considered contributing factors in direct mortality of salmon in GOA. State of Alaska hatchery enhancement programs were initiated in GOA and have a potential beneficial contribution to the effect of mortality on salmon stocks. Long-term climate change and regime shifts are not expected to result in the direct mortality of salmon.

- **Cumulative Effects.** Given the poor stock status of salmon runs in western Alaska, decreasing bycatch in BSAI and GOA may help to restore stock and improve recovery of salmon. Bycatch of chinook salmon originating in the Pacific Northwest may be reduced as well. The combined effects of mortality on BSAI and GOA chinook and other salmon resulting from direct catch, bycatch, internal catch, and reasonably foreseeable future external events both human controlled and natural are considered conditionally significant beneficial for FMP 4.1. A combined decrease in bycatch potential of BSAI and GOA bycatch potential in the BSAI fisheries under this FMP could support continued recovery of depressed stocks in BSAI and improve sustainability of the Alaskan salmon stock as a whole.

<u>Change in Prey Availability</u>

- **Direct/Indirect Effects.** The potential effects of FMP 4.1 on prey availability for BSAI and GOA chinook and other salmon are unknown. A relationship between fisheries bycatch of prey and salmon prey availability has not been defined.

- **Persistent Past Effects.** It has not been determined if past effects are currently impacting prey availability for BSAI and GOA chinook and other salmon.

- **Reasonably Foreseeable Future External Effects.** In BSAI and GOA, a relationship between state commercial and subsistence fisheries bycatch of prey and salmon prey availability has not been defined and potential effects are unknown. Land management practices are not considered contributing factors in prey availability of salmon, as it is not likely that they would impact the marine environment in which salmon forage. State of Alaska hatchery enhancement programs occur in GOA, but do not include prey species of salmon. Long-term climate change and regime shifts could have impacts on certain prey species of Pacific salmon in BSAI and GOA depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on the prey structure of salmon cannot be determined at this time.

- **Cumulative Effects.** The combined effects of potential changes in prey availability for BSAI and GOA chinook and other salmon resulting from direct internal catch, bycatch, and reasonably foreseeable future external events both human controlled and natural are unknown under FMP 4.1.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of FMP 4.1 on genetic structure of salmon populations in BSAI and GOA are unknown.

- **Persistent Past Effects.** It has not been determined if past effects may be impacting the genetic structure of the BSAI and GOA chinook and other salmon populations.

- **Reasonably Foreseeable Future External Effects.** In BSAI and GOA, salmon bycatch composition has not been determined. Potential effects of state commercial and subsistence fisheries, along with sport fisheries in the GOA, on genetic structure of salmon populations are unknown. Potential effects of state commercial and subsistence fisheries on genetic structure of salmon populations are unknown. Significant impacts to genetic structure of salmon populations by land management practices are not expected and are not considered contributing factors to a possible change in the baseline condition. State of Alaska hatchery enhancement programs focus on building certain salmon stocks. Because actual stock composition for all species of salmon is unknown, the potential effects of this program on genetic structure of salmon populations in GOA are not known. Long-term climate change and regime shifts are not expected to result in direct mortality which would potentially affect genetic structure of BSAI and GOA chinook and other salmon stocks.

- **Cumulative Effects.** Due to the uncertainty of current stock composition for chinook and other salmon in BSAI and GOA, the combined effects of changes in genetic structure on salmon populations in Alaska resulting from direct internal catch, bycatch, and reasonably foreseeable future external events both human controlled and natural are unknown under FMP 4.1.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of FMP 4.1 on reproductive success for BSAI and GOA chinook and BSAI other salmon are considered conditionally significant beneficial. Potential effects on GOA other stocks are unknown.

- **Persistent Past Effects.** Given the poor stock status of salmon runs in western Alaska, it may be inferred that reproductive success has been impacted in certain populations of BSAI region. Successful reproduction of salmon depends on the spawning adults' ability to reach destined spawning habitat. Persistent past effects of mortality on salmon stocks exist, and it is likely that reproductive success of these stocks has suffered as a result. Other past effects tied to freshwater life stages of salmon may play a role in the reproductive success of certain salmon populations. Stocks in GOA are currently considered stable, so it is inferred that any past effects on the population have been mitigated over time.

- **Reasonably Foreseeable Future External Effects.** External effects on Alaskan salmon populations differ between BSAI and GOA and will be discussed independently for each region.

  In BSAI, state commercial and subsistence fisheries catch of western Alaska chinook and other salmon populations could cause potential adverse impacts to reproductive success of these already depressed stocks. Successful reproduction of salmon relies on spawning adults' ability to reach destined spawning habitat. The direct take of these fish would prevent their return to spawning grounds. In considering this depressed stock condition, impacts of catch and bycatch by state fisheries could hinder recovery of depressed stocks and are considered a potential adverse contribution to the population as a whole. Degradation of watersheds used by spawning salmon caused by poor land management practices could significantly impact the reproductive success of BSAI salmon stocks. Thus, these practices are considered potential adverse contributions to possible changes in reproductive success of this population.

  Salmon stocks in GOA are considered stable, so potential effects of state commercial, subsistence, and sport fisheries on reproductive success of this stock are considered insignificant for this population. For reasons stated above, land management practices are considered as potential adverse contributions to the reproductive success of GOA salmon stocks. Hatchery enhancement programs in GOA may help to restore depressed stocks and maintain stable stocks in Alaska and are considered potentially beneficial to the reproductive success of salmon.

  Long-term climate change and regime shifts could have impacts on the reproductive success of Pacific salmon in BSAI and GOA depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on reproductive success of BSAI and GOA salmon cannot be determined.

- **Cumulative Effects.** Successful reproduction of salmon relies on spawning adults' ability to reach destined spawning habitat. Given the poor stock status of salmon runs in western Alaska combined with decreases in bycatch potential for BSAI and GOA predicted under FMP 4.1 may result in beneficial impacts to the BSAI chinook and other salmon stocks. Decreasing bycatch in BSAI and GOA may enable more spawners to reach the destined spawning grounds. The potential combined effects from internal and external events could result in conditionally significant benefits to the reproductive success of BSAI salmon. Although current stock status of GOA chinook and other salmon is stable, combined effects of changes in reproductive success in Alaskan salmon populations resulting from decreased internal catch and reasonably foreseeable future external events both human controlled and natural cannot be determined for GOA other salmon stocks under FMP 4.1.

Cumulative Effects Analysis FMP 4.2

Summaries of the cumulative effects analysis associated with FMP 4.2 are shown in Table 4.8-2. For further information on persistent past effects included in this analysis, see Section 3.5.2.2 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effects of FMP 4.2 on fishing mortality of BSAI and GOA chinook and other salmon are considered conditionally significant beneficial.

- **Persistent Past Effects.** Past foreign fisheries in Japan and Russia are associated with direct catch and bycatch of salmon in BSAI and GOA. U.S. bilateral agreements with these countries attempted to reduce gear conflicts between State of Alaska salmon fisheries and foreign fisheries while allocating salmon resources to the state fisheries. These bilateral agreements were considered marginal management measures for protection of salmon stocks. Before 1959, salmon fisheries in Alaska were managed federally. The state took over salmon management after statehood in 1959. However, the domestic fleet continued to grow during the years to follow and by the 1970's, the state initiated a limited entry system upon the realization that salmon stocks were being overfished. Persistent past effects of mortality on Alaskan salmon stocks exist and are associated with past foreign, JV, and domestic groundfish fisheries.

- **Reasonably Foreseeable Future External Effects.** External effects on Alaskan salmon populations differ between BSAI and GOA and will be discussed independently for each region.

  In BSAI, state commercial and subsistence fisheries exert effects on mortality of western Alaska chinook and other salmon populations. The magnitude of this effect cannot be determined; however, the current stock status indicates that salmon runs in western Alaska are depressed. Considering this stock condition, impacts of catch and bycatch by state fisheries could hinder recovery of depressed stocks and are considered a potential adverse contribution to the population as a whole. Land management practices heavily influence the condition of watersheds used by spawning salmon, but are not considered contributing factors in direct mortality of salmon. In addition, long-term climate change and regime shift are not expected to result in direct mortality of salmon.

  In GOA, state commercial, subsistence, and sport fisheries exert effects on mortality of chinook and other salmon populations, but they are not considered contributing factors in mortality of salmon stocks as a whole. As mentioned in BSAI above, land management practices are an important factor influencing spawning habitat of salmon but are not considered contributing factors in direct mortality of salmon in GOA. State of Alaska hatchery enhancement programs were initiated in GOA and have a potential beneficial contribution to effects of mortality on salmon stocks. Long-term climate change and regime shifts are not expected to result in direct mortality of salmon.

- **Cumulative Effects.** Given the poor stock status of salmon runs in western Alaska, eliminating bycatch in BSAI and GOA may help to restore stock and improve recovery of salmon. Bycatch of chinook salmon originating in the Pacific Northwest may be reduced as well. The combined effects of mortality on BSAI and GOA chinook and other salmon resulting from direct internal catch, bycatch, and reasonably foreseeable future external events both human controlled and natural are considered conditionally significant beneficial for FMP 4.2. A combined decrease in bycatch potential in the BSAI and GOA fisheries under this FMP could support continued recovery of depressed stocks in the BSAI and GOA and improve sustainability of the Alaskan salmon stock as a whole.

Change in Prey Availability

- **Direct/Indirect Effects.** The potential effects of FMP 4.2 on prey availability for BSAI and GOA chinook and other salmon are unknown. A relationship between fisheries bycatch of salmon prey items and salmon prey availability has not been defined.

- **Persistent Past Effects.** It has not been determined if past effects are currently impacting prey availability for BSAI and GOA chinook and other salmon.

- **Reasonably Foreseeable Future External Effects.** In BSAI and GOA, a relationship between state commercial and subsistence fisheries bycatch of prey and salmon prey availability has not been defined and potential effects are unknown. Land management practices are not considered contributing factors in prey availability of salmon, as it is not likely that they would impact the marine environment in which salmon forage. State of Alaska hatchery enhancement programs occur in GOA, but do not include prey species of salmon. Long-term climate change and regime shifts could have impacts on certain prey species of Pacific salmon in BSAI and GOA depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on the prey structure of salmon cannot be determined.

- **Cumulative Effects.** The combined effects of potential changes in prey availability for BSAI and GOA chinook and other salmon resulting from direct internal catch, bycatch, and reasonably foreseeable future external events both human controlled and natural are unknown under FMP 4.2.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of FMP 4.2 on genetic structure of salmon populations in BSAI and GOA are unknown.

- **Persistent Past Effects.** It has not been determined if past effects may be impacting the genetic structure of the BSAI and GOA chinook and other salmon populations.

- **Reasonably Foreseeable Future External Effects.** In BSAI and GOA, salmon bycatch composition has not been determined so potential effects of state commercial and subsistence fisheries on genetic structure of salmon populations are unknown. Significant impacts to genetic structure of salmon populations by land management practices are not expected and are not considered contributing factors to a possible change in baseline condition. State of Alaska hatchery enhancement programs focus on building certain salmon stocks, but because actual stock composition for all species of salmon is unknown, the potential effects of this program on genetic structure of salmon populations in GOA are not known. Long-term climate change and regime shifts are not expected to result in direct mortality which would potentially affect genetic structure of BSAI chinook and other salmon stocks.

- **Cumulative Effects.** Due to the uncertainty of current stock composition for chinook and other salmon in BSAI and GOA, the combined effects of changes in genetic structure on salmon populations in Alaska resulting from direct internal catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are unknown under FMP 4.2.

<u>Change in Reproductive Success</u>

- **Direct/Indirect Effects.** The potential effects of FMP 4.2 on reproductive success for BSAI chinook and other salmon are considered conditionally significant beneficial. Potential effects on GOA other salmon stocks are unknown.

- **Persistent Past Effects.** Given the poor stock status of salmon runs in western Alaska it may be inferred that reproductive success has been impacted in certain populations of BSAI region. Successful reproduction of salmon depends on spawning adults' ability to reach destined spawning habitat. Persistent past effects of mortality on salmon stocks exist, and it is likely that reproductive success of these stocks has suffered as a result. Other past effects tied to freshwater life stages of salmon may play a role in the reproductive success of certain salmon populations. Stocks in GOA are currently considered stable, so it is inferred that any past effects on the population have been mitigated over time.

- **Reasonably Foreseeable Future External Effects.** External effects on Alaskan salmon populations differ between BSAI and GOA and will be discussed independently for each region.

  In BSAI, state commercial and subsistence fisheries catch of chinook and other salmon populations could cause potential adverse impacts to reproductive success of these already depressed stocks. Successful reproduction of salmon relies on spawning adults' ability to reach destined spawning habitat. The direct take of these fish would prevent their return to spawning grounds. Considering this depressed stock condition, impacts of catch and bycatch by state fisheries could hinder recovery of depressed stocks and are considered a potential adverse contribution to the population as a whole. Degradation of watersheds used by spawning salmon caused by poor land management practices could significantly impact the reproductive success of BSAI salmon stocks. Thus, these practices are considered potential adverse contributions to possible changes in reproductive success of this population.

  Salmon stocks in GOA are considered stable. Potential effects of state commercial, subsistence, and sport fisheries on reproductive success of this stock are considered insignificant for this population. For reasons stated above, land management practices are considered as potential adverse contributions to the reproductive success of GOA salmon stocks. Hatchery enhancement programs in GOA may help to restore depressed stocks and maintain stable stocks in Alaska and are considered potentially beneficial to the reproductive success of salmon.

Long-term climate change and regime shifts could have impacts on the reproductive success of Pacific salmon in BSAI and GOA depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on reproductive success of BSAI and GOA salmon cannot be determined.

- **Cumulative Effects.** Given the poor stock status of salmon runs in western Alaska, elimination of bycatch for BSAI and GOA under FMP 4.2 may result in beneficial impacts to the BSAI chinook and other salmon stocks. Thus, eliminating bycatch in BSAI and GOA may enable more spawners to reach the destined spawning grounds and potential combined effects from internal and external events could result in conditionally significant benefits to the reproductive success of BSAI chinook salmon and other salmon. Although current stock status of GOA chinook and other salmon is stable, combined effects of changes in reproductive success in Alaskan salmon populations resulting from decreased internal bycatch and reasonably foreseeable future external events (both human controlled and natural) cannot be determined for GOA stocks under FMP 4.2.

4.8.2.3 Pacific Herring

Pacific herring are managed by the ADF&G. Harvest policy and allocations among gear user groups is established by the Alaska Board of Fisheries. Annual harvest quotas are set by ADF&G under an exploitation rate harvest policy; herring exploitation rates are capped at a maximum level of 20 percent statewide. All directed herring fisheries occur in state waters and are managed by regulatory stocks.

A detailed discussion of the modeling approach used in this analysis is included in Section 4.5.2.3. Given the low herring bycatch levels that are predicted across all FMPs, bycatch removals would not be expected to have significantly different impacts on herring abundance estimates between FMPs.

Direct/Indirect Effects FMP 4.1 and 4.2

Direct and indirect effects for Pacific herring include mortality along with changes in reproductive success, prey availability, and habitat. These effects, which are associated with changes in catch, are considered insignificant for the following reasons: bycatch of herring in the groundfish fisheries is low, the fisheries do not target herring prey, and spatial/temporal overlap between the groundfish fisheries and herring habitat is minimal. In addition, annual quota setting processes implemented by ADF&G are responsive to fluctuations in herring biomass.

Cumulative Effects Analysis FMP 4.1 and 4.2

A summary of the cumulative effects analysis associated with FMP 4.1 and FMP 4.2 is shown in Table 4.5-34. For further information on persistent past effects included in this analysis, see Section 3.5.2.3 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA herring is insignificant under FMP 4.1 and 4.2 given the low amounts predicted for herring bycatch, and because current management of herring by ADF&G is responsive to fluctuations in herring biomass. The herring savings areas reduce herring bycatch potential by triggering closures in years when herring are abundant within fishing grounds.

- **Persistent Past Effects.** Domestic herring fisheries became prominent in the early 1900s with peak catches occurring in the 1920s and 1930s. Foreign herring harvests became prominent in the BSAI in the late 1950s, with highs in the late 1960s and early 1970s. Overexploitation of herring likely resulted during these years of high catch. By 1980, foreign harvest of herring had been eliminated; however, years of unregulated catch of herring may have impacted herring populations long-term. In addition, past federal groundfish fisheries bycatch combined with the directed state fisheries have exceeded the state's herring harvest policy in the past and may still exert lingering effects on current herring populations in the BSAI and GOA.

- **Reasonably Foreseeable Future External Effects.** Directed state herring fisheries still occur, but are closely managed by the state (ADF&G). Fishing quotas are based on variable exploitation rates that account for declines in stock and are capped at a maximum rate of 20 percent. State of Alaska subsistence catch is accounted for in ADF&G herring management plans. These fisheries are not considered contributing factors to changes in herring mortality. Future acute and chronic marine pollution could occur and is considered potentially adverse to herring mortality, especially for those populations that are still recovering from EVOS in the GOA. Long-term climate change and regime shifts are not considered contributing factors as they are not expected to result in direct mortality.

- **Cumulative Effects.** ADF&G Pacific herring management plans are responsive to changes in herring biomass, and fishing quotas are based on variable exploitation rates that account for declines in stock and are capped at a maximum rate of 20 percent. Thus, although some persistent past effects may still be present on certain herring populations in the BSAI and GOA, the combined effects of mortality on Pacific herring resulting from direct internal catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 4.1 and 4.2.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effect of federal groundfish fisheries on reproductive success of BSAI and GOA herring is insignificant under FMP 4.1 and 4.2 due to the low amounts of estimated herring bycatch and because current management of herring by ADF&G is responsive to fluctuations in herring biomass. Thus, if a change in reproductive success occurs, it would most likely be reflected in corresponding changes to biomass, which are incorporated into ADF&G management plans of Pacific herring.

- **Persistent Past Effects.** Herring spawning habitat in the GOA, specifically PWS, was contaminated with oil resulting from the EVOS in 1989. It has been found that this type of contamination exposure to adult and larval herring can result in many adverse effects such as increased rates of egg mortality, larval deformities, and immune system deficiencies. It is presumed that the effects of EVOS still exist and subsets of herring populations in the GOA are still recovering (see foregoing discussion of cumulative effects on Pacific herring mortality).

- **Reasonably Foreseeable Future External Effects.** Directed state herring fisheries still occur, but are closely managed by the state (ADF&G). Fishing quotas are based on variable exploitation rates that account for declines in stock. State of Alaska subsistence catch is accounted for in ADF&G herring management plans. Thus, these fisheries are not considered contributing factors to changes in herring reproductive success. Future acute and chronic marine pollution could occur and is considered potentially adverse to herring reproductive success, especially for those populations that are still recovering from EVOS in the GOA. Long-term climate change and regime shifts could have impacts to the reproductive success of Pacific herring depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on herring cannot be determined at this time.

- **Cumulative Effects.** ADF&G Pacific herring management plans are responsive to changes in herring biomass and fishing quotas are based on variable exploitation rates that account for declines in stock. Although certain herring populations in the GOA have been impacted by EVOS, the stock as a whole is considered to be recovering. Thus, some persistent past effects may still be present on certain herring populations in the BSAI and GOA, but the combined effects on Pacific herring reproductive success resulting from direct internal catch, bycatch, and reasonably foreseeable future external events both human controlled and natural are considered insignificant for FMP 4.1 and FMP 4.2.

Change in Prey Availability

- **Direct/Indirect Effects.** The potential effect of federal groundfish fisheries on prey availability for BSAI and GOA herring is insignificant under FMP 4.1 and FMP 4.2 because current management of herring by ADF&G is responsive to fluctuations in herring biomass and spatial/temporal overlap between the fisheries and herring habitat is minimal. However, if the groundfish fisheries were to somehow impact herring habitat it would most likely be reflected in corresponding changes to biomass, which are accounted for in ADF&G management plans of Pacific herring. In addition, the herring savings areas reduce herring bycatch potential and protect important habitat by triggering closures in years when herring are abundant within fishing grounds.

- **Persistent Past Effects**. No persistent past effects impacting prey availability of herring have been identified.

- **Reasonably Foreseeable Future External Effects.** Pacific herring prey primarily on zooplankton which are not affected by state directed herring fisheries or state subsistence fisheries. Thus, these fisheries are not considered contributing factors to changes in prey availability for herring. Future acute and chronic marine pollution could occur, but effects on prey such as zooplankton are unknown. Long-term climate change and regime shifts could have impacts to many species that contribute to the prey structure of Pacific herring. The nature of these impacts depends on the direction of the climatic shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on herring cannot be determined at this time.

- **Cumulative Effects.** Potential effects of future natural events such as marine pollution and climatic shifts on prey availability for Pacific herring are unknown for FMP 4.1 and FMP 4.2.

Change in Habitat

- **Direct/Indirect Effects.** The potential effect of federal groundfish fisheries on habitat of BSAI and GOA herring is insignificant under FMP 4.1 and FMP 4.2 because current management of herring by ADF&G is responsive to fluctuations in herring biomass. Spatial/temporal overlap between the fisheries and herring habitat is minimal. Thus, if a change in important habitat occurs, it would most likely be reflected in corresponding changes to biomass, which are accounted for in ADF&G management plans of Pacific herring. The herring savings areas reduce herring bycatch potential and protect important habitat by triggering closures in years when herring are abundant within fishing grounds.

- **Persistent Past Effects.** Herring spawning habitat in the GOA, specifically PWS, was contaminated with oil resulting from the EVOS in 1989. The long-term effects of this event to herring habitat are unknown. It is presumed that the effects of EVOS still exist, and subsets of herring populations in the GOA are still recovering.

- **Reasonably Foreseeable Future External Effects.** No evidence of fishery impact on habitat of herring exists. Thus, fisheries are not considered contributing factors to changes in herring habitat at this time. Future acute and chronic marine pollution could occur and is considered potentially adverse to some herring habitat, especially those that are still recovering from EVOS in the GOA. Long-term climate change and regime shifts are not expected to significantly change physical habitat of Pacific herring.

- **Cumulative Effects.** Potential impacts of future natural events, such as marine pollution and climatic shifts, in addition to lingering contamination from EVOS on certain habitat of herring in the GOA exist, but effects are not known for FMP 4.1 and FMP 4.2.

4.8.2.4 Crab

Alaska king, bairdi Tanner, and opilio Tanner (snow crab) crab fisheries are managed by the State of Alaska with federal oversight and the following guidelines established in the BSAI king and Tanner crab FMP (NPFMC 1989). Section 4.5.2.4 contains further information on current stock status and management of crab in Alaska.

For the cumulative effects analysis, crab stocks in BSAI and GOA will be placed in the following groups: bairdi Tanner, opilio Tanner (only BSAI), red king, blue king, and golden king.

Direct/Indirect Effects FMP 4.1 and 4.2

Direct and indirect effects for all species of crab in BSAI and GOA include mortality along with changes in biomass, reproductive success, prey availability, and habitat. These effects may be attributed to fishing activities both directed and undirected, but may be linked to natural events such as long-term climatic change and decadal regime shifts. Significance of these effects is based on the likelihood that population-level changes will result from internal events within the groundfish fishery. An effect that is considered insignificant corresponds to a change that is not likely to result in population-level effects on crab or that lies within the range of natural variability for the species.

Cumulative Effects Analysis FMP 4.1 and 4.2

Summaries of the cumulative effects analyses associated with FMP 4.1 and 4.2 are shown in Table 4.8-2. For further information on persistent past effects included in this analysis, see Section 3.5.2.4 of this Programmatic SEIS.

The foundation of the cumulative effects analysis is the baseline description for each species that includes population status and trends, if known, and the major human and natural influences that have affected the population in the past and that continue up to the present.

For each species, the predicted direct and indirect effects of the groundfish fishery are then analyzed for their contribution to the overall impacts from all sources, including reasonably foreseeable future events resulting from human and natural events external to the fishery. The reasonably foreseeable future events include other U.S. and foreign fisheries, acute and chronic environmental pollution, and natural events such as climatic and oceanographic fluctuations. Cumulative effects are each rated according to the same significance criteria as the direct/indirect effects of the fishery and are based on the potential for population-level effects.

Mortality

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** Under FMP 4.1, predicted catch of these crab species both decreases and increases from the current baseline condition in FMP 4.1 and is completely eliminated in FMP 4.2. Under FMP 4.1, trawl closure areas and protection areas are more extensive than other proposed FMPs, concentrating red king crab bycatch to a small area on the western edge of their distribution. Most bycatch of opilio and bairdi Tanner crab would come from the open areas east of the Pribilof Islands. In addition, bairdi Tanner crab catch would be shifted to the north as a result of closures in Bristol Bay and areas north of Unimak Island. Predicted crab bycatch varies by fishery. Although current bycatch limits and quota-setting processes are responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries, these stocks are currently considered depressed and in some instances, overfished. Under these proposed FMPs, it is possible that bycatch of crab could decrease and additional protection measures could enhance habitat and possible recovery of depressed stocks. Thus, FMP 4.1 and 4.2 are considered to have conditionally significant beneficial effects on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI. The conditional rating is based on the lack of recovery for these stocks under current management plans.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey In review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between State of Alaska crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, adverse past effects of mortality on BSAI and GOA crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur and are managed by ADF&G in cooperation with NOAA Fisheries. These fisheries are considered to have a potential adverse effect on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI, since no signs of recovery have been shown. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed, but is not in effect at the time of this writing this time. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time. BSAI red king crab stocks do not have rebuilding plans in effect, and the population is currently considered depressed. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in mortality.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. Under these proposed FMPs, it is possible that bycatch of crab could decrease and additional protection measures could enhance habitat and possible recovery of depressed stocks. Persistent past effects on crab populations in the BSAI may still exist, and stocks are considered depressed with no signs of recovery to date. It is unclear if additional protection measures and a decrease or elimination of crab bycatch will mitigate the combined effects of mortality resulting from past events, direct internal catch, bycatch, and reasonably foreseeable future external events on depressed stocks. Thus, cumulative effects of FMP 4.1 and FMP 4.2 on BSAI crab stocks cannot be determined.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Under FMP 4.1, predicted catch of golden king crab in BSAI and GOA were combined with those predictions for blue king crab. The BSAI predictions showed increases in catch for FMP 4.1 when compared to current catch rates, while FMP 4.2 eliminates bycatch over the next five years. Model projections for GOA catch showed decreases in catch for FMP 4.1 compared to current catch in this region, while FMP 4.2 eliminates bycatch. However, significance of these predicted changes in catch on mortality is unknown due to lack of survey information for determining current stock status of golden king crab. Thus, effects of FMP 4.1 and FMP 4.2 on mortality of BSAI and GOA golden king crab are unknown.

- **Persistent Past Effects.** See foregoing discussion for crab bycatch in yellowfin sole and Pacific ocean perch fisheries. Adverse past effects of mortality on BSAI and GOA crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for golden king crab, but the overall stock status of golden king crab stocks in BSAI and GOA are currently unknown. Thus, the potential effects of these fisheries on mortality are not known. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in crab mortality.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. Under these proposed FMPs, it is possible that bycatch of golden king crab could decrease or be eliminated and additional protection measures could enhance habitat and possible recovery of depressed stocks. However, persistent past effects on these crab populations in the BSAI and GOA may still exist. Some GOA stocks are considered depressed, but the overall stock status of golden king crab in BSAI and GOA is unknown. Thus, potential combined effects of mortality resulting from past events, direct internal catch, bycatch, and reasonably foreseeable future external events cannot be determined at this time for FMP 4.1 and FMP 4.2.

Bairdi Tanner, Red King, and Blue King Crab in GOA

Opilio Tanner crab populations are not encountered during ADF&G surveys in the GOA. It is inferred that this crab species is not prevalent in this region. Therefore, opilio Tanner crab is not included in this analysis.

- **Direct/Indirect Effects.** Under FMP 4.1, predicted catch of bairdi Tanner, red king, and blue king crab in GOA showed decreases from current catch levels baseline for the next five years while FMP 4.2 eliminates crab bycatch. However, significance of these predicted changes in catch on mortality is unknown for bairdi Tanner and blue king crab due to lack of survey information for determining current stock status as a whole. Thus, effects of FMP 4.1 and FMP 4.2 on mortality of GOA bairdi Tanner and blue king crab are unknown. GOA red king crab stocks are considered severely depressed according to ADF&G survey information. It is unclear if possible decreases in catch or elimination of crab bycatch proposed under these FMPs will mitigate driving factors of mortality in these stocks. Potential effects of FMP 4.1 and FMP 4.2 on mortality in GOA red king crab populations are unknown due to the lack of recovery that has been observed in these stocks under current management plans. Under these proposed FMPs, it is possible that bycatch of crab could decrease and additional protection measures could enhance habitat and possible recovery of depressed stocks. Thus, FMP 4.1 and 4.2 are considered to have conditionally significant beneficial effects on GOA red king crab. The rating is conditional based on the lack of recovery for these stocks under current management plans.

- **Persistent Past Effects.** See previous discussion of past GOA crab bycatch. Adverse past effects of mortality on BSAI and GOA crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for bairdi Tanner and blue king crab, but their overall stock status in GOA is currently unknown. Thus, the potential effects of these fisheries on mortality of bairdi Tanner and blue king crab stocks are not known. GOA stocks of red king crab are considered severely depressed according to current ADF&G surveys. The depressed nature of these stocks, in addition to external mortality associated with state directed, subsistence, and scallop fisheries could adversely impact recovery and sustainability of red king crab stocks in GOA. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in crab mortality.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on bairdi Tanner, red king, and blue king crab stocks in GOA may still exist. Some GOA stocks of bairdi Tanner and blue king crab are considered depressed, but their overall stock status is unknown. Thus, potential combined effects of mortality resulting from past, present, and future events, internal catch, and reasonably foreseeable future external events cannot be determined for bairdi Tanner and blue king crab stocks at this time for FMP 4.1 and FMP 4.2. It is unclear if additional protection measures and decreases or elimination of crab bycatch put forth under these FMPs will mitigate the combined effects of mortality, resulting from past events, internal catch, and reasonably foreseeable future external events on severely depressed red king crab stocks. Therefore, cumulative effects of FMP 4.1 and FMP 4.2 on GOA red king crab cannot be determined at this time.

Change in Biomass

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** Under FMP 4.1, predicted catch of these crab species decreases and increases from the current baseline condition in FMP 4.1 and is completely eliminated in FMP 4.2. Under FMP 4.1, trawl closure areas and protection areas are more extensive than other proposed FMPs, concentrating red king crab bycatch to a small area on the western edge of their distribution. Most bycatch of opilio and bairdi Tanner crab would come from the open areas east of the Pribilof Islands. In addition, bairdi Tanner crab catch would be shifted to the north as a result of closures in Bristol Bay and areas north of Unimak Island. Predicted crab bycatch varies by fishery. Although current bycatch limits and quota-setting processes are responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries, these stocks are currently considered depressed and in some instances, overfished. Under these proposed FMPs, it is possible that bycatch of crab could decrease and additional protection measures could enhance habitat and possible recovery of depressed stocks. Thus, FMP 4.1 and FMP 4.2 are considered to have conditionally significant beneficial effects on changes in biomass of bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI. The conditional rating is based on the lack of recovery these stocks have been shown under current management plans.

- **Persistent Past Effects.** See previous discussion of crab bycatch in yellowfin sole and Pacific ocean perch fisheries. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey In review). Adverse past effects of mortality on BSAI and GOA crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur and are considered to have a potential adverse effect on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI, since no signs of recovery have been shown. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed, but is not in effect at the time of this writing. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time. BSAI red king crab stocks do not have rebuilding plans in effect, and the population is currently considered depressed. Potential effects of long-term climate change and regime shifts on crab biomass have not be determined.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. Under these proposed FMPs, it is possible that bycatch of crab could decrease or be eliminated and additional protection measures could enhance habitat and possible recovery of depressed stocks. Persistent past effects on crab populations in the BSAI may still exist, and stocks are considered depressed with no signs of recovery to date. It is unclear if additional protection measures and a decrease or elimination of crab bycatch will mitigate the combined effects of mortality and subsequent changes in biomass, resulting from past events, internal catch, and reasonably foreseeable future external events on depressed stocks. Thus, cumulative effects of FMP 4.1 and FMP 4.2 on BSAI crab stocks cannot be determined at this time.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current biomass of golden king crab in BSAI and GOA, potential effects of FMP 4.1 and FMP 4.2 on changes to biomass cannot be determined.

- **Persistent Past Effects.** See previous discussion of crab bycatch in yellowfin sole and Pacific ocean perch fisheries. The potential effects of past fishing mortality on biomass of golden king crab stocks in BSAI and GOA cannot be determined because catch composition is unknown, and biomass estimates over time do not exist for these stocks.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for golden king crab, but the overall stock status of golden king crab stocks in BSAI and GOA is unknown, and biomass estimates have not been determined. Thus, the potential effects of these fisheries on biomass are not known. Effects of long-term climate change and regime shifts on crab biomass have not been determined.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. Under these proposed FMPs, it is possible that bycatch of golden king crab could decrease or be eliminated and additional protection measures could enhance habitat and possible recovery of depressed stocks. However, persistent past effects on these crab populations in the BSAI and GOA may still exist. Some GOA stocks are considered depressed, but the overall stock status and biomass estimates of golden king crab in BSAI and GOA are unknown. Thus, potential combined effects of changes in biomass, resulting from past events, direct internal catch, bycatch, and reasonably foreseeable future external events cannot be determined at this time for FMP 4.1 and FMP 4.2.

Bairdi Tanner, Red King, and Blue King Crab in GOA

Opilio Tanner crab populations are not encountered during ADF&G surveys in the GOA. It is inferred that this crab species is not prevalent in this region. Therefore, opilio Tanner crab is not included in this analysis.

- **Direct/Indirect Effects.** Under FMP 4.1, predicted catch of bairdi Tanner, red king, and blue king crab in GOA showed decreases from current baseline for the next five years while FMP 4.2 eliminates crab bycatch. However, significance of these predicted changes in catch on mortality is unknown for bairdi Tanner and blue king crab due to lack of survey information for determining current stock status as a whole. Thus, effects of FMP 4.1 and FMP 4.2 on mortality and subsequent changes in biomass of GOA bairdi Tanner and blue king crab are unknown. GOA red king crab stocks are considered severely depressed according to ADF&G survey information. It is unclear if possible decreases in catch or elimination of crab bycatch proposed under these FMPs will mitigate driving factors of mortality in these stocks. Potential effects of FMP 4.1 and FMP 4.2 on changes in biomass of GOA red king crab populations are unknown due to the lack of recovery that has been observed in these stocks under current management plans. Under these proposed FMPs, it is possible that bycatch of crab could decrease and additional protection measures could enhance habitat and possible recovery of depressed stocks. Thus, FMP 4.1 and FMP 4.2 are considered to have conditionally significant beneficial effects on changes in biomass of red king crab stocks in the GOA. The conditional rating is based on the lack of recovery observed for these stocks under current management plans.

- **Persistent Past Effects.** Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries (see previous discussion of persistent past effects on mortality). Adverse effects of past fishing mortality on biomass of bairdi Tanner, blue king, and red king crab stocks in GOA may still exist as recovery of depressed stocks has not been observed.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for bairdi Tanner and blue king crab, but their overall stock status in GOA is currently unknown. Thus, the potential effects of these fisheries on biomass of bairdi Tanner and blue king crab stocks cannot be determined. GOA stocks of red king crab are considered severely depressed according to current ADF&G surveys. The depressed nature of these stocks, in addition to external mortality associated with state directed, subsistence, and scallop fisheries could adversely impact recovery and sustainability of red king crab stocks in GOA. Effects of long-term climate change and regime shifts on crab biomass have not been determined.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on bairdi Tanner, red king, and blue king crab stocks in GOA may still exist. Some GOA stocks of bairdi Tanner and blue king crab are considered depressed, but their overall stock status and biomass estimates are unknown. Thus, potential combined effects of changes in biomass, resulting from past events, direct internal catch, bycatch, and reasonably foreseeable future external events cannot be determined for bairdi Tanner and blue king crab stocks at this time for FMP 4.1 and FMP 4.2. It is unclear if additional protection measures and decreased or elimination of crab bycatch put forth under these FMPs will mitigate the combined effects of mortality and subsequent changes to biomass, resulting from past events, internal catch, and reasonably foreseeable future external events on severely depressed red king crab stocks. Cumulative effects of FMP 4.1 and FMP 4.2 on GOA red king crab cannot be determined at this time.

Change in Reproductive Success

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects**. These stocks are currently considered depressed and in some instances, overfished. Changes in reproductive success within BSAI crab populations may be an underlying factor in the depressed nature of these stocks. However, a direct causation between spawning-recruitment reproductive success and depressed stock status cannot be concluded at this time. Therefore, the potential effects of FMP 4.1 and FMP 4.2 on changes to reproductive success cannot be determined.

- **Persistent Past Effects.** See previous discussion of persistent past effects on mortality. Past fisheries may have indirectly impacted reproductive success of these stocks by removing vital brood stocks and/or adversely impacting spawning and nursery habitat as a result of bottom trawling. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea, and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations Dew and McConnaughey In review). Past effects may still exist as these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur. Directed crab fishing seasons are set to avoid mating and molting periods, so these fisheries are not considered contributing factors to changes in reproductive success of bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed, but is not in effect at the time of this writing. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time. BSAI red king crab stocks do not have rebuilding plans in effect, and the population is currently considered depressed. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Crab seasons are set to avoid mating and molting periods. However, persistent past effects on crab populations in the BSAI may still exist, and stocks are considered depressed with no signs of recovery to date. A relationship between spawning-recruitment success and other factors impeding on reproductive potential to depressed stock status cannot be drawn at this time. Thus, potential effects on reproductive success resulting from past, present, and future events, internal catch, and reasonably foreseeable future external events are unknown for FMP 4.1 and FMP 4.2.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of golden king crab in BSAI and GOA, potential effects of FMP 4.1 and FMP 4.2 on changes to reproductive success cannot be determined.

- **Persistent Past Effects.** See previous discussion of crab bycatch in yellowfin sole and Pacific ocean perch fisheries on mortality. Current stock status of BSAI and GOA golden king crab has not been determined, so potential past effects on reproductive success are unknown.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur. Crab seasons are set to avoid mating and molting periods, so these fisheries are not considered contributing factors to changes in reproductive success of golden king crab. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Crab seasons are set to avoid mating and molting periods. However, persistent past effects on golden king crab populations in the BSAI and GOA are not known. Potential effects on reproductive success resulting from past events, direct internal catch, bycatch, and reasonably foreseeable future external events are unknown for FMP 4.1 and FMP 4.2.

Bairdi Tanner, Red King, and Blue King Crab in GOA

Opilio Tanner crab populations are not encountered during ADF&G surveys in the GOA. It is inferred that this crab species is not prevalent in this region. Therefore, opilio Tanner crab is not included in this analysis.

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of blue king crab in GOA, potential effects of FMP 4.1 and FMP 4.2 on changes to reproductive success cannot be determined. Survey data collected by ADF&G for certain bairdi Tanner crab stocks in western GOA show signs of possible recovery while other GOA stocks are still considered depressed. Red king crab populations in GOA are at historic lows according to ADF&G survey information. Changes in reproductive success within GOA crab populations may be an underlying factor in the depressed nature of these stocks. However, a direct causation between reproductive success and depressed stock status cannot be concluded at this time. Therefore, the potential effects of FMP 4.1 and FMP 4.2 on changes to reproductive success cannot be determined for bairdi Tanner and red king crab populations in GOA.

- **Persistent Past Effects.** See previous discussion of persistent past effects on mortality. Past fisheries may have indirectly impacted reproductive success of these stocks by removing vital brood stocks and/or adversely impacting spawning and nursery habitat as a result of bottom trawling. Past effects may still exist as these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur. Crab seasons are set to avoid mating and molting periods, so these fisheries are not considered contributing factors to changes in reproductive success of these stocks. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Crab seasons are set to avoid mating and molting periods. However, persistent past effects on crab populations in the GOA may still exist, and some stocks are considered depressed with no signs of recovery to date. Thus, potential effects on reproductive success resulting from past events, direct internal catch, bycatch, and reasonably foreseeable future external events are unknown for FMP 4.1 and FMP 4.2.

<u>Change in Prey Availability</u>

Bairdi Tanner, Opilio Tanner, Red King, Blue King, and Golden King Crab in BSAI and GOA

Opilio Tanner crab populations are not encountered during ADF&G surveys in the GOA. It is inferred that this crab species is not prevalent in this region. Therefore, only BSAI opilio Tanner crab is included in this analysis.

- **Direct/Indirect Effects.** Diet composition of crab has not been determined, but crab are known to be benthic feeders. Competition for prey species of crab resulting from groundfish fisheries catch has not been shown, and it is unclear if FMP 4.1 and FMP 4.2 would impact prey structure and availability for all species of crab throughout BSAI and GOA. Thus, potential effects of FMP 4.1 and FMP 4.2 on changes in prey availability cannot be determined.

- **Persistent Past Effects.** Crab are benthic feeders and generally feed on invertebrates. Catch of crab prey in current and past groundfish fisheries is minimal. Thus, past effects on crab prey structure and availability in BSAI and GOA have not been identified.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur. Competition for prey species of crab resulting from groundfish fisheries catch has not been shown, and these fisheries are not considered contributing factors to changes in prey availability. Rebuilding plans currently in effect in BSAI do not address crab prey structure and availability and are not considered contributing factors to potential changes in prey availability. Long-term climate change and regime shifts may impact crab prey structure depending on the direction of the change. However, it is impossible to determine the possible effects that these changes may have on crab populations throughout BSAI and GOA.

- **Cumulative Effects.** Diet composition of crab has not been determined and potential changes to prey structure resulting from Direct/Indirect Effects and reasonable foreseeable future events cannot be determined for all species of crab in BSAI and GOA for FMP 4.1 and FMP 4.2.

<u>Change in Habitat</u>

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** These stocks are currently considered depressed and in some instances, overfished. However, a direct link between changes to habitat and the depressed stock status of these crab species in the BSAI cannot be concluded at this time. It is inferred that current crab management plans are mitigating past habitat disruption and providing protection for crab stocks, but recovery has not been shown. Under these proposed FMPs, protection areas are more extensive than other FMPs, and it is likely that the elimination or severe restriction of trawling in BSAI would enhance recovery of crab habitat. However, it is impossible to predict the potential population-level effects that may result. Thus, FMP 4.1 and FMP 4.2 are considered to have conditionally significant beneficial effects on changes in habitat of bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI. The conditional rating is based on the lack of recovery for these stocks under current management plans.

- **Persistent Past Effects.** See previous discussion of persistent past effects on mortality. Past fisheries may have directly or indirectly impacted spawning and nursery habitat as a result of bottom trawling. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea, and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey In review). Thus, past fisheries may have directly or indirectly impacted spawning and nursery habitat as a result of trawling and using other types of fishing gear that interact with bottom habitat. Past effects may still exist as these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur. Although much of the known habitat areas of BSAI crab are currently protected by no trawl zones and conservation zones, it is possible that other critical habitat areas are not included in these measures. These fisheries are considered potential adverse factors in possible changes to crab habitat based on the lack of recovery that has been observed for these stocks under current management plans. Formal stock rebuilding plans are in place for BSAI bairdi and opilio

Tanner crab stocks. St. Matthew Island blue king crab stock has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed but is not in effect at this time. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time and offer protection of critical habitat. BSAI red king crab stocks do not have rebuilding plans in effect. The population is currently considered depressed, and possible habitat-related effects have not been determined. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors in possible changes that may occur.

- **Cumulative Effects.** Persistent past effects on crab habitat in the BSAI may still exist, and stocks are considered depressed with no signs of recovery to date. Although much of the known habitat areas of BSAI crab are currently protected by no trawl zones and conservation zones, recovery has not been shown. Under these proposed FMPs, protection areas are more extensive than other FMPs, and it is likely that the elimination or severe restriction of trawling in BSAI would enhance recovery of crab habitat. However, it is impossible to estimate the potential population-level effects that may result. Thus, potential cumulative effects on changes to crab habitat resulting from internal effects and reasonable foreseeable future events cannot be determined for FMP 4.1 and FMP 4.2.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of golden king crab in BSAI and GOA, it is difficult to identify habitat-related effects as they pertain to changes in these crab populations throughout BSAI and GOA. Potential effects of FMP 4.1 and FMP 4.2 to crab habitat are unknown.

- **Persistent Past Effects.** See previous discussion of persistent past effects on mortality. Past fisheries may have directly or indirectly impacted spawning and nursery habitat as a result of bottom trawling. Past effects may still exist as many of these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur and are considered potential adverse factors in possible changes to crab habitat based on the lack of recovery that has been observed for many of the crab stocks under current management plans and the depressed nature of some golden king crab stocks in GOA currently. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors in possible changes that may occur.

- **Cumulative Effects.** Some GOA golden king crab stocks are considered depressed, and past effects may still exist as many of these stocks have not shown signs of recovery to date. Although much of the known habitat areas of BSAI and GOA crab are currently protected by no trawl zones and conservation zones, recovery of depressed stocks has not been shown. Under these proposed FMPs, protection areas are more extensive than other FMPs, and it is likely that the elimination or severe restriction of trawling in BSAI and GOA would enhance recovery of crab habitat. However, it is impossible to predict the potential population-level effects that may result. Thus, potential effects on golden king crab habitat resulting from past events, internal catch, and reasonably foreseeable future external events cannot be determined for FMP 4.1 and FMP 4.2 without first establishing the overall population and essential habitat status of this species.

Bairdi Tanner, Red King, and Blue King Crab in GOA

Opilio Tanner crab populations are not encountered during ADF&G surveys in the GOA. It is inferred that this crab species is not prevalent in this region. Therefore, opilio Tanner crab is not included in this analysis.

- **Direct/Indirect Effects.** Red king and bairdi Tanner stocks in the GOA are currently considered depressed while blue king crab stock status is unknown, but presumed to be depressed based on limited survey data. Population data is limited for both bairdi Tanner and blue king crab stocks, thus the cumulative effects of FMP 4. 1 and FMP 4.2 on the habitat suitability of these stocks are unknown. Red king crab stocks in the GOA are severely depressed., However, a relationship between changes to habitat and depressed stock status cannot be drawn at this time. It is inferred that current crab management plans are mitigating past habitat disruption and providing protection for crab stocks, but recovery of stocks has not been shown. Under these proposed FMPs, protection areas are more extensive than other FMPs, and it is likely that the elimination or severe restriction of trawling in GOA would enhance recovery of crab habitat. However, it is impossible to predict the potential population-level effects that may result. Thus, the potential effects of FMP 4.1 and FMP 4.2 on changes to bairdi Tanner, red king, and blue king crab habitat in GOA are unknown. Thus, FMP 4.1 and FMP 4.2 are considered to have conditionally significant beneficial effects on changes in habitat of red king crab stocks in BSAI. The conditional rating is based on the lack of recovery observed for these stocks under current management plans.

- **Persistent Past Effects.** See previous discussion of persistent past effects on mortality. Past fisheries may have directly or indirectly impacted spawning and nursery habitat as a result of bottom trawling. Past effects may still exist as some of these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State of Alaska crab, scallop, and subsistence fisheries continue to occur. These fisheries are considered potential adverse factors in possible changes to crab habitat based on the lack of recovery that has been observed for some of these stocks under current management plans. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors in possible changes to GOA crab habitat that may occur.

- **Cumulative Effects.** Persistent past effects on crab habitat in the GOA may still exist and stocks are considered depressed with no signs of recovery to date. Although much of the known habitat areas of GOA crab are currently protected by no trawl zones and conservation zones, it is possible that other critical habitat areas are not included. Under these proposed FMPs, protection areas are more extensive than other FMPs, and it is likely that the elimination or severe restriction of trawling in GOA would enhance recovery of crab habitat. However, it is impossible to predict the potential population-level effects that may result. Thus, potential cumulative effects on GOA bairdi Tanner, red king, and blue king crab habitat resulting from past events, direct internal catch, bycatch, and reasonably foreseeable future external events cannot be determined for FMP 4.1 and FMP 4.2.

4.8.3 Other Species Alternative 4 Analysis

The other species category consists of the following species:

- Squid (order Teuthoidea).
- Sculpin (family Cottidae).
- Shark (Somniosus pacificus, Squalus acanthias, Lamna ditropis).
- Skate (genera Bathyraja and Raja).
- Octopi (Octopus dofleini, Opistholeutis california, and Octopus leioderma).

An aggregate TAC limits the catch of species in this category. Within the other species category, only shark are identified to the species level by fishery observers. Furthermore, accuracy of catch estimates depends on the level of coverage in each fishery. Estimates of observer coverage in the BSAI is 70 to 80 percent, whereas the GOA has only approximately 30 percent observer coverage. Coverage can vary for certain target fisheries and vessel sizes (Gaichas 2002). Further description of this management is described in detail in Section 3.5.3.

Formal stock assessments for other species are not currently conducted in the BSAI and GOA, and biomass estimates for the species included in this category are limited and often unreliable. Thus, changes in total biomass, reproductive success, genetic structure of population, habitat, or mortality rates under any FMP alternative cannot be determined due to lack of a baseline condition . While changes in bycatch relative to the comparative baseline are reported here, it is important to emphasize that determinations cannot be made as to how these changes in catch actually impact the other species populations, or whether these impacts might be adverse, beneficial, or neutral. There are numerous direct and indirect effects that may impact the current and future status of individual species within this group and/or this group as a whole. These effects are presented in detail in the section that follows.

Direct/Indirect Effects FMP 4.1 – Other Species

Direct and indirect effects for other species include mortality along with changes in reproductive success, genetic structure of population, and habitat. The significance of these effects caused by changes in catch for any of these non-target species groups is unknown, because information on stock status is lacking in order to determine how these stocks respond to changes in catch. Although the differences in catch between the comparative baseline and FMP 4.1 are relatively large in some cases, we still predict similar (unknown) effects on each stock.

The following component of FMP 4.1 was not implemented in the projection model used to generate these results: "For species managed as members of a stock complex, rather than setting TAC as the aggregate of the individual members' ABCs, the max ABC value for each component stock would be determined and the TAC set equal to the lowest value." If this component of FMP 4.1 were implemented along with all of the other management measures in this FMP, it is likely that catches of other species would be considerably lower than those reported here. This is because setting the TAC of all complexes to the lowest single species ABC would result in very low TACs for all rockfish and flatfish complexes as well as the other species complex, which would be quite constraining to target fisheries that encountered any members of the species complex. Therefore, the catch estimates reported here are the maximum likely to be taken under this alternative if it were fully implemented in reality.

Under FMP 4.1, total catch of BSAI squid and other species and GOA other species is predicted to drop to approximately one-third to one-half of the currently observed levels. This is due to predicted decreases in catches of the target species. Most of this decrease in both areas is predicted in the catch of skates. Species-specific catch projections are presented below.

<u>Squid</u>

In the BSAI, squid catch is predicted to be cut to one third of the current level over the five projection years, likely following trends in the pollock fishery. Squid catch is predicted to remain at or below the currently low levels over the five-year projection period in the GOA, likely reflecting stable catches in the pollock fishery.

<u>Sculpin</u>

Catches of BSAI sculpins are predicted to be cut in half relative to current catches. GOA sculpin catch is predicted to decrease by 200 mt relative to current levels.

<u>Shark</u>

BSAI shark species have been separated into Pacific sleeper shark, salmon shark, dogfish, and other shark. Catches of all of these species are predicted to remain relatively low and stable throughout the projection period. It is somewhat surprising that catch of Pacific sleeper shark is predicted to increase slightly under FMP 4.1, reversing the trend of nearly every other group under this alternative. As in the BSAI, shark catches are partitioned into Pacific sleeper shark, salmon shark, dogfish, and other shark in the GOA. While all shark catch in the GOA is predicted to be relatively low, catches of other shark are predicted to remain stable and catches of Pacific sleeper shark, salmon shark, and dogfish are predicted to decrease relative to current levels.

<u>Skate</u>

Catches of skate are predicted to decrease relative to current levels. Adoption of Amendment 63 by NPFMC would result in the separation of GOA skate species from the other species complex. In turn, they would be added to the Target Species category with an ABC and TAC set for skates and skate complexes (NPFMC 2003a). The NPFMC has requested a separate OFL and ABC for combined big and longnose skates in the central GOA due to concerns regarding a developing fishery. Efforts to address existing data gaps for skate species are underway and improved collection of data is expected under this amendment.

Octopi

Octopus catch in the BSAI is predicted to remain stable at 300 to 400 mt per year. The trace amounts of octopus catch reported in the GOA are predicted to decrease slightly over the projection period, with no discernable differences in the currently unknown population impacts.

Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with Alternative 4, FMP 4.1 is shown in Table 4.5-43. For further information on persistent past effects included in this analysis, see Section 3.5.3 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA other species is unknown under Alternative 4, FMP 4.1. The current baseline condition is unknown since species-specific catch information is deficient for this complex because species identification does not occur in the fisheries.

- **Persistent Past Effects.** Under current other species management in the BSAI and GOA, a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and non-specified species. It is difficult to determine how much protection is afforded by a TAC set with the use of data-poor criteria.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to the specific species within this complex are unknown, since the current baseline condition has not been determined. Long-term climate change and regime shifts are not expected to result in direct mortality.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries, and potential impacts of mortality on this species complex as a whole are unknown. The combined effects of mortality on other species resulting from internal catch and reasonably foreseeable future external events both human controlled and natural are unknown.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of changes in reproductive success on BSAI and GOA other species are unknown under Alternative 4, FMP 4.1. The current baseline condition is unknown, and species-specific reproductive status has not been determined.

- **Persistent Past Effects.** Current reproductive status of the other species complex is unknown. It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and non-specified species. This possible overexploitation could have impacts to reproductive success if sex-ratios of these species are significantly altered or if sex-specific aggregations are overfished. However, persistent past effects on the population have not been determined.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to reproductive success of the specific species within this complex are unknown, since current baseline condition and species-specific reproductive status have not been determined. Long-term climate change and regime shifts could have impacts to the reproductive success of the other species depending on the direction of the shift. It has been shown in other aquatic species that warm climatic trends favor recruitment while cool climatic trends weaken recruitment, but it is currently undetermined how the other species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Current reproductive status of species within this complex are unknown and persistent past effects have not been identified. The combined effects of changes to reproductive success on other species resulting from internal catch and reasonably foreseeable future external events both human controlled and natural are unknown.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of changes in genetic structure of the other species population in BSAI and GOA are unknown, under Alternative 4, FMP 4.1. The current baseline condition is unknown, and genetic structure of species-specific populations within this complex have not been determined.

- **Persistent Past Effects.** The current genetic composition of the other species complex is unknown. It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and non-specified species. This possible overexploitation could impact the genetic structure of the population if genetic composition within these species groups has been significantly altered. It is unclear if persistent past effects on the populations exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, their potential impacts to genetic structure of the specific species' populations within this complex are unknown. Long-term climate change and regime shifts are not expected to result in direct mortality and would not be considered contributing effects to changes in genetic structure of populations.

- **Cumulative Effects.** For all members of the other species complex, life history, and distribution information are minimal in both the BSAI and the GOA. Current genetic structure of species-specific populations within this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to genetic structure of populations within the other species complex resulting from internal catch and reasonably foreseeable future external events both human controlled and natural are unknown.

Change in Biomass

- **Direct/Indirect Effects.** The potential effect of change in biomass on BSAI and GOA other species is unknown under Alternative 4, FMP 4.1. The current baseline condition is unknown, and species-specific catch information is lacking for this complex since species identification does not occur in the fisheries. Formal stock assessments are not conducted for other species, and most biomass estimates for BSAI and GOA other species are unreliable or unknown.

- **Persistent Past Effects.** It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and Non-specified Species. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown.

- **Reasonably Foreseeable Future External Effects**. In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to specific species within this complex are unknown since current baseline condition has not been determined. Long-term climate change and regime shifts could have impacts on the biomass of the other species depending on the direction of the shift. It has been shown in other aquatic species that warm regimes favor recruitment while cool regimes weaken recruitment, but it is currently not known how the other species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries, and potential impacts of changes in biomass on this species complex as a whole are unknown. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown. The combined effects of these changes on other species resulting from internal catch and reasonably foreseeable future external events both human controlled and natural are unknown.

Change in Habitat

- **Direct/Indirect Effects.** The potential effects of habitat changes to BSAI and GOA other species are unknown under Alternative 4, FMP 4.1. A current baseline condition has not been determined.

- **Persistent Past Effects.** Under current management in the BSAI and GOA, impacts to habitat could be occurring for some of the species within the other species complex. However, the species included in this complex have diverse habitat preferences and distribution patterns. Persistent past effects potentially impacting habitat for some or all of these species could exist, but without a baseline condition established, those effects remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to habitat of the specific species within this complex are unknown. Long-term climate change and regime shifts are not expected to result in significant change to physical habitat and are not considered contributing factors to potential effects.

- **Cumulative Effects.** For all members of the other species complex, life history, and distribution information are minimal in both the BSAI and the GOA. These species have diverse habitat preferences and persistent past effects potentially impacting habitat could exist, but without a baseline condition established, those effects remain unknown. The combined effects of changes to habitat on other species resulting from internal catch and reasonably foreseeable future external events both human controlled and natural are unknown.

Direct/Indirect Effects FMP 4.2 – Other Species

Direct and indirect effects for other species include mortality along with changes in reproductive success, genetic structure of population, and habitat. The significance of these effects caused by changes in catch for any of these non-target species groups are unknown, because information on stock status is lacking in order to determine how these stocks respond to changes in catch.

Federal groundfish catch of all groups within the other species category in both the BSAI and GOA are reduced to zero under FMP 4.2. While this eliminates all effects of federal fishing on all species in this group, we still cannot determine what impact this has on populations within the other species category since so little is known about the effects of fishing on these populations.

Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with Alternative 4, FMP 4.2 is shown in Table 4.5-43. For further information on persistent past effects included in this analysis, see Section 3.5.3 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of eliminating federal fishing mortality on BSAI and GOA other species is unknown under Alternative 4, FMP 4.2. The current baseline condition is unknown, and species-specific catch information is lacking for this complex since species identification does not occur in the fisheries.

- **Persistent Past Effects.** It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and Non-specified Species. It is difficult to determine how much protection is afforded by a TAC set with the use of data-poor criteria.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to the specific species within this complex are unknown since current baseline conditions has not been determined. Long-term climate change and regime shifts are not expected to result in direct mortality.

- **Cumulative Effects.** For all members of the other species complex, life history, and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of mortality on this species complex as a whole are unknown. The combined effects of mortality on other Species resulting from internal catch and reasonably foreseeable future external events both human controlled and natural are unknown.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of changes in reproductive success on BSAI and GOA other species are unknown under Alternative 4, FMP 4.2. The current baseline condition is unknown, and species-specific reproductive status has not been determined.

- **Persistent Past Effects.** Current reproductive status of the other species complex is unknown. It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and non-specified species. This possible overexploitation could have impacts to reproductive success if sex-ratios of these species are significantly altered or if sex-specific aggregations are overfished. However, persistent past effects on the population have not been determined.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to reproductive success of the specific species within this complex are unknown, since current baseline condition and species-specific reproductive status have not been determined. Long-term climate change and regime shifts could have impacts to the reproductive success of the other species depending on the direction of the shift. It has been shown in other aquatic species that warm regimes favor recruitment while cool regimes weaken recruitment, but it is currently unknown how the other species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the other species complex, life history, and distribution information are minimal in both the BSAI and the GOA. Current reproductive status of species with this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to reproductive success on other species resulting from elimination of internal catch and occurrence of reasonably foreseeable future external events both human controlled and natural are unknown.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of changes in genetic structure of the other species population in BSAI and GOA are unknown under Alternative 4, FMP 4.2. The current baseline condition is unknown, and genetic structure of species-specific populations within this complex have not been determined.

- **Persistent Past Effects.** The current genetic composition of the other species complex is unknown. It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and non-specified species. This possible overexploitation could have impact on the genetic structure of the population if genetic composition within these species groups has been significantly altered. It is unclear if persistent past effects on the populations exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, their potential impacts to genetic structure of the specific species' populations within this complex are unknown. Long-term climate change and regime shifts are not expected to result in direct mortality and would not be considered contributing effects to changes in genetic structure of populations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Current genetic structure of species-specific populations within this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to genetic structure of populations within the other species complex resulting from elimination of internal catch and occurrence of reasonably foreseeable future external events both human controlled and natural are unknown.

Change in Biomass

- **Direct/Indirect Effects.** The potential effect of eliminating federal fishing on change in biomass in BSAI and GOA other species is unknown under Alternative 4, FMP 4.2. The current baseline condition is unknown, and species-specific catch information is lacking for this complex since species identification does not occur in the fisheries. Formal stock assessments are not conducted for Other species, and most biomass estimates for BSAI and GOA other species are unreliable or not known.

- **Persistent Past Effects.** It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and Non-specified Species. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continues to take other species as bycatch. However, potential impacts to specific species within this complex are unknown, since the current baseline condition has not been determined. Long-term climate change and regime shifts could have impacts on the biomass of the other species depending on the direction of the shift. It has been shown in other aquatic species that warm regimes favor recruitment while cool regimes weaken recruitment, but it is currently not known how the other species will respond to climatic fluctuations

- **Cumulative Effects.** For all members of the other species complex, life history, and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of changes in biomass on this species complex as a whole are unknown. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown. The combined effects of these changes on other species resulting from elimination of internal catch and occurrence of reasonably foreseeable future external events both human controlled and natural are unknown.

Change in Habitat

- **Direct/Indirect Effects.** The potential effects of habitat changes to BSAI and GOA other species are unknown under Alternative 4, FMP 4.2. A current baseline condition has not been determined.

- **Persistent Past Effects.** Under current management in the BSAI and GOA, impacts to habitat could be occurring for some of the species within the other species complex. However, the species included in this complex have diverse habitat preferences and distribution patterns. Although persistent past effects potentially impacting habitat for some or all of these species could exist, without a baseline condition established, those effects remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to habitat of the specific species within this complex are unknown. Long-term climate change and regime shifts are not expected to result in significant change to physical habitat and are not considered contributing factors to potential effects.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. These species have diverse habitat preferences. Although persistent past effects potentially impacting habitat could exist, without a baseline condition established, they remain unknown. The combined effects of changes to habitat on other species resulting from elimination of internal catch and occurrence of reasonably foreseeable future external events both human controlled and natural are unknown.

4.8.4 Forage Fish Alternative 4 Analysis

The BSAI and GOA FMPs were amended in 1998 to establish a forage species category to prevent the development of directed fisheries on these ecologically important non-target species. Forage fish are described in more detail under Section 3.5.4.

Direct/Indirect Effects of FMP 4.1 – BSAI and GOA Forage Fish

Total and Spawning Biomass

Total and spawning biomass of BSAI and GOA forage fish is unknown at this time. The level of forage fish bycatch under FMP 4.1 is not expected to affect biomass because the level of incidental catch is already low.

Catch/Fishing Mortality

A directed fishery on forage species is prohibited by Amendments 36 and 39 in the BSAI and GOA FMP. However, forage fish are taken in small amounts as incidental catch in several target fisheries. The bulk (>90 percent most years) of the forage fish bycatch is made up of smelt species (Osmeridae) from the pollock fishery. In the BSAI region, model projections for FMP 4.1 indicate incidental catch of forage fish would drop sharply (Table H.4-22 in Appendix H). Over the next five years the incidental catch of forage fish in the GOA is projected to remain at similar levels to the baseline under FMP 4.1 (Table H.4-41 in Appendix H).

Fishing mortality of BSAI and GOA forage fish is unknown at this time. As described above, forage fish bycatch and hence fishing mortality, in the BSAI would drop under FMP 4.1. In the GOA the fishing mortality is predicted to continue at current levels.

Spatial/Temporal Concentration of Fishing Mortality

Little is known about the current spatial or temporal concentration of fishing mortality for forage species. It is unknown how the spatial or temporal concentration of fishing effort is expected to change under FMP 4.1.

Status Determination

The MSST of forage fish species is unknown at this time, but it is highly unlikely that management practices under FMP 4.1 would lead to stocks dropping below a sustainable level.

Age and Size Composition and Sex Ratio

The age and size composition of the species in the forage fish group is unknown. However, it is assumed that the age and size composition of forage fish would not change under FMP 4.1. The sex ratio of forage fish is assumed to be 50:50. There is no information available that would suggest this would change under FMP 4.1.

Habitat-Mediated Impacts

Little is known about the relationship between forage fish and their habitat. It is unknown how any of the considered FMPs would change the suitability of the habitat occupied by forage fish.

Predation-Mediated Impacts

The predator-prey interactions of forage fish are very complex and difficult to quantify. With the given data it would be extremely difficult to accurately assess the predator-prey impacts of FMP 4.1.

Cumulative Effects Analysis of FMP 4.1 – BSAI and GOA Forage Fish

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI and GOA forage fish is rated as insignificant under FMP 4.1.

- **Persistent Past Effects** have not been identified for fishing mortality in the BSAI and GOA forage fish stock.

- **Reasonably Foreseeable Future External Effects.** Possible impacts on mortality are indicated due to potential adverse contributions of marine pollution, since acute and/or chronic pollution events could cause forage fish mortality. Climate changes and regime shifts are considered non-contributing factors, since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of forage fish (see Sections 3.5.4 and 3.10). Alaska subsistence and personal use fisheries are identified as potential adverse contributors to forage fish mortality; however, the removal of these species is expected to be minimal.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI and GOA forage fish and is rated as insignificant. Removals at projected levels are small and not expected to have a population level impact. The combined effect of internal and external removals is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** The total and spawning biomass for BSAI and GOA forage fish is unknown at this time.

- **Persistent Past Effects** have not been identified for the change in biomass in the BSAI and GOA forage fish stock.

- **Reasonably Foreseeable Future External Effects.** Changes in biomass are indicated due to the potential adverse contributions of marine pollution, since acute and/or chronic pollution events could cause forage fish mortality. Climate changes and regime shifts have been identified as having potential beneficial or adverse contributions on the forage fish biomass level. A strong Aleutian Low and increased water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts see Sections 3.5.4 and 3.10. The Alaska subsistence and personal use fisheries have been identified as a potential adverse contributor to the change in biomass level of BSAI and GOA forage fish. Subsistence and personal use fisheries concentrate mostly on the smelt species, and it is unlikely that these fisheries would have a population level effect.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI and GOA forage fish, but the effect is unknown. Total and spawning biomass are unavailable for the forage fish species at this time.

Spatial/Temporal Concentration of Catch

- **Direct/Indirect Effects.** Under FMP 4.1, the effect of the spatial/temporal concentration of catch is unknown.

- **Persistent Past Effects.** The genetic structure of the BSAI and GOA forage fish are not identified. Climate changes and regime shifts are identified as influencing the reproductive success of BSAI and GOA forage fish. For example, some Osmeridae species have shown a decline in recruitment since the late 1970s coinciding with the increase water temperature.

- **Reasonably Foreseeable Future External Effects.** The reproductive success of forage fish due to climate changes and regime shifts are potentially beneficial or adverse. Marine pollution has been identified as a potential adverse contribution, since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI and GOA forage fish. The Alaska subsistence and personal use fisheries are identified as having potential adverse contributors to the genetic structure and reproductive success of BSAI and GOA forage species. As stated above, these fisheries mainly target smelt species. It is unlikely the removals in these fisheries would be large enough and taken in a localized manner such that it would jeopardize the capacity of the stocks to maintain current population levels.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the forage fish catch; however, this effect is unknown. Information on the spatial/temporal concentration of the BSAI and GOA forage fish bycatch is currently insufficient.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.1, the change in prey availability for the BSAI and GOA forage fish is unknown.

- **Persistent Past Effects** are identified for the change in prey availability of the BSAI and GOA forage fish stock and include climate changes and regime shifts. Crab and shrimp have shown variation in abundance associated with changes in climate and water temperatures. However, studies on most benthic invertebrates have not been conducted (see Sections 3.5.4 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** The climate changes and regime shifts on the BSAI and GOA forage fish stock are potential beneficial or adverse. Marine pollution has been identified as a potential adverse contribution, since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels. Alaska subsistence and personal use fisheries are identified as potential adverse contributors to the prey availability of BSAI and GOA forage fish. However, the catch/bycatch of these species is expected to be minimal and unlikely to have a population level impact.

- **Cumulative Effects.** A cumulative effect is identified for the change in prey availability; however, this effect is unknown. Information on forage fish prey interactions is insufficient.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.1, the change in habitat suitability for the BSAI and GOA forage fish is unknown.

- **Persistent Past Effects** identified for BSAI and GOA forage fish include climate changes and regime shifts. For more information, see Sections 3.5.4 and 3.10.

- **Reasonably Foreseeable Future External Effects.** The climate changes and regime shifts on the BSAI and GOA forage fish stock are potential beneficial or adverse. Marine pollution has been identified as a potential adverse contribution since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Alaska subsistence and personal use fisheries are identified as potential adverse contributors to forage fish habitat suitability. For more information on the effects of fishery gear on essential fish habitat see Section 3.6.

- **Cumulative Effects.** A cumulative effect is identified for BSAI and GOA forage fish habitat suitability; however, this effect is unknown. Information of forage fish habitat and the distribution of the fisheries on these habitats is insufficient at this time.

Direct/Indirect Effects of FMP 4.2 – BSAI and GOA Forage Fish

Total and Spawning Biomass

Total and spawning biomass of BSAI and GOA forage fish is unknown at this time. Due to complex ecosystem interactions the effect of FMP 4.2 on the biomass of forage fish is difficult to predict.

Catch/Fishing Mortality

Under FMP 4.2, no fishing would be allowed unless it could be proven that the fishery did not have an adverse effect on the environment. With the cessation of all fishing, there would be no bycatch of forage species. Until a fishery that takes forage fish as bycatch was allowed to open, there would be no fishing mortality for forage fish under FMP 4.2.

Spatial/Temporal Concentration of Fishing Mortality

As stated above, there would be no fishing mortality under FMP 4.2.

Status Determination

Assuming no fishing pressure, it would be highly unlikely that forage fish species would drop below a hypothetical MSST.

Age and Size Composition

The age and size composition of the species in the forage fish group is unknown. The age and size composition of forage fish would most likely not change under FMP 4.2.

Sex Ratio

The sex ratio of forage fish is assumed to be 50:50. There is no information available that would suggest this would change under FMP 4.2.

Habitat-Mediated Impacts

Little is known about the relationship between forage fish and their habitat. It is unknown how any of the considered FMPs would change the suitability of the habitat occupied by forage fish.

Predation-Mediated Impacts

The predator-prey interactions of forage fish are very complex and difficult to predict. With the given data it would be extremely difficult to accurately assess the predator-prey impacts of FMP 4.2.

Cumulative Effects Analysis of FMP 4.2 – BSAI and GOA Forage Fish

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI and GOA forage fish is rated as insignificant under FMP 4.2.

- **Persistent Past Effects** have not been identified for fishing mortality in the BSAI or GOA forage fish stock.

- **Reasonably Foreseeable Future External Effects** on mortality the same as those indicated under FMP 4.1.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI and GOA forage fish and is rated as insignificant. The effect of external removals is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** The total and spawning biomass for BSAI and GOA forage fish is unknown at this time.

- **Persistent Past Effects** have not been identified for the change in biomass in the BSAI or GOA forage fish stock.

- **Reasonably Foreseeable Future External Effects** on the change in biomass are the same as those described under FMP 4.1.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI and GOA forage fish, but the effect is unknown. Total and spawning biomass are unavailable for the forage fish species at this time.

Spatial/Temporal Concentration of Catch

- **Direct/Indirect Effects.** Under FMP 4.2, the effect of the spatial/temporal concentration of catch is unknown.

- **Persistent Past Effects** identified for the change in genetic structure and reproductive success of the BSAI and GOA forage fish are the same as those indicated under FMP 4.1.

- **Reasonably Foreseeable Future External Effects** identified for the change in genetic structure and reproductive success of the BSAI and GOA forage fish are the same as those indicated under FMP 4.1.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the forage fish catch; however, this effect is unknown. Information on the spatial/temporal concentration of the BSAI and GOA forage fish bycatch is currently insufficient.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 4.2, the change in prey availability for the BSAI and GOA forage fish is unknown.

- **Persistent Past Effects** identified for the change in prey availability are the same as those indicated under FMP 4.1.

- **Reasonably Foreseeable Future External Effects** identified for the change in prey availability are the same as those indicated under FMP 4.1.

- **Cumulative Effects.** A cumulative effect is possible for change in prey availability; however, this effect is unknown. Information on forage fish prey interactions is insufficient.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 4.2, the change in habitat suitability for the BSAI and GOA forage fish is unknown.

- **Persistent Past Effects** identified for the change in habitat suitability are the same as those described under FMP 4.1.

- **Reasonably Foreseeable Future External Effects** identified for the change in habitat suitability are the same as those described under FMP 4.1.

- **Cumulative Effects.** A cumulative effect is possible for BSAI and GOA forage fish habitat suitability; however, this effect is unknown. Information of forage fish habitat and the distribution of the fisheries on these habitats is insufficient at this time.

4.8.5 Non-Specified Species Alternative 4 Analysis

Grenadiers have been chosen to illustrate potential effects to non-specified species because they are currently the major catch in the non-specified FMP category. Non-specified species refers to a huge and diverse category encompassing every species not listed in the current FMP as a target, prohibited, forage, or other species. Considering a single species group from this category, such as grenadier, does not represent the diverse effects to all species in the category. However, because information is lacking for nearly all of these groups, and they are caught in small or unknown amounts (due to a lack of reporting requirements in this category), only potential effects to grenadier are discussed.

Formal stock assessments are not conducted for grenadiers. Thus, changes in total biomass, reproductive success, genetic structure of population, habitat, or mortality rates under any FMP alternative cannot be determined due to lack of a baseline condition. Changes in bycatch of grenadiers were predicted based on modeled changes in target species catches and population trajectories. Sablefish target fisheries have the most grenadier bycatch. While changes in bycatch relative to the comparative baseline are reported here, it is important to emphasize that determinations cannot be made as to how these changes in catch actually impact grenadier populations or whether these impacts might be adverse, beneficial, or neutral.

Direct/Indirect Effects FMP 4.1 – BSAI and GOA Non-Specified Species

Direct and indirect effects for grenadier include mortality along with changes in reproductive success, genetic structure of population, and habitat. The significance of these effects caused by changes in catch for any of these non-target species groups are unknown because information on stock status is lacking with regard to how these stocks respond to changes in catch. For many non-target species, the differences in catch between the comparative baseline and FMP 4.1 are relatively small, such that diverse alternatives may have similar unknown effects on each stock.

The following component of FMP 4.1 was not implemented in the projection model used to generate these results: "For species managed as members of a stock complex, rather than setting TAC as the aggregate of the individual members' ABCs, the max ABC value for each component stock would be determined and the TAC set equal to the lowest value." If this component of FMP 4.1 were implemented along with all of the other management measures in this FMP, it is likely that catches of grenadiers would be considerably lower than those reported here. Setting the TAC of all complexes to the lowest single species ABC would result in very low TACs for all rockfish and flatfish complexes as well as the other species complex, which would be quite constraining to target fisheries that encounter any members of the species complex. Therefore, the catch estimates reported here are considered maximum amounts likely to be taken under this alternative if it were fully implemented.

Under FMP 4.1, catch of grenadiers in both the BSAI is predicted to remain within the currently observed range. In the GOA, grenadier catch is predicted to decrease slightly to just under 8,000 mt per year.

Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with Alternative 4, FMP 4.1 is shown in Table 4.5-46. For further information on persistent past effects included in this analysis, see Section 3.5.5 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA grenadier is unknown under FMP 4.1. The current baseline condition is unknown. Catch information is lacking for all members of the non-specified category, since species identification does not occur in the fisheries.

- **Persistent Past Effects.** No management or monitoring of any species in this category exists, and retention of any non-specified species is permitted. No reporting requirements for non-specified species exist, and there are no catch limitations or stock assessments. It is possible that grenadier, and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited as stock status remains unknown. Grenadier continue to constitute the largest portion on the non-target species bycatch in the GOA, and mortality is considered a persistent past effect.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, the state-managed commercial fisheries and IPHC halibut longline fishery continue to take grenadier and other non-specified species as bycatch. However, potential impacts to specific species within this complex are unknown, since the current baseline condition has not been determined. Long-term climate change and regime shifts are not considered contributing factors as they are not expected to result in direct mortality.

- **Cumulative Effects.** For grenadiers and other species within the non-specified complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of mortality on this species complex as a whole are unknown. The combined effects of mortality on grenadiers, and other species with the non-specified complex, resulting from internal catch and reasonably foreseeable future external events both human controlled and natural are unknown for FMP 4.1.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of changes in reproductive success on BSAI and GOA grenadier, and presumably all other species within the non-specified complex, are unknown under FMP 4.1. The current baseline condition is unknown, and species-specific reproductive status has not been determined.

- **Persistent Past Effects.** Current reproductive status of grenadier is unknown. It is possible that grenadier, and all other species included in the non-specified category, in the BSAI and GOA, could be disproportionately exploited; however, stock status remains unknown. This possible over exploitation could have impacts to reproductive success if sex ratios of these species are significantly altered or if sex-specific aggregations are overfished. This overfishing could lead to reduced recruitment. It is unknown if persistent past effects on the population exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries specifically sablefish and Greenland turbot longline, and IPHC halibut longline fishery continue to take grenadier and other non-specified species as bycatch. However, potential impacts to reproductive success of the specific species within this complex are unknown, since current baseline condition and species-specific reproductive status have not been determined. Long-term climate change and regime shifts could have impacts on the reproductive success of grenadiers and other non-specified species depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how grenadiers, and all other members of the non-specified category, will respond to climatic fluctuations.

- **Cumulative Effects.** For grenadiers and all other species within the non-specified category, life history and distribution information are minimal in both the BSAI and the GOA. Current reproductive status of species within this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to reproductive success on grenadiers and other non-specified species resulting from internal catch and reasonably foreseeable future external events both human controlled and natural are unknown for FMP 4.1.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of changes in genetic structure of grenadier and other species within the non-specified complex, populations in BSAI and GOA are unknown under FMP 4.1. The current baseline condition is unknown and genetic structure of species-specific populations within this complex have not been determined.

- **Persistent Past Effects.** The current genetic composition of the non-specified species complex is unknown. It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited; however, stock status remains unknown. This possible overexploitation could have impacts on the genetic structure of the population if genetic composition within these species groups have been significantly altered. It is unclear if persistent past effects on the populations exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries specifically sablefish and Greenland turbot longline, and IPHC halibut longline fishery continue to take grenadier and other non-specified species as bycatch. However, their potential impacts to genetic structure of the specific species populations within this complex are unknown. Long-term climate change and regime shifts are not expected to result in direct mortality and would not be considered contributing factors in changes to genetic structure of populations.

- **Cumulative Effects.** For grenadiers and all members of the non-specified species category, life history and distribution information are minimal in both the BSAI and the GOA. Current genetic structure of species-specific populations within this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to genetic structure of populations within the non-specified species complex resulting from internal catch and reasonably foreseeable future external events both human controlled and natural are unknown for FMP 4.1.

Change in Biomass

- **Direct/Indirect Effects.** The potential effect of change in biomass on BSAI and GOA grenadiers is unknown under FMP 4.1. The current baseline condition is unknown for all members of the non-specified complex, and species-specific catch information is lacking, since species identification does not occur in the fisheries. Formal stock assessments are not conducted. Biomass estimates in the BSAI and GOA for grenadiers, other than those conducted since 1999 for the giant grenadier, are not known.

- **Persistent Past Effects.** It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA, could be disproportionately exploited; however, stock status remains unknown. The current non-management of grenadiers could mask declines in individual grenadier species and lead to overfishing of a given grenadier species. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries specifically sablefish and Greenland turbot longline, and IPHC halibut longline fishery continue to take grenadier and other non-specified species as bycatch. However, potential impacts to the specific species within this complex are unknown, since current baseline condition has not been determined. Long-term climate change and regime shifts could have impacts on the biomass of grenadiers, and all other members of the non-specified group, depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment, while cool trends weaken recruitment, but it is currently not known how these non-specified species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the non-specified species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries, and potential impacts of changes in biomass to grenadier and all other non-specified species are unknown. Although persistent past effects of changes to biomass could exist, without a baseline condition established, they remain unknown. The combined effects of these changes on BSAI and GOA grenadiers and all other species in the non-specified group, resulting from internal catch and reasonably foreseeable future external events both human controlled and natural are therefore unknown for FMP 4.1.

Direct/Indirect Effects FMP 4.2 – BSAI and GOA Non-Specified Species

Direct and indirect effects for grenadier include mortality along with changes in reproductive success, genetic structure of population, and habitat. The significance of these effects caused by changes in catch for any of these non-target species groups are unknown because information on stock status is lacking with regard to how these stocks respond to changes in catch. For many non-target species, the differences in catch between the comparative baseline and FMP 4.2 are relatively small, such that diverse alternatives may have similar unknown effects on each stock.

Federal groundfish fisheries catches of grenadiers and all groups within the non-specified species category in both the BSAI and GOA are reduced to zero under FMP 4.2. While this eliminates all effects of federal fishing on all species in this group, impacts on grenadiers or other populations within the non-specified species category cannot be determined, since little is known about the effects of fishing on these populations.

Cumulative Effects Analysis

A Summary of the cumulative effects analysis associated with Alternative 4, FMP 4.2 is shown in Table 4.5-46. For further information on persistent past effects included in this analysis, see Section 3.5.5 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of eliminating federal fishing mortality on BSAI and GOA grenadier is unknown under FMP 4.2. The current baseline condition is unknown, and catch information is lacking for all members of the non-specified category since species identification does not occur in the fisheries.

- **Persistent Past Effects.** No management or monitoring of any species in this category exists, and retention of any non-specified species is permitted. No reporting requirements for non-specified species exist, and there are no catch limitations or stock assessments. It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited, but stock status remains unknown. Grenadier continue to constitute the largest portion on the non-target species bycatch in the GOA, and mortality is considered a persistent past effect.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, the state-managed commercial fisheries and IPHC halibut longline fishery continue to take grenadier and other non-specified species as bycatch. However, potential impacts to specific species within this complex are unknown since current baseline condition has not been determined. Long-term climate change and regime shifts are not considered contributing factors, as they are not expected to result in direct mortality.

- **Cumulative Effects.** For grenadiers and other species within the non-specified complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of mortality on this species complex as a whole are unknown. The combined effects of mortality on grenadiers and other species with the non-specified complex, resulting from elimination of internal catch and occurrence of reasonably foreseeable future external events both human controlled and natural are unknown for FMP 4.2.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of changes in reproductive success on BSAI and GOA grenadier and presumably all other species within the non-specified complex are unknown under FMP 4.2. The current baseline condition is unknown, and species-specific reproductive status has not been determined.

- **Persistent Past Effects.** Current reproductive status of grenadier is unknown. It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited; however, stock status remains unknown. This possible overexploitation could have impacts to reproductive success if sex-ratios of these species are significantly altered or if sex-specific aggregations are overfished. This overfishing could lead to reduced recruitment. It is unknown if persistent past effects on the population exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries specifically sablefish and Greenland turbot longline, and IPHC halibut longline fishery continue to take grenadier and other non-specified species as bycatch. However, potential impacts to reproductive success of the specific species within this complex are unknown since current baseline condition and species-specific reproductive status have not been determined. Long-term climate change and regime shifts could have impacts to the reproductive success of grenadiers and other non-specified species depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how grenadiers, and all other members of the non-specified category, will respond to climatic fluctuations.

- **Cumulative Effects.** For grenadiers and all other species within the non-specified category, life history and distribution information are minimal in both the BSAI and the GOA. Current reproductive status of species with this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to reproductive success on grenadiers and other non-specified species resulting from elimination of internal catch and occurrence of reasonably foreseeable future external events both human controlled and natural are unknown for FMP 4.2.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of changes in genetic structure of grenadier, and other species within the non-specified complex populations in BSAI and GOA are unknown under FMP 4.2. The current baseline condition is unknown and genetic structure of species-specific populations within this complex have not been determined.

- **Persistent Past Effects.** The current genetic composition of the non-specified species complex is unknown. It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited; however, stock status remains unknown. This possible overexploitation could have impacts to the genetic structure of the population if genetic composition within these species groups have been significantly altered. It is unclear if persistent past effects on the populations exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries specifically sablefish and Greenland turbot longline, and IPHC halibut longline fishery continue to take grenadier and other non-specified species as bycatch. However, their potential impacts to genetic structure of the specific species' populations within this complex are unknown. Long-term climate change and regime shifts are not expected to result in direct mortality and would not be considered contributing factors in changes to genetic structure of populations.

- **Cumulative Effects.** For grenadiers and all members of the non-specified species category, life history and distribution information are minimal in both the BSAI and the GOA. Current genetic structure of species-specific populations within this complex are unknown and persistent past effects have not been identified. The combined effects of changes to genetic structure of populations within the non-specified species complex resulting from elimination of internal catch and occurrence of reasonably foreseeable future external events both human controlled and natural are unknown for FMP 4.2.

Change in Biomass

- **Direct/Indirect Effects.** The potential effect of change in biomass on BSAI and GOA grenadiers is unknown under FMP 4.2. The current baseline condition is unknown for all members of the non-specified complex, and species-specific catch information is lacking, since species identification does not occur in the fisheries. Formal stock assessments are not conducted. Biomass estimates in the BSAI and GOA for grenadiers, other than those conducted since 1999 for the giant grenadier, are not known.

- **Persistent Past Effects.** It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited; however, stock status remains unknown. The current non-management of grenadiers could mask declines in individual grenadier species and lead to overfishing of a given grenadier species. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries specifically sablefish and Greenland turbot longline, and IPHC halibut longline fishery continue to take grenadier and other non-specified species as bycatch. However, potential impacts to the specific species within this complex are unknown, since the current baseline condition has not been determined. Long-term climate change and regime shifts could have impacts on the biomass of grenadiers, and all other members of the non-specified group, depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how these non-specified species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the non-specified species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries, and potential impacts of changes in biomass to grenadier and all other non-specified species are unknown. Although persistent past effects of changes to biomass could exist, without a baseline condition established, they remain unknown. The combined effects of these changes on BSAI and GOA grenadiers and all other species in the non-specified group resulting from elimination of internal catch and occurrence of reasonably foreseeable future external events both human controlled and natural are unknown for FMP 4.2.

4.8.6 Habitat Alternative 4 Analysis

This policy represents an extremely precautionary approach to managing fisheries under scientific uncertainty. It shifts the burden of proof from demonstration of adverse impacts to prohibit or proscribe a fishery, to demonstration of no-adverse impact for authorization of a fishery. It would involve a strict interpretation of the precautionary principle. This policy assumes that fishing does produce adverse impacts on the environment. The initial restrictive and precautionary conservation and management measures would be modified or relaxed when additional, reliable scientific information becomes available.

Direct/Indirect Effects FMP 4.1 – Habitat

Alternative 4 represents a fundamental change in the management of the fisheries by presuming that the current groundfish fisheries are producing large-scale adverse effects on the marine ecosystem. Figure 4.2-6 illustrates the suite of year-round closures in the BSAI and GOA management areas. Under this FMP bookend, current levels of fishing are reduced and 20 to 50 percent of the management area would be designated as no-take marine reserves (i.e., no commercial fishing) within the 1,000-m bathymetric line. A special management area would be established in the Aleutian Islands to protect coral habitat. Trawling itself would be restricted to those fisheries that cannot be prosecuted with other gear types (i.e, the flatfish fisheries). Given these changes, management impacts to habitat are expected to be significantly reduced relative to baseline levels.

Direct and indirect effects of the FMP on habitat are discussed for changes to living habitat through direct mortality of benthic organisms and changes to benthic community structure through benthic community diversity and geographic diversity of impacts and protection. Due to their habitat type differences, the Bering Sea, Aleutian Islands, and GOA are rated and discussed separately.

Changes to Living Habitat – Direct Mortality of Benthic Organisms

- **Bering Sea**. Bottom trawling restrictions and major reductions in target species catches should reduce damage and mortality to living substrate. These restrictions should over-ride any shifts in fishing effort related to location of closure areas. For these reasons, the predicted impact of FMP 4.1 on mortality and damage to living habitat is significantly beneficial.

- **Aleutian Islands**. Bottom trawling restrictions and major reductions in target species catch should reduce damage and mortality to living substrate. For short-lived biota with fast recovery rates, recovery may occur quickly. For other species of living substrates such as long-lived corals and perhaps some sponges, increases over baseline levels may not occur or may occur after many years. For these reasons, the predicted impact of FMP 4.1 on mortality and damage to living habitat is significantly beneficial.

- **GOA**. Closures illustrated by FMP 4.1 encompass most of the heavily fished areas in the GOA suggesting areas with high target species density will be closed and catch may have to come from areas of less density. However, major reductions in target species catches that are a component of this FMP scenario should over-ride any negative impacts due to geographic shifts in fishing effort and should result in less overall impacts. For these reasons, the impact of FMP 4.1 on mortality and damage to living habitat is predicted to be significantly beneficial.

Changes to Benthic Community Structure – Benthic Community Diversity and Geographic Diversity of Impacts and Protection

- **Bering Sea**. Table 4.5-49 shows that of the Bering Sea fishable area, 33.5 percent is closed to bottom trawling under FMP 4.1. Figure 4.8-1 shows areas closed to trawling at various times of the year under this FMP, while Figure 4.8-2 depicts those areas closed to fixed gear. Figure 4.8-3 overlays the closures over fishing intensity and shows that closure boundaries along 56° 30'N latitude and 165°W longitude and 57° 30'N between 165° and 166°W longitude bisect two clusters of heavily fished habitat, providing a diversity of fishing impact for habitat in the vicinity of the boundary. Other large expanses of high fishing intensity are either untouched by any closure (along 56° 30'N from 165° to 167°W longitude and further north at about 57° 10'N, from 56° 50'N to 57° 30'N latitude and 165° to 166° 40'W longitude) or totally encompassed by the closure (the cod corridor, along the north side of the Alaska Peninsula), resulting in no diversity of impact for the habitat in those areas. Still, given the size and location of the closed areas, the predicted overall effects of FMP 4.1 on benthic community diversity and on geographic diversity of impacts are significantly beneficial to habitat.

- **Aleutian Islands**. Figures 4.8-1 and 4.8-2 show the closure areas under FMP 4.1 broken down by gear type, bottom trawl and fixed gear. No closure boundaries illustrated under FMP 4.1 appear to bisect any existing cluster of high fishing intensity. However, increased levels of reallocated effort will likely result in some large scale improvements as a result of the suite of closures (see Figure 4.8-3). As shown on Table 4.5-49, about 85 percent of the fishable area in the Aleutians is closed to bottom trawling at one time or another during the year under this FMP, with about 70 percent of these closures being year-round no-take protected areas. Sufficient area would be closed as no-take reserves, with very little fishable area left open. The redistributed effort could produce areas of high fishing intensity with contrasting closed area boundaries. This would result in an increase in the geographic diversity of impacts. Based on these observations, the change of FMP 4.1 on benthic community diversity and geographic diversity of impacts is predicted to be significantly beneficial relative to the baseline.

- **GOA.** As shown on Figures 4.8-1 and 4.8-2, closures illustrated by FMP 4.1 are well distributed among geographical habitat types. The closure areas are large compared to the GOA spatial habitat or bathymetric resolution, and thus tend to encompass much of a bathymetric feature. Table 4.5-49 shows that FMP 4.1 closes nearly 81 percent of the fishable area in the GOA to trawling at one time or another during the year. About 38 percent of the fishable area is designated as no-take marine reserves. However, Figure 4.8-4 shows that the closures encompass clusters of historically high fishing intensity, leaving little diversity or contrast of fishing intensity within a bathymetric feature or habitat type. Therefore, little to no improvement in geographic diversity of impact would result. An overall improvement to geographic diversity of impacts could have been realized with smaller closure areas strategically placed so as not to encompass entire habitat types or clusters of fishing intensity. For example, the 13 closure areas on the upper slope should include some portion of areas where high fishing intensity has occurred, but need not be as large as illustrated in this FMP 4.1 bookend. Increased levels of reallocated effort may provide some large scale contrasts in fishing intensity. Effectiveness and evaluation may be confounded due to variable distribution of habitat in the GOA. Based on these observations, the predicted effects of FMP 4.1 on benthic community diversity is significantly beneficial. However, the predicted effects of FMP 4.1 on geographic diversity of impacts are insignificant compared to the baseline.

Cumulative Effects FMP 4.1

Cumulative effects on habitat for FMP 4.1 are summarized on Table 4.5-50. The following discussion is broken down by geographic area.

Bering Sea

Changes to Living Habitat – Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects**. As described in earlier sections, this effect is predicted to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the Bering Sea. Mortality of long-lived species such as tree corals and other sessile epifauna is likely to be persistent in these areas. The areas historically and recently closed to fishing, described in Section 3.6, may have recovered or may be recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Offal discharge, port expansion and use, and marine pollution all have the potential to cause direct mortality of benthic organisms and changes to living habitat. Offal discharge can occur from offshore catcher processors and onshore processors. However, impacts which include mortality due to smothering and/or reduced oxygen are expected to be more prevalent in inshore, closed bay locations. Improvements in offal pre-treatment and discharge regulations in recent years have reduced impacts and potentially improved conditions. Port expansion and increased use are possible at several locations in the Bering Sea area, including Port Moller, Port Heiden, Dillingham, St. Paul and St. George. Again the impacts include mortality due to smothering, and/or burying and would only affect nearshore zones and bays. Marine pollution is identified as having a reasonably foreseeable potentially adverse contribution because if large enough in scale, acute and/or chronic pollution events could cause mortality to benthic organisms. Again, areas more likely to be impacted are nearer to shore. Natural events such as storm surges and waves have the potential to cause direct morality through burial. These effects, like the others, are expected in shallow waters where the wave energy is transmitted to the bottom without much attenuation through the water column. Climate changes and regime shifts are not expected to cause direct mortality of benthic organisms.

- **Cumulative Effects** are identified for mortality of Bering Sea benthic organisms, and the effect is judged to be conditionally significant adverse. While benefits accrue due to the extensive reductions in TAC and establishment of MPAs, the cumulative rating is conditionally adverse due to the fact that the baseline is already considered to be impacted, and additional impacts, both internal from the FMP and external as shown on the table, cannot be eliminated. Neither the location of future closures nor their designation as no-take reserves or as gear-specific/species specific MPAs is certain. Therefore, the cumulative effect of the FMP on mortality could be conditionally significant adverse.

  However, if the closures proposed under FMP 4.1 were to be further defined based on additional information regarding important habitats in need of protection, and were properly designed and located to protect the sensitive habitats, future closures could provide successful mitigation of the effects of fishing. Over time, valued habitat that has been adversely affected by fishing could recover. Therefore, under that condition, cumulative effects may have more of a conditionally significant beneficial rating rather than conditionally significant adverse.

Changes to Benthic Community Structure

- **Direct/Indirect Effects**. As described earlier in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the Bering Sea. Changes to benthic community structure, including a reduction in species diversity, have been observed in heavily fished areas of the world (see Section 3.6 for discussion and references). However, the areas historically and recently closed to fishing, described in Section 3.6, may be recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Offal discharge, port expansion and use, and marine pollution have the potential to cause changes to benthic communities. If long-term, as in the case of a change in a weather pattern, wind-induced waves and surges could also cause sufficient changes to the substrate such that the benthic community is impacted. As discussed above, all of these impacts are more likely to be observed in nearshore areas. Regime shifts, and large-scale environmental fluctuations associated with ENSO and La Niña events have been identified as having impacts on both the physical and biological systems in the North Pacific. These changes could have either beneficial or adverse effects on the benthic community (see Sections 3.6 and 3.10).

- **Cumulative Effects** are identified for changes in benthic community structure of the Bering Sea, and the effect is judged to be conditionally significant adverse. However, as described above for mortality, while the reduction in bottom trawling and major reductions in target species catches prescribed in the FMP could provide benefits to community structure (see previous discussion for mortality), the baseline is already considered to be impacted, and additional impacts both internal from the FMP and external, as shown on the table, cannot be eliminated.

  As described previously for mortality, if the closures proposed under FMP 4.1 were to be further defined based on additional information regarding important habitats in need of protection, cumulative effects may have a conditionally significant beneficial rating rather than conditionally significant adverse.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects**. As described previously in this section, the effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected because fishing effort and distribution has changed over time as areas have been closed and remain closed. Figures 3.6-6 and 3.6-7 illustrate the spatial measures that were in effect before 1980 or were later established by regulations following the publication of the Final Groundfish Programmatic SEIS in November of 1980. As discussed in Section 3.6, during the late 1970s and early 1980s, there was little domestic fishing for groundfish species. Most of the restricted areas were implemented to spatially and temporally restrict the foreign fishery to prevent conflicts with domestic fisheries through bycatch of species important to U.S. fishermen, or grounds preemption and gear conflicts. Most domestic fishing efforts focused on crab, salmon, and herring. Figures 3.6-6 and 3.6-7 illustrate that in 1980, there were more restrictions placed on foreign fixed gear fisheries than trawl fisheries. This was due to the need to give priority to the domestic fisheries that used similar gear and fishing grounds. Table 4.5-51 shows that in 1980 almost nine percent of the fishable area in the Bering Sea was closed to trawling, with 2.2 percent closed to all fishing. There were no longline-only closures in the Bering Sea at that time.

- **Reasonably Foreseeable Future External Effects** include port expansion and the potential resultant changes to offal discharge and marine pollution episodes. As ports in the Bering Sea are expanded and new ports are created, additional dock space for harboring the fishing fleet is made available. While the fleet might not necessarily expand, the opening of new ports may allow vessels of all sizes to access new or relatively unfished areas. On the other hand depending on distribution, fishing pressure in heavily fished areas may be eased as access to other areas becomes available. Of course, closed areas that are proposed to continue under this FMP would not be affected by the redistribution of home ports. Depending on the distribution of fishing effort, previously un-impacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects** are identified for changes in distribution of fishing effort, and the effect is judged conditionally significant adverse. The maps and statistics discussed above show that FMP 4.1 would protect more benthic habitat from trawl gear (34 percent) than was protected in 1980 (8.6 percent). Several closure areas under this FMP cover a portion of high fishing intensity, thereby providing improvement in the geographic diversity of impacts. However, fishing will still occur, and the baseline is considered to be already adversely impacted. Therefore, the combination of the past external effects, along with the continuation of fishing effort in areas potentially already impacted, leads to the conditionally adverse rating in the cumulative case. However, as described for mortality, better definition and focus of the closures could lead to a conditionally significant beneficial rating.

Aleutian Islands

<u>Changes to Living Habitat – Direct Mortality of Benthic Organisms</u>

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the Aleutian Islands. Prevalence of long-lived species of coral makes impacts a particular concern in the Aleutians. Mortality of long-lived species such as tree corals and other sessile epifauna is likely to be persistent in these areas. However, mobile epibenthic predators are not likely to exhibit lingering effects, since they can move into areas that are not fished (see Section 3.6). The areas historically and recently closed to fishing described in Section 3.6 may have recovered or may be recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Dredging, longline fisheries, pot fisheries, offal discharge, port expansion and use, and marine pollution have the potential to cause direct mortality of benthic organisms and changes to living habitat. Dredging due to scallop fisheries and/or navigation can occur in localized areas (often in conjunction with port development) and can cause burial or smothering of benthic fauna. Damage to living substrates by longline and pot fisheries (see Section 3.6) has been documented and is expected to continue in the heavily fished areas. Offal discharge can occur from offshore catcher processors and onshore processors. However, impacts including mortality due to smothering and/or reduced oxygen are expected to be more prevalent in inshore, protected bay locations. However, improvements in offal pre-treatment and discharge regulations in recent years have reduced impacts and have potentially improved conditions. Port expansion and increased use are possible at several locations in the Aleutian Islands including Atkutan, Adak, Unalaska, Cold Bay, Dutch Harbor, and King Cove. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution because large enough acute and/or chronic pollution events could cause mortality to benthic organisms. Again, areas more likely to be impacted are located nearer to shore. Natural events such as storm surges and waves have the potential to cause direct morality through burial. These effects, like the others, are expected in shallow waters where the wave energy is transmitted to the bottom without much attenuation through the water column. Climate changes and regime shifts are not expected to cause direct mortality of benthic organisms.

- **Cumulative Effects** are identified for mortality of Aleutian Islands benthic organisms, and the effect is judged to be conditionally significant adverse. As described above for the Bering Sea, the rating is conditionally significant adverse in the cumulative case because fishing is still occurring, and the baseline is considered to be adversely impacted. However, also as described for the Bering Sea, further definition and refinement of the closure areas may allow for a conditionally significant beneficial cumulative effects rating.

Changes to Benthic Community Structure

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the Aleutians. Changes to benthic community structure including a reduction in species diversity have been observed in heavily fished areas of the world (see Section 3.6 for discussion and references). However, the areas historically and recently closed to fishing described in Section 3.6 may have recovered or may be recovering with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Dredging, longline, and pot fisheries, offal discharge, port expansion and use, and marine pollution have the potential to cause changes to benthic communities. If long-term, as in the case of a change to a weather pattern, wind induced waves and surges could also cause sufficient changes to the substrate such that the benthic community is impacted. As discussed previously for mortality, all of these impacts are more likely to be observed in nearshore areas. Regime shifts and large-scale environmental fluctuations associated with ENSO and La Niña events have been identified as having impacts on both the physical and biological systems in the North Pacific (see Sections 3.6 and 3.10). These changes could have either beneficial or adverse effects on the benthic community.

- **Cumulative Effects** are identified for changes in benthic community structure of the Aleutians, but the effect is judged to be conditionally significant adverse. As described previously for morality, the baseline is considered to be adversely affected. It is not certain whether the closures under this FMP would be effective. Due to the fact that impacts are not eliminated, the cumulative effect is rated conditionally significant adverse.

  However, as described previously for mortality, if the closures proposed under FMP 4.1 were to be further defined and designed to protect important habitats, mitigation of fishing-related impacts could occur and cumulative effects may have more of a conditionally significant beneficial rating rather than conditionally significant adverse.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected because fishing effort and distribution has changed as areas have been closed and remain closed. As discussed previously for the Bering Sea, during the late 1970s and early 1980s, there was little domestic fishing for groundfish species. Most domestic fishing effort focused on crab, salmon, and herring. Figures 3.6-6 and 3.6-7 illustrate that in 1980, there were more restrictions placed on foreign fixed gear fisheries than trawl fisheries to give priority to the domestic fisheries that used similar gear and fishing grounds. Table 4.5-51 shows that in 1980 about 31 percent of the fishable area in the Aleutians was closed to trawling, with about six percent closed to all fishing. There were no longline-only closures in the Aleutian Islands at that time.

- **Reasonably Foreseeable Future External Effects** include other fisheries, port expansion, and the potential resultant changes to offal discharge and marine pollution episodes. Depending on changes in distribution of fishing effort, sensitive areas could either be further impacted or allowed to recover. As with the Bering Sea, ports in the Aleutians will be expanded and new ports created, and additional dock space for harboring the fishing fleet will be made available. While the fleet might not necessarily expand, the distribution of fishing effort is likely to change and previously un-impacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects** are identified for changes in distribution of fishing effort, and the effect is judged conditionally significant adverse. The maps and statistics discussed previously show that FMP 4.1 would protect more benthic habitat from trawl gear (85 percent) than was protected in 1980 (31 percent). Sufficient area would be closed as no-take reserves (70 percent of fishable area).The redistributed effort would result in an increase in the geographic diversity of impacts. Since the baseline is considered to be adversely impacted and the impacts are not eliminated in either external or internal fisheries, the cumulative effect is rated as conditionally significant adverse. However, as described for the Bering Sea, further definition and refinement of the closure areas may allow for a conditionally significant beneficial cumulative effects rating.

GOA

Changes to Living Habitat –Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the GOA. Mortality of long-lived species such as tree corals and other sessile epifauna is likely to be persistent in these areas. However, mobile epibenthic predators are not likely to exhibit lingering effects because they can move into areas that are not fished (see Section 3.6). The areas historically and recently closed to fishing described in Section 3.6 may be recovered or may be recovering with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects**. As described for the Bering Sea and Aleutian Islands, dredging, longline fisheries, pot fisheries, offal discharge, port expansion and use, marine pollution, and natural events have the potential to cause direct mortality of benthic organisms and changes to living habitat. Port expansion and increased use are possible at several locations in the GOA including Kodiak, Sand Point, Chignik, Port Lions, Ouzinkie, Valdez, and Seward. The impacts include mortality due to smothering and/or burying and would likely only affect nearshore zones and bays. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution because large enough acute and/or chronic pollution events could cause mortality to benthic organisms. Natural events such as storm surges and waves have the potential to cause direct morality through burial. These effects, like the others, would be expected in shallow waters where the wave energy is transmitted to the bottom without much attenuation through the water column. Climate changes and regime shifts are not expected to cause direct mortality of benthic organism.

- **Cumulative Effects** are identified for mortality of GOA benthic organisms, but the effect is judged to be conditionally significant adverse. While reductions in bottom trawling and major reductions in target species catches are prescribed in the FMP, the baseline is considered to be impacted and additional impacts, both external and internal are not eliminated. However, as described for the Bering Sea and Aleutian Islands, further definition and refinement of the closure areas may allow for a conditionally significant beneficial cumulative effects rating.

Changes to Benthic Community Structure

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the GOA. Changes to benthic community structure including a reduction in species diversity have been observed in heavily fished areas of the world (see Section 3.6 for discussion and references). However, the areas historically and recently closed to fishing described in Section 3.6 may be recovered or may be recovering with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects**. As described for the other regions, dredging, longline and pot fisheries, offal discharge, port expansion and use, marine pollution, and natural events have the potential to cause changes to benthic communities. These changes could have either beneficial or adverse effects on the benthic community.

- **Cumulative Effects** are identified for changes in benthic community structure of the GOA, and the effect is judged to be conditionally significant adverse. As described previously for mortality, while reductions in bottom trawling and major reductions in target species catches are prescribed in the FMP, the baseline is considered to be impacted and both external and internal additional impacts are not eliminated. However, as described previously further definition and refinement of the closure areas may allow for a conditionally significant beneficial cumulative effects rating.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a an insignificant change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected because fishing effort and distribution has changed over time as areas have been closed and remain closed. As discussed for the other regions, during the late 1970s and early 1980s, there was little domestic fishing for groundfish species. Most domestic fishing effort focused on crab, salmon, and herring, and there were more restrictions placed on foreign fixed gear fisheries than trawl fisheries. Figures 3.6-6 and 3.6-7 and Table 4.5-51 show that in 1980 about five percent of the fishable area in the GOA was closed to trawling, with about seven percent closed to all fishing. The largest closures in the GOA concerned longline fishing where almost 61 percent of the fishable area was closed to longlining. Therefore, in 1980 about 73 percent of the fishable area in the GOA was closed to fishing of one type or another at some time.

- **Reasonably Foreseeable Future External Effects** include other fisheries, port expansion and the potential resultant changes to offal discharge and marine pollution episodes. Depending on changes in distribution of fishing effort, sensitive areas could either be additionally impacted or allowed to recover. As ports in the GOA are expanded and new ports created, additional dock space for harboring the fishing fleet will be made available, and changes in the distribution of fishing effort could result. Depending on the distribution of fishing effort, previously un-impacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects** are identified for changes in distribution of fishing effort, but the effect is judged conditionally significant adverse. The maps and statistics discussed above show that FMP

4.1 would protect much more benthic habitat from trawl gear (81 percent) than was protected in 1980 (16 percent). However, the closures encompass clusters of historically high fishing intensity, leaving little diversity or contrast of fishing intensity within a bathymetric feature or habitat type. Therefore, little to no improvement in geographic diversity of impact would result. Also, in 1980 more benthic habitat was protected from fixed gear (over 60 percent of the fishable area) than would be protected under FMP 4.1 (38 percent of the fishable area in the GOA). While fixed gear impacts are believed to cause less of an impact on benthic communities, research has shown that considerable bycatch of coral and other large benthic structures occur with this gear type. Therefore, because the baseline is considered to be adversely impacted and the impacts are not eliminated in either external or internal fisheries, the cumulative effect is rated as conditionally significant adverse.

However, as described previously for mortality, if the closures proposed under FMP 4.1 were to be further defined and designed to protect important habitats, mitigation of fishing-related impacts could occur and cumulative effects may have more of a conditionally significant beneficial rating rather than conditionally significant adverse.

Direct and Indirect Effects FMP 4.2 – Habitat

All fishing is suspended under this FMP until the fisheries can be reviewed and certified by the agency as having no significantly adverse effects on the resource and its environment. Figure 4.2-7 illustrates the year-round suspension of fishing in the BSAI and GOA management areas. Significantly adverse effects identified for each fishery would have to be mitigated through improved fishery practices or management measures before the fishery could be authorized in the EEZ. Such a scenario may result in a 2-year suspension with some fisheries being quickly certified (i.e., those with little or no bycatch) and others taking longer. Some fisheries may never be certified, or could only be certified following a period of scientific research.

Direct and indirect effects of the FMP on habitat are discussed for changes to living habitat through direct mortality or benthic organisms, and changes to benthic community structure through benthic community diversity and geographic diversity of impacts and protection. Due to their habitat type differences the Bering Sea, Aleutian Islands, and GOA are rated and discussed separately.

<u>Changes to Living Habitat – Direct Mortality of Benthic Organisms</u>

- **Bering Sea**. Protection of living habitat will increase from baseline levels. When $F = 0$, the estimate of equilibrium impact level is zero, which is less than estimates for under-baseline F levels. Benthic organisms will begin to increase in abundance toward the equilibrium from original baseline levels. For these reasons, it is predicted that FMP 4.2 would result in significantly beneficial change to mortality and damage to living habitat. However, for species like tree corals, returning to equilibrium levels may take an extremely long time.

- **Aleutian Islands**. When impact rates are zero, soft coral, tunicate, and other fast to intermediate recovering living habitats will increase from baseline levels, and gorgonian coral will cease to decrease from baseline levels. For these reasons, changes to mortality and damage to living habitat are predicted to be significantly beneficial due to FMP 4.2. However, for species like tree corals, returning to equilibrium levels may take an extremely long time.

- **GOA**. Living habitat will increase from baseline levels. When *F* = 0, the estimate of equilibrium impact level is zero, which is less than estimates for under-baseline *F* levels. Benthic organisms will begin to increase in abundance toward the equilibrium from original baseline levels. For these reasons, it is predicted that FMP 4.2 would result in significantly beneficial change to mortality and damage to living habitat. However, returning to equilibrium levels may take an extremely long time for species like tree corals.

Changes to Benthic Community Structure – Benthic Community Diversity and Geographic Diversity of Impacts and Protection

- **Bering Sea, Aleutian Islands, and GOA**. With *F* = 0, there will be no fishing impacts to induce geographic diversity of impacts, and the benthic community may progress towards its unfished level over the short-term. Some species may recover extremely slowly or not at all depending on life history requirements and the length of the fishery suspension. Based on these results, the predicted change of FMP 4.2 on benthic community diversity and geographic diversity of impacts is predicted to be significantly beneficial relative to the baseline.

Cumulative Effects FMP 4.2

Cumulative effects of habitat for FMP 4.2 are summarized on Table 4.8-3. The following discussion is broken down by geographic area.

Bering Sea

Changes to Living Habitat – Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the Bering Sea. These effects include persistent mortality of long-lived species such as tree corals and other sessile epifauna. See the cumulative effects write-up for FMP 4.1 for additional discussion.

- **Reasonably Foreseeable Future External Effects.** Offal discharge, port expansion and use, marine pollution, and natural events have the potential to cause direct mortality of benthic organisms and changes to living habitat (see the cumulative effects discussion for FMP 4.1 in the Bering Sea).

- **Cumulative Effects** are identified for mortality of Bering Sea benthic organisms, and the effect is judged to be conditionally significant adverse. As described for FMP 4.1, while beneficial effects of no fishing under the FMP accrue, the baseline is considered to be adversely impacted. Over the period of analysis for the FMP (out to five years), it is considered that the lingering past effects, particularly on long-lived species, will not be mitigated, especially since fishing in some form will likely occur within two years of cessation. However, careful definition and refinement of the areas open to fishing will occur under the new management regime because all fishing must be done in an environmentally safe manner. Therefore, as with FMP 4.1, the combination of external and internal effects lead to the cumulative rating of conditionally significant beneficial to conditionally significant adverse depending on the location of fishing when it resumes and recovery times of habitat.

Changes to Benthic Community Structure

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the Bering Sea. Persistent changes to benthic community structure including a reduction in species diversity have been observed in heavily fished areas of the world (see Section 4.8.6).

- **Reasonably Foreseeable Future External Effects**. As described for FMP 4.1, offal discharge, port expansion and use, marine pollution, and natural events have the potential to cause changes to benthic communities. These changes could have either beneficial or adverse effects on the benthic community.

- **Cumulative Effects** are identified for changes in benthic community structure of the Bering Sea, and the effect is judged to be conditionally significant adverse for reasons described above under mortality. Over the period of analysis for the FMP (out to five years), it is considered that the lingering past effects, particularly on long-lived species, will not be mitigated, especially because fishing in some form will likely occur within two years of cessation. The combination of external and internal effects lead to the cumulative rating of conditionally significant adverse. However, as described above for mortality, once fishing is allowed it must occur in an environmentally safe manner and effects would be similar to those described for FMP 4.1. Therefore, cumulative effects could range from conditionally significant beneficial to conditionally significant adverse.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects**. As described above in this section, the effects of FMP 4.2 on geographic diversity of impacts is significantly beneficial .

- **Persistent Past Effects** are expected because fishing effort and distribution has changed over time as areas have been closed and remain closed. Figures 3.6-6 and 3.6-7 and Table 4.5-51 show that in 1980 almost nine percent of the fishable area in the Bering Sea was closed to trawling, with 2.2 percent closed to all fishing. There were no longline-only closures in the Bering Sea at that time. The cumulative effects section for FMP 4.1 provides additional details regarding past effects.

- **Reasonably Foreseeable Future External Effects** include port expansion and the potential resultant changes to distribution of fishing effort, offal discharge, and marine pollution episodes (see the discussion for FMP 4.1). Depending on the distribution of fishing effort, previously un-impacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects**. Once fishing commences, the predicted change to geographic diversity of impacts is expected to be similar as that described for the FMP 4.1 bookend.

Aleutian Islands

Changes to Living Habitat – Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the Aleutian Islands. Prevalence of long-lived species of coral makes impacts a particular concern in the Aleutians. Mortality of long-lived species such as tree corals and other sessile epifauna is likely to be persistent in these areas (see the FMP 4.1 cumulative effects write-up).

- **Reasonably Foreseeable Future External Effects**. As described for FMP 4.1, dredging, longline fisheries, pot fisheries, offal discharge, port expansion and use, marine pollution, and natural events have the potential to cause direct mortality of benthic organisms and changes to living habitat.

- **Cumulative Effects** are identified for mortality of Aleutian Islands benthic organisms, and the effect is judged to be conditionally significant adverse. As described for FMP 4.1, benefits will accrue due to the cessation of fishing; however, the baseline is considered to be adversely impacted and impacts are not eliminated under this FMP. Over the period of analysis for the FMP (out to five years), it is considered that the lingering past effects, particularly on long-lived species, will not be mitigated, especially because fishing in some form will likely occur within two years of cessation. Therefore, the combination of external and internal effects lead to the cumulative rating of conditionally significant adverse. However, as described above for mortality, once fishing is allowed it must occur in an environmentally safe manner and effects would be similar to those described for FMP 4.1. Therefore, cumulative effects could range from conditionally significant beneficial to conditionally significant adverse.

Changes to Benthic Community Structure

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the Aleutians. Changes to benthic community structure including a reduction in species diversity have been observed in heavily fished areas of the world (see the FMP 4.1 cumulative effects discussion for the Aleutian Islands).

- **Reasonably Foreseeable Future External Effects**. As described for FMP 4.1, dredging, longline and pot fisheries, offal discharge, port expansion and use, marine pollution, and natural events have the potential to cause changes to benthic communities. These changes could have either beneficial or adverse effects on the benthic community.

- **Cumulative Effects** are identified for changes in benthic community structure of the Aleutians, and the effect is judged to range from conditionally significant adverse to conditionally significant beneficial for reasons described above under mortality.

<u>Geographic Diversity of Impacts and Protection</u>

- **Direct/Indirect Effects**. As described previously in this section, this effect is significantly beneficial.

- **Persistent Past Effects** are expected because fishing effort and distribution has changed as areas have been closed and remain closed. Figures 3.6-6 and 3.6-7 and Table 4.5-51 show that in 1980 about 31 percent of the fishable area in the Aleutians was closed to trawling, with about six percent closed to all fishing. There were no longline-only closures in the Aleutian Islands at that time (see Section 4.8.6).

- **Reasonably Foreseeable Future External Effects** include other fisheries, port expansion and the potential resultant changes to distribution of fishing effort, offal discharge, and marine pollution episodes. Depending on the distribution of fishing effort, previously un-impacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case (see the FMP 4.1 discussion).

- **Cumulative Effects**. Once fishing commences, the predicted change to geographic diversity of impacts is expected to be similar as that described for the FMP 4.1 bookend.

GOA

<u>Changes to Living Habitat – Direct Mortality of Benthic Organisms</u>

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the GOA. Mortality of long-lived species such as tree corals and other sessile epifauna is likely to be persistent in these areas (see the FMP 4.1 discussion).

- **Reasonably Foreseeable Future External Effects**. As described for FMP 4.1, dredging, longline fisheries, pot fisheries, offal discharge, port expansion and use, marine pollution, and natural events have the potential to cause direct mortality of benthic organisms and changes to living habitat in the GOA.

- **Cumulative Effects** are identified for mortality of GOA benthic organisms, and the effect is judged to be conditionally significant adverse. As described for FMP 4.1, benefits will accrue due to the cessation of fishing; however, the baseline is considered to be adversely impacted and impacts are not eliminated under this FMP. Over the period of analysis for the FMP (out to five years), it is considered that the lingering past effects, particularly on long-lived species, will not be mitigated, especially because fishing in some form will likely occur within two years of cessation. Therefore, the combination of external and internal effects lead to the cumulative rating of conditionally significant adverse. However, as described previously for mortality, once fishing is allowed it must occur in an environmentally safe manner and effects would be similar to those described for FMP 4.1. Therefore, cumulative effects could range from conditionally significant beneficial to conditionally significant adverse.

Changes to Benthic Community Structure

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to result in a significantly beneficial change to the baseline, but as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects** are expected in heavily fished areas of the GOA. Changes to benthic community structure including a reduction in species diversity have been observed in heavily fished areas of the world (see the FMP 4.1 discussion).

- **Reasonably Foreseeable Future External Effects**. As described for FMP 4.1 in the GOA, dredging, longline and pot fisheries, offal discharge, port expansion and use, marine pollution, and natural events have the potential to cause changes to benthic communities. These changes could have either beneficial or adverse effects on the benthic community.

- **Cumulative Effects** are identified for changes in benthic community structure of the GOA, and the effect is judged to range from conditionally significant adverse to conditionally significant beneficial for reasons described previously for mortality.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects**. As described previously in this section, this effect is judged to be significantly beneficial.

- **Persistent Past Effects** are expected because fishing effort and distribution has changed as areas have been closed and remain closed. Figures 3.6-6 and 3.6-7 and Table 4.5-51 show that in 1980 about five percent of the fishable area in the GOA was closed to trawling, with about seven percent closed to all fishing. The largest closures in the GOA concerned longline fishing where almost 61 percent of the fishable area was closed to longlining. Therefore, in 1980 about 73 percent of the fishable area in the GOA was closed to fishing of one type or another at some time (see the FMP 4.1 cumulative effect discussion).

- **Reasonably Foreseeable Future External Effects** include other fisheries, port expansion and the potential resultant changes to distribution of fishing effort, offal discharge, and marine pollution episodes. Depending on the distribution of fishing effort, previously un-impacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects**. Once fishing resumes, The predicted change to geographic diversity of impacts is expected to be similar as that described for the FMP 4.1 bookend.

4.8.7 Seabirds Alternative 4 Analysis

4.8.7.1 Short-Tailed Albatross

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Incidental Take

Under FMP 4.1, seabird protection measures would be established for all species with the goal of reducing incidental take of ESA-listed species and species of management concern to levels approaching zero. For short-tailed albatross, reducing take to levels approaching zero has been the goal of NOAA Fisheries and USFWS for at least ten years, so there is no change in intent from the baseline condition. From a practical standpoint, this policy will lead to essentially the same development and implementation of regulations for the longline and trawl fleets as are described for FMP 3.2 in Section 4.7.7.1. Since the seabird avoidance techniques are likely to be the same, the difference between FMP 3.2 and FMP 4.1 will be the greatly reduced fishing effort under FMP 4.1. Longline effort under FMP 4.1 is predicted to be only about six percent of the baseline effort in the BSAI and 30 percent of the baseline effort in the GOA. Combined with highly effective deterrence techniques, this major reduction in fishing effort will essentially eliminate the chances of incidentally taking short-tailed albatross on longline gear. Trawl effort would be reduced under FMP 4.1 to approximately 60 percent of the baseline effort in the BSAI and 30 percent of the baseline in the GOA. Combined with mitigation measures, this reduction in trawl effort should substantially reduce the chances of taking short-tailed albatross in trawl gear or third wire collisions.

Under FMP 4.2, all fishing efforts would cease until particular fisheries were certified as having minimal environmental effects. The process of certification has not been defined, so which fisheries are likely to pass such certification tests are unknown. When the management policy is first enacted; however, no commercial groundfish fishing would be allowed except under special experimental permits for certification purposes. This is the situation that will be analyzed for the effects of FMP 4.2 on seabirds. With the virtual elimination of fishing effort, the incidental take of short-tailed albatross will be reduced to zero. The expected take of short-tailed albatross under FMP 4.1 and FMP 4.2 would therefore approach zero and be considered insignificant at the population level.

Changes in Food Availability

Short-tailed albatross forage over vast areas of ocean and are unlikely to be affected by any potential localized disturbance or depletion of prey from the fishery as managed under FMP 4.1 or FMP 4.2. The fisheries are considered to have insignificant effects on short-tailed albatross through availability of food.

Benthic Habitat

Short-tailed albatross are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 4.1 or FMP 4.2. The fisheries are therefore considered to have no effects on short-tailed albatross through benthic habitat.

Cumulative Effects of FMP 4.1 and FMP 4.2

The past/present effects on short-tailed albatross are described in Section 3.7.4 (Table 3.7-12). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The cumulative effects for this species would be dominated by factors external to the groundfish fisheries and would be the same as those described in Section 4.5.7.1 (Table 4.5-52) and summarized below.

Mortality

- **Direct/Indirect Effects**. Under FMP 4.1, the new seabird protection measures for the longline fleet that are described in Section 3.7.1 would be installed and then improved through further research. In addition, effective seabird protection measures for the trawl fleet would be developed through collaborative research and would lead to a reduced likelihood of taking short-tailed albatross in the longline and trawl groundfish fleets. Combined with a greatly reduced level of fishing effort under FMP 4.1, these measures are expected to reduce incidental take of short-tailed albatross to a level approaching zero, which is considered insignificant at the population level. Under FMP 4.2, the groundfish fisheries would be suspended; therefore, there would be insignificant effects on short-tailed albatross through mortality.

- **Persistent Past Effects**. The most important persistent influence on the short-tailed albatross population is their near extinction due to commercial feather hunting. Conservation efforts have allowed the population to recover at or near to its biologically maximum rate. The total fishery-related mortality of short-tailed albatross is unknown, but it does not appear to be having an overriding effect on the population growth rate.

- **Reasonably Foreseeable Future External Effects**. The short-tailed albatross population may be substantially affected by several natural and human-caused mortality factors that may or may not occur in the future, including volcanic eruptions on their main breeding site, Torishima Island, and increased rates of incidental take in fisheries throughout their range. If the species experiences a substantial increase in mortality that threatens its recovery, it may lead to further efforts to protect the species from fishery interactions.

- **Cumulative Effects**. The population of short-tailed albatross is susceptible to several natural and human-caused mortality factors that may or may not occur in the future, including an extremely small chance of incidental take in the groundfish fisheries under FMP 4.1, and zero chance of incidental take under FMP 4.2. Therefore, the cumulative effect on short-tailed albatross is considered to be conditionally adverse at the population level through mortality.

Changes in Food Availability

- **Direct/Indirect Effects** The groundfish fisheries would continue to take a very small amount of squid and forage fish as bycatch. This effect is considered insignificant at the population level for short-tailed albatross.

- **Persistent Past Effects**. Short-tailed albatross primarily prey on squid and small schooling fishes that have been targeted by fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be minimal compared to natural fluctuations in primary productivity and oceanographic factors. Pollution from a variety of land and marine sources has potentially affected short-tailed albatross prey in the past, but specific toxicological effects are unknown.

- **Reasonably Foreseeable Future External Effects**. There are no foreseeable fisheries that will likely have more than a negligible effect on short-tailed albatross prey availability. Pollution is likely to affect short-tailed albatross prey in the future, but specific predictions on the nature and scope of the effects, especially as they relate to the availability of prey to short-tailed albatross, can not be made at this time.

- **Cumulative Effects**. The cumulative effect of all fisheries on the abundance and distribution of short-tailed albatross prey is considered to be insignificant at the population level under FMP 4.1 and FMP 4.2.

Benthic Habitat

Short-tailed albatross feed at the surface, and their prey live in the upper and middle levels of the water column. Therefore, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernable effect on their prey. Therefore, no cumulative effect on benthic habitat is identified for short-tailed albatross.

4.8.7.2 Laysan Albatross and Black-Footed Albatross

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Incidental Take

New seabird protection measures for the longline and trawl sectors, in addition to greatly reduced fishing effort would reduce incidental take of albatross to levels approaching zero. The overall effect of FMP 4.1 and FMP 4.2 on the incidental take of these albatross species is considered insignificant.

Changes in Food Availability

Albatross forage over vast areas of ocean and are unlikely to be affected by any potential localized disturbance or depletion of prey from the groundfish fishery. FMP 4.1 and FMP 4.2 are therefore considered to have insignificant effects on these species through availability of food.

Benthic Habitat

Albatross are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of the groundfish fishery. FMP 4.1 and FMP 4.2 are considered to have no effects on these species through benthic habitat.

Cumulative Effects of FMP 4.1 and FMP 4.2

The past/present effects on Laysan and black-footed albatross are described in Sections 3.7.2 and 3.7.3 (Tables 3.7-6 and 3.7-7). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The cumulative effects for these species would be dominated by factors external to the groundfish fisheries and would be the same as those described in Section 4.5.7.2 (Tables 4.5-53 and 4.8-4) and summarized below.

Mortality

- **Direct/Indirect Effects**. Under FMP 4.1, the new seabird protection measures for the longline fleet that are described in Section 3.7.1 would be installed and then improved through further research. In addition, effective seabird protection measures for the trawl fleet would be developed through collaborative research and would thus lead to reduced incidental take of albatross in the longline and trawl groundfish fleets. Combined with a greatly reduced level of fishing effort under FMP 4.1, these measures are expected to reduce incidental take of albatross substantially below the baseline level of incidental take, which is considered insignificant at the population level for both albatross species. Under FMP 4.2, the groundfish fisheries would be suspended, thus there would be no effect on Laysan and black-footed albatross through mortality.

- **Persistent Past Effects**. For black-footed and Laysan albatross, past mortality factors include large contributions from foreign longline fisheries and Hawaiian pelagic longline fisheries, a smaller contribution from the BSAI and GOA longline fisheries, and an unknown contribution from other longline fisheries (IPHC), trawl fisheries, and vessel collisions throughout their range. Both species have been experiencing population declines over the past decade. The contribution of toxic and plastic pollution on their nesting grounds and in the marine environment is unknown for both albatross species.

- **Reasonably Foreseeable Future External Effects**. New seabird protection measures have recently been established for the Hawaiian pelagic longline fleets that are expected to reduce take of albatross in those fisheries. It is expected that incidental take of black-footed and Laysan albatross in foreign longline fisheries will remain high and will continue to exceed the threshold for population level effects.

- **Cumulative Effects**. The populations of black-footed and Laysan albatross are undergoing measurable declines and several human-caused mortality factors have been identified and are expected to continue in the future, including minimal contributions from the groundfish fisheries under FMP 4.1, and zero contribution from the groundfish fisheries under FMP 4.2. Therefore, the cumulative effects on black-footed and Laysan albatross are considered to be significantly adverse at the population level through mortality.

Changes in Food Availability

- **Direct/Indirect Effects**. The groundfish fisheries would continue to take a very small amount of squid and forage fish as bycatch. This effect is considered insignificant at the population level for both albatross species. While groundfish vessels contribute to overall marine pollution through spills and vessel accidents, the effects of this pollution on albatross prey populations can not be assessed at this time.

- **Persistent Past Effects**. Albatross primarily prey on squid species and small schooling fishes that have been targeted by fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be minimal compared to climate and oceanographic factors. Since albatross can forage over huge areas, they are unlikely to have been affected by localized disturbance or depletion of their prey fields caused by fisheries. Pollution from a variety of land and marine sources has potentially affected albatross prey in the past. However, very little is known about the specific toxicological effects on prey species important to albatross or what sources of pollution may be the most important.

- **Reasonably Foreseeable Future External Effects**. There are no foreseeable fisheries that are likely to have more than a negligible effect on albatross prey availability. Pollution is likely to affect albatross prey in the future, but specific predictions on the nature and scope of the effects, especially as they relate to the availability of prey to albatross, can not be made at this time.

- **Cumulative Effects**. The cumulative effect of all fisheries on the abundance and distribution of albatross prey is considered to be insignificant at the population level for all species.

Benthic Habitat

Since albatross feed at the surface or with shallow dives and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernable effect on their prey. Therefore, no cumulative effect is identified for these species.

4.8.7.3 Shearwaters

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Incidental Take

New seabird protection measures for the longline and trawl sectors and greatly reduced fishing effort would greatly reduce incidental take of shearwaters, which is currently considered insignificant at the population-level. The overall effect of FMP 4.1 and FMP 4.2 on the incidental take of these shearwater species is considered insignificant.

Changes in Food Availability

Shearwaters forage over vast areas of ocean and are unlikely to be affected by any potential localized disturbance or depletion of prey from the groundfish fishery. FMP 4.1 and FMP 4.2 are considered to have insignificant effects on these species through availability of food.

Benthic Habitat

Shearwaters are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of the groundfish fishery. FMP 4.1 and FMP 4.2 are considered to have no effects on these species through benthic habitat.

Cumulative Effects of FMP 4.1 and FMP 4.2

The past/present effects on sooty and short-tailed shearwaters are described in Section 3.7.6 (Table 3.7-14). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The cumulative effects for these species would be dominated by factors external to the groundfish fisheries and would be the same as those described in Section 4.5.7.3 (Table 4.5-54 and 4.8-4) and summarized below.

Mortality

- **Direct/Indirect Effects**. Under FMP 4.1, effective seabird protection measures would be developed for the longline and trawl fleets through collaborative research and would lead to reduced incidental take of shearwaters in both sectors. Combined with a greatly reduced level of fishing effort under FMP 4.1, these measures are expected to reduce incidental take of shearwaters substantially below the baseline level of incidental take, which is considered insignificant at the population level for both shearwater species. Under FMP 4.2, the groundfish fisheries will be suspended; therefore, there would be no effects on shearwaters through mortality.

- **Persistent Past Effects**. For sooty and short-tailed shearwaters, mortality factors include large contributions from subsistence and commercial harvest of chicks on the nesting grounds, as well as climatic and oceanic fluctuations that cause periodic mass starvation, substantial contributions from foreign, Hawaiian, and BSAI and GOA groundfish longline and trawl fisheries, and a smaller contribution from vessel collisions throughout their range. It is difficult to assess the population trends in these abundant and widespread species, but there are some indications that both species may be declining. The contribution of toxic and plastic pollution on their nesting grounds and in the marine environment is unknown for both species.

- **Reasonably Foreseeable Future External Effects**. Incidental take of shearwaters will likely continue in external longline and trawl fisheries as in the past unless longline and trawl deterrence techniques that are effective for diving species are developed and applied.

- **Cumulative Effects**. The populations of shearwaters may be undergoing declines and several human-caused mortality factors have been identified and are expected to continue in the future, including small contributions from the groundfish fisheries under FMP 4.1, and no contributions from the groundfish fishery under FMP 4.2. Therefore, the cumulative effects on sooty and short-tailed shearwaters are considered to be conditionally adverse at the population level through mortality.

Changes in Food Availability

- **Direct/Indirect Effects**. The groundfish fisheries would continue to take a very small amount of squid as bycatch. This effect is considered insignificant at the population level for both shearwater species. While groundfish vessels contribute to overall marine pollution through spills and vessel accidents, the effects of this pollution on shearwater prey populations can not be assessed at this time.

- **Persistent Past Effects**. Short-tailed and sooty shearwaters are susceptible to periodic widespread food shortages that have caused massive die-offs in Alaskan waters. Natural fluctuations in primary productivity and oceanographic factors are considered to be the driving forces that determine the abundance of their main prey (euphausiids) rather than competitive interactions with other predators. Since shearwaters can forage over huge areas, they are unlikely to have been affected by localized disturbance or depletion of their prey fields caused by fisheries. Pollution from a variety of land and marine sources has potentially affected shearwater prey in the past. However, very little is known about the specific toxicological effects on species important to these seabirds or what sources of pollution may be the most important.

- **Reasonably Foreseeable Future External Effects**. There are no foreseeable fisheries that are likely to have more than a negligible effect on shearwater prey availability. Pollution is likely to affect shearwater prey in the future, but specific predictions on the nature and scope of the effects, especially as they relate to the availability of prey to shearwaters, can not be made at this time.

- **Cumulative Effects**. The cumulative effect of all fisheries on the abundance and distribution of shearwater prey is considered to be insignificant at the population level for both shearwater species.

Benthic Habitat

Since shearwaters feed at the surface or with shallow dives, and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernable effect on their prey. Therefore, no cumulative effect on benthic habitat is identified for these species.

4.8.7.4 Northern Fulmar

Direct/Indirect Effects FMP 4.1 and FMP 4.2

Incidental Take

New seabird protection measures for the longline and trawl sectors, in addition to greatly reduced fishing effort would reduce incidental take of fulmars to hundreds of birds or less under FMP 4.1, rather than over 15,000 per year under baseline conditions. Incidental take under FMP 4.2 would approach zero. For such an abundant species, this level of take would be considered negligible on a population level. This reduced level of take would eliminate concerns over possible colony level effects. The overall effect on the incidental take of fulmars is considered insignificant.

Changes in Food Availability

Fulmars forage over vast areas of ocean and are unlikely to be affected by any potential localized disturbance or depletion of prey from the groundfish fishery. FMP 4.1 and FMP 4.2 are therefore considered to have insignificant effects on fulmars through availability of food.

Benthic Habitat

Fulmars are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of the groundfish fishery. FMP 4.1 and FMP 4.2 are considered to have no effects on fulmars through benthic habitat.

Cumulative Effects of FMP 4.1 and FMP 4.2

The past/present effects on northern fulmars are described in Section 3.7.5 (Table 3.7-13) and the predicted direct and indirect effects of the groundfish fishery are described in Section 4.5.7.4 (Table 4.5-55). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Tables 4.5-55 and 4.8-4 and summarized below.

Mortality

- **Direct/Indirect Effects**. Under FMP 4.1, the new seabird protection measures for the longline fleet that are described in Section 3.7.1 would be installed and then improved through further research. In addition, effective seabird protection measures for the trawl fleet would be developed through collaborative research and would lead to reduced incidental take of fulmars in the longline and trawl groundfish fleets. Combined with a greatly reduced level of fishing effort under FMP 4.1, these measures are expected to reduce incidental take of fulmars substantially below the baseline level of incidental take, which is considered insignificant at the population level.

- **Persistent Past Effects**. For northern fulmars, past mortality factors include large contributions from the BSAI and GOA groundfish fisheries and other net and longline fisheries in the North Pacific and

Bering Sea. There is no indication of an area-wide population decline, but there is some concern that particular colonies may be experiencing declines related to the groundfish fisheries. Other potential mortality factors that have been identified include acute and chronic effects of pollution, underestimated mortality in all fisheries, and higher than normal rates of natural mortality (i.e. starvation) due climatic and oceanographic fluctuations.

- **Reasonably Foreseeable Future External Effects**. Incidental take of fulmars is expected to continue in all offshore fisheries in the BSAI and GOA. The IPHC fisheries will be subject to new seabird avoidance measures, so incidental take from the halibut and sablefish fleet is expected to decline substantially. Future oil spills and other incidents of pollution are likely, but their effects on fulmars will depend on many factors that can not be predicted.

- **Cumulative Effects**. The population of northern fulmars appears to be stable and the primary human-caused mortality factors, including contributions from the groundfish fisheries under FMP 4.1 are expected to decline in the future, and no contribution under FMP 4.2. Therefore, the cumulative effects on fulmars are considered to be insignificant at the population level through mortality.

<u>Changes in Food Availability</u>

- **Direct/Indirect Effects**. The groundfish fisheries would continue to take a very small amount of forage fish and pelagic invertebrates as bycatch. This effect is considered insignificant at the population level for northern fulmars. While groundfish vessels contribute to overall marine pollution through accidental spills and vessel accidents, the effects of this pollution on fulmar prey populations can not be assessed at this time.

- **Persistent Past Effects**. Fulmars prey on squid and small schooling fishes that have been targeted by fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be minimal compared to climate and oceanographic factors. Since fulmars can forage over huge areas, they are unlikely to have been affected by localized disturbance or depletion of their prey fields caused by fisheries. Pollution from a variety of land and marine sources has potentially affected fulmar prey in the past. However, very little is known about the specific toxicological effects on species important to fulmars or what sources of pollution may be the most important.

- **Reasonably Foreseeable Future External Effects**. There are no foreseeable fisheries that will likely have more than a negligible effect on fulmar prey availability. Pollution is likely to affect fulmar prey in the future, but specific predictions on the nature and scope of the effects, especially as they relate to the availability of prey to fulmars, can not be made at this time.

- **Cumulative Effects**. The cumulative effect of all fisheries on the abundance and distribution of fulmar prey is considered to be insignificant at the population level.

Benthic Habitat

Since fulmars feed at the surface or with shallow dives and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernible effect on their prey. Therefore, no cumulative effect on benthic habitat is identified for this species.

4.8.7.5 Species of Management Concern (Red-Legged Kittiwakes, Marbled and Kittlitz's Murrelets)

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Incidental Take

Since incidental take of these species approaches zero under the baseline conditions, the major reduction of fishing effort plus new seabird protection measures under FMP 4.1 would essentially eliminate the chances of taking these species in any groundfish fishery. Incidental take under FMP 4.2 would approach zero. The effect of the groundfish fishery on incidental take of these species is considered insignificant at the population level.

Changes in Food Availability

The effects of the groundfish fishery on prey availability for these species is considered insignificant under the baseline conditions (Section 4.5.7.5). Since overall TAC is greatly reduced under FMP 4.1 and eliminated in the short-term under FMP 4.2, and many areas potentially important to foraging seabirds may be placed in MPAs, the potential effect of the fisheries is substantially reduced from the baseline conditions. The effect of FMP 4.1 and FMP 4.2 on the prey availability of these species is considered insignificant at the population level.

Benthic Habitat

Red-legged kittiwakes are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of groundfish management. Marbled and Kittlitz's murrelets feed on species that depend on benthic habitats for at least part of their life cycles. However, benthic habitats in their nearshore foraging areas would not be affected directly by groundfish trawls as these take place further offshore. FMP 4.1 and FMP 4.2 are considered to have insignificant effects on the murrelet species through benthic habitat.

Cumulative Effects of FMP 4.1 and FMP 4.2

The past/present effects on red-legged kittiwakes, marbled murrelets, and Kittlitz's murrelets are described in Sections 3.7.13 and 3.7.17 (Table 3.7-22 and 3.7-26) and the predicted direct and indirect effects of the groundfish fishery are described (Table 4.5-56). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The cumulative effects for these species would be dominated by factors external to the groundfish fisheries and would be the same as those described in Section 4.5.7.5 (Tables 4.5-56 and 4.8-4) and summarized below.

Mortality

- **Direct/Indirect Effects**. Under FMP 4.1, new seabird protection measures for the longline and trawl fleets would be implemented and fishing effort would be much less than under baseline conditions. The incidental takes of red-legged kittiwakes and both murrelets are expected to be very rare, if they occur at all, and are insignificant at the population level under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects**. Past sources of mortality that may continue to have an effect on these species include subsistence hunting and egging (red-legged kittiwakes), incidental take in coastal salmon gillnet and other net fisheries (murrelets), oil spills (murrelets), and logging of nest trees (marbled murrelets). Incidental take in the BSAI and GOA groundfish fisheries appears to have contributed very little to the mortality of these species.

- **Reasonably Foreseeable Future External Effects**. All of the mortality factors listed above in persistent past effects are likely to continue in the future. For red-legged kittiwakes, the introduction of nest predators or a large oil spill around the Pribilof Islands in nesting season could have significant effects on mortality. For the murrelet species, oil spills in nearshore habitats and incidental take in salmon and other net fisheries are likely to remain the largest factors in the future. The contribution from chronic sources of pollution, both from terrestrial and marine sources, may contribute to future mortality. If the Kittlitz's murrelet population continues to decline and the species is listed under the ESA, new regulations may be placed on the various nearshore net fisheries to monitor and reduce incidental take of the species. These measures would also benefit marbled murrelets.

- **Cumulative Effects**. The three species in this group have all experienced substantial population declines in the recent past and are all susceptible to future human-caused mortality factors, including potentially minimal contributions from the groundfish fishery. The decline of red-legged kittiwakes on the Pribilofs may have been reversed recently, but it is not clear if their recovery will continue in the future. The cumulative effect for red-legged kittiwake is considered conditionally significant adverse at the population level through mortality. Both murrelet species continue to decline in their core areas and are considered to have significantly adverse cumulative effects at the population level through mortality.

Changes in Food Availability

- **Direct/Indirect Effects**. The groundfish fisheries would continue to take a very small amount of forage fish and pelagic invertebrates as bycatch. The effect of the fishery on the abundance and distribution of seabird prey species is considered insignificant at the population level for all three species in this group. While groundfish vessels contribute to overall marine pollution and disturbance, the effects of vessel hazards on seabird prey populations can not be assessed at this time.

- **Persistent Past Effects**. All three species prey on small schooling fishes and an assortment of invertebrates that have been targeted or taken as bycatch by external fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be small compared to climate and oceanographic factors. Pollution from a variety of land and marine sources, including the EVOS, has likely affected the prey of these species in the past. Since murrelets are easily disturbed by marine vessels of all kinds, high concentrations of vessel traffic in some areas may have effectively excluded murrelets from certain important foraging areas.

- **Reasonably Foreseeable Future External Effects**. Future squid and herring fisheries as well as other net fisheries that take forage fish as bycatch may have an effect on prey availability for these species. Pollution is likely to affect prey in the future but specific predictions on the nature and scope of the effects, especially as they relate to the availability of prey on a scale important to the birds, can not be made at this time.

- **Cumulative Effects**. While the groundfish fisheries are considered to have an insignificant effect on prey availability on their own, the dynamic interaction of natural and human-caused events, including fisheries and pollution, on the availability of forage fish and invertebrate prey to seabirds is beginning to be explored with directed research. Since this dynamic could conceivably be adverse or beneficial depending on different circumstances, the cumulative effect on prey availability is considered to be unknown for these three species.

Benthic Habitat

Red-legged kittiwakes are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of the groundfish fishery; therefore, there are no cumulative effects on red-legged kittiwakes under FMP 4.1 and FMP 4.2. Marbled and Kittlitz's murrelets feed on species that depend on benthic habitats for at least part of their life cycles, but they forage in shallow waters that are inshore of the groundfish fishery. Since the groundfish fishery would contribute minimally to potential effects on benthic habitats important to murrelets, an insignificant cumulative effect is identified for these species.

4.8.7.6 Other Piscivorous Species (Most Alcids, Gulls, and Cormorants)

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Incidental Take

The surface-feeding gulls in this piscivore group would benefit the most from protection measures and reductions in fishing effort for the longline fleet, while the diving alcids and cormorants would benefit the most from mitigation and reductions in effort for the trawl fleet. All species would be expected to have substantially reduced levels of mortality relative to baseline conditions. Since the baseline level of take is already considered insignificant at the population level for these species (Section 4.5.7.6), reduced levels of take would also be considered insignificant.

Changes in Food Availability

As described in Section 4.5.7.6, the potential effects of the groundfish fishery on piscivore prey availability are considered to be insignificant on the population level under the baseline conditions. Under FMP 4.1, total TAC and fishing effort in the trawl and longline fleets would be substantially reduced. This would reduce the potential impact of the fishery on forage fish even more than the baseline condition. In addition, under FMP 4.1, 20 to 50 percent of the BSAI and GOA would be designated as no-fishing marine reserves. To the extent that these reserves were established in areas important to seabirds, these no-fishing areas could serve as refugia from potential fishery-induced disturbance or localized depletions of seabird prey. The contribution of the fishery to the food supply of gulls in the form of fishery discards would be reduced in proportion to the reductions in TAC. If this supplemental food supply is important to the survival or reproductive rates of particular species (i.e. the large gulls), an assumption that has not been tested in Alaska, the reduction in offal under FMP 4.1 could have population level effects for some species. However, other species like kittiwakes and murres would likely benefit from reduced rates of predation if the large gull populations were reduced. These predator/prey relationships exist independent of the fishery, and there is no reason to consider shifts in the balance one way or the other as adverse or beneficial. The overall effect of FMP 4.1 on the availability of food for piscivorous species is considered to be insignificant on the population level. Since FMP 4.2 would reduce the potential effects on piscivores even more, those effects are also considered insignificant at the population level.

Benthic Habitat

Specific effects of trawling on seabird prey species in the BSAI and GOA (through habitat change rather than by direct take) are poorly known. However, none of the species in this group appears to have experienced consistent or widespread population declines, so there is no indication that the carrying capacity of the environment has been decreased through changes to benthic habitat (or any other mechanism). Overall trawl effort in the BSAI and GOA under FMP 4.1 is predicted to be substantially less than the baseline conditions and eliminated under FMP 4.2. The effects on piscivorous seabirds through potential changes in benthic habitat are considered insignificant at the population level.

Cumulative Effects of FMP 4.1 and FMP 4.2

The past/present effects on the species in this group, including most alcids, gulls, and cormorants, are described in the species accounts of Section 3.7 (Tables 3.7-16 through 3.7-28). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Tables 4.5-57 and 4.8-4 and summarized below.

Mortality

- **Direct/Indirect Effects**. Under FMP 4.1, new seabird protection measures for the longline and trawl fleets would be implemented and fishing effort would be much less than under baseline conditions. Under FMP 4.2, the groundfish fisheries would be suspended. The incidental takes of all species in this group are expected to be insignificant at the population level under FMP 4.1 and FMP 4.2.

- **Persistent Past Effects**. Past sources of mortality that may continue to have an effect on these species include subsistence hunting and egging, incidental take in a variety of foreign and U.S. coastal and pelagic fisheries, oil spills and other pollution, fox farming, and regime shifts that have caused episodes of mass starvation. Incidental take in the BSAI and GOA groundfish fisheries appears to have contributed relatively little to the mortality of these species.

- **Reasonably Foreseeable Future External Effects**. All of the mortality factors listed above in persistent past effects are likely to continue in the future except for fox farming. A similar, though unintentional, effect is the possible introduction of nest predators (i.e. rats) to seabird colonies. Conservation concerns focus on preventing potential impacts around breeding colonies during the nesting season, since populations are concentrated in time and space. For some species, human impacts in nearshore habitats will likely have a much greater effect on their populations than offshore fisheries. The contribution from chronic sources of pollution, both from terrestrial and marine sources, may also contribute to future mortality.

- **Cumulative Effects**. Although a number of past and future human-caused mortality factors, including potentially small contributions from the groundfish fishery, have been identified for the species in this group, none of them have experienced substantial, consistent, or area-wide population declines in the recent past. The cumulative effects for these species are considered insignificant at the population level through mortality.

Changes in Food Availability

- **Direct/Indirect Effects**. The groundfish fisheries would continue to take a small amount of forage fish and invertebrate prey as bycatch. The effect of the fishery on the abundance and distribution of seabird prey species is considered insignificant at the population level for all species in this group. While groundfish vessels contribute to overall marine pollution and disturbance, the effects of vessel hazards on seabird prey populations can not be assessed at this time.

- **Persistent Past Effects**. All species in this group prey on small schooling fish and an assortment of invertebrates that have been targeted or taken as bycatch by external fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be small compared to climate and oceanographic factors. Pollution from a variety of land and marine sources has likely affected the prey of these species in the past. Since some of the alcids are easily disturbed by marine vessels of all kinds, high concentrations of vessel traffic in some areas may have effectively excluded them from certain important foraging areas.

- **Reasonably Foreseeable Future External Effects**. Future squid and herring fisheries as well as other net fisheries that take forage fish as bycatch may have an effect on prey availability for these species. Pollution is likely to affect prey in the future but specific predictions on the nature and scope of the effects, especially as they relate to the availability of prey on a scale important to the birds, can not be made at this time.

- **Cumulative Effects**. The groundfish fisheries contribute to the dynamic interaction of natural and human-caused events that affect the availability of forage fish and invertebrate prey to seabirds. While this dynamic is beginning to be explored with directed research, the lack of substantial, consistent, or area-wide population declines in these species indicates that the baseline conditions do not have an overriding adverse effect on the natural fluctuations of these seabird populations. Since no new major contributing factors are expected in the future under FMP 4.1 or FMP 4.2, the cumulative effect on prey availability is considered insignificant at the population level for these species.

Benthic Habitat

- **Direct/Indirect Effects**. Bottom trawls, and to a lesser extent pelagic trawls and pot gear, have the potential to modify benthic habitats and have indirect effects on the food web of diving piscivorous species. The overall effects of FMP 4.1 on piscivorous seabirds through potential changes in benthic habitat are considered insignificant. Under FMP 4.2, the groundfish fisheries would be suspended, therefore, their effects on piscivorous seabirds through benthic habitat is insignificant.

- **Persistent Past Effects**. Benthic habitats important to the diving species in this group have been affected by various foreign and U.S. fisheries for many years and include nearshore as well as offshore fisheries. The magnitude and longevity of the effects of these different types of fisheries have only begun to be investigated, so it is unclear what or where habitat effects are persistent, especially in regard to the indirect effects on prey species important to seabirds. Natural sources of benthic habitat disruption, such as strong ocean currents, ice scouring, and foraging by gray whales and walrus may have persistent effects in certain areas.

- **Reasonably Foreseeable Future External Effects**. All future fisheries in the BSAI and GOA that use bottom contact fishing gear are likely to affect benthic habitat to some extent. Natural sources of benthic habitat disruption will also continue.

- **Cumulative Effects**. The groundfish fisheries contribute to the many human-caused and natural factors that alter benthic habitats important to the food web of piscivorous seabirds. While there has been limited research on specific effects of benthic habitat disturbance on seabirds, the lack of substantial, consistent, or area-wide population declines in these species indicates that the baseline conditions do not have an overriding adverse effect on the natural fluctuations of these seabird populations. Since no new major contributing factors are expected in the future under FMP 4.1 or FMP 4.2, the cumulative effect on benthic habitat is considered insignificant at the population level for these species.

4.8.7.7 Other Planktivorous Species (Storm-Petrels and Most Auklets)

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Incidental Take

Since incidental take of these species approaches zero under the baseline conditions, the major reduction of fishing effort plus new seabird protection measures would essentially eliminate the chances of taking these species in any groundfish fishery. The effects of incidental take on these species are considered insignificant at the population level.

Food Availability

As described in Section 4.5.7.7, the effect of the groundfish harvest on planktonic prey is considered insignificant to the populations of planktivorous species under the baseline conditions. Since the intensity of the fishery would be greatly reduced from the baseline effort, the effect of FMP 4.1 or FMP 4.2 on prey availability for planktivores would also be considered insignificant at the population level.

Benthic Habitat

Storm-petrel and auklets are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of groundfish management. FMP 4.1 and FMP 4.2 are considered to have no effects on these species through benthic habitat.

Cumulative Effects of FMP 4.1 and FMP 4.2

The past/present effects on the species in this group, including storm-petrels and most auklets, are described in Sections 3.7.7 and 3.7.18 (Table 3.7-15 and 3.7-27). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Tables 4.5-58 and 4.8-4 and summarized below.

Mortality

- **Direct/Indirect Effects**. Incidental take of all seabirds is expected to decrease under FMP 4.1 due to new seabird protection measures for the longline and trawl fleets. Under FMP 4.2, the groundfish fisheries would be suspended. The incidental take of all species in this group is expected to be insignificant at the population level.

- **Persistent Past Effects**. Past sources of mortality that may continue to have an effect on these species include subsistence harvest, incidental take in foreign and U.S. coastal and pelagic fisheries, oil spills and other marine pollution, fox farming, and regime shifts that have caused episodes of mass starvation. Incidental take in the BSAI and GOA groundfish fisheries appears to have contributed relatively little to the mortality of these species.

- **Reasonably Foreseeable Future External Effects**. All of the mortality factors listed above in persistent past effects are likely to continue in the future except for fox farming. A similar, though unintentional, effect is the possible introduction of nest predators (i.e. rats) to seabird colonies. The contribution from chronic sources of pollution, both from terrestrial and marine sources, may contribute to future mortality.

- **Cumulative Effects**. Although a number of past and future human-caused mortality factors, including potentially small contributions from the groundfish fishery, have been identified for the species in this group, none of them have experienced substantial, consistent, or area-wide population declines in the recent past. The cumulative effects for these species are considered insignificant at the population level through mortality.

Changes in Food Availability

- **Direct/Indirect Effects**. The groundfish fisheries would continue to take a small amount of forage fish and invertebrate prey as bycatch. Indirect effects on zooplankton and juvenile fish abundance through changes in the abundance of target fish predators is considered minor compared to seasonal changes in primary productivity and oceanographic factors. The effect of the fishery on the abundance and distribution of seabird prey species is considered insignificant at the population level for all species in this group. While groundfish vessels contribute to overall marine pollution and disturbance, the effects of vessel hazards on seabird prey populations cannot be assessed at this time.

- **Persistent Past Effects**. Factors that have affected the abundance and distribution of zooplankton and juvenile fish include bycatch in squid and forage fish fisheries, marine pollution, and the decimation of planktivorous whales by commercial whaling. These effects are considered minor compared to seasonal and oceanographic fluctuations.

- **Reasonably Foreseeable Future External Effects**. Future squid and herring fisheries as well as other net fisheries that take forage fish as bycatch may have minimal effects on prey availability for these species. Pollution is likely to affect prey in the future but specific predictions on the nature and scope of the effects, especially as they relate to the availability of prey on a scale important to the birds, can not be made at this time.

- **Cumulative Effects**. The groundfish fisheries contribute in an indirect way to human influences on planktonic prey availability, which are considered minimal compared to natural fluctuations. These cumulative effects are considered insignificant on the population level for all species in this group.

Benthic Habitat

Since these planktivorous seabirds feed at the surface or with shallow dives and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernable effect on their prey. Therefore, no cumulative effect on benthic habitat is identified for these species.

4.8.7.8 Spectacled Eiders and Steller's Eiders

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Incidental Take

Under FMP 4.1 and FMP 4.2, the potential of the fisheries to cause incidental take of Steller's eider would be even less than the baseline condition, which already approaches zero. The fisheries are considered to have insignificant effects on the populations of these species through incidental take under FMP 4.1. There is a possibility of expansion into spectacled eider critical habitat under FMP 4.1; however, the effects from this expansion are considered insignificant. There would continue to be no overlap between spectacled eider critical habitat and the groundfish fishery FMP 4.2; therefore, there would be no direct/indirect effect on spectacled eiders through mortality.

Changes in Food Availability

There is a possibility of expansion into spectacled eider critical habitat under FMP 4.1, however the effects from this expansion are considered insignificant. Because there would continue to be no overlap between spectacled eider critical habitat and the groundfish fishery under FMP 4.2, there would be no direct/indirect effect on spectacled eiders through food availability. Under FMP 4.1, there would be little overlap between the groundfish fisheries and foraging habitats for Steller's eider. The effects of FMP 4.1 on the prey abundance and availability for Steller's eiders are considered insignificant at the population level. FMP 4.2 would have no overlap with Steller's eider foraging areas and would have no effects on Steller's eider prey.

Benthic Habitat

Under FMP 4.1, two management programs designed to conserve fish populations may actually lead to increased fishing in some eider habitats in spite of greatly reduced overall fishing effort. First, the establishment of MPAs and no-fishing zones in many areas that were fished under the baseline conditions would force the groundfish fleet to look for new areas to fish. Second, increased rationalization of the fishery would tend to give fishermen more time and opportunity to explore for new fishing grounds. It is not known whether the fishery would have the economic incentive to start fishing more heavily in the Steller's eider critical habitat in Kuskokwim Bay or to expand northward to spectacled eider critical habitat north of St. Matthew Island. It is not known whether disturbance of benthic habitat by fishing gear in these areas would have enough impact on benthic invertebrate populations to decrease eider foraging success. Although FMP 4.1 creates conditions under which these areas may be affected by benthic habitat disturbance, the level and type of disturbance needed to create population level effects on eiders are unknown. The effects of FMP 4.1 on the benthic habitat of spectacled and Steller's eider are considered unknown. Under FMP 4.2, the fishery would be halted, so there would be no direct/indirect effects on either eider species through benthic habitat.

Cumulative Effects of FMP 4.1 and FMP 4.2

The past/present effects on spectacled and Steller's eiders are described in Sections 3.7.9 and 3.7.10 (Table 3.7-17 and 3.7-18). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Tables 4.5-59 and 4.8-1and summarized below.

Mortality

- **Direct/Indirect Effects**. Under FMP 4.1, incidental take of eiders is expected to be less than the baseline condition, which already approaches zero, and is considered to be insignificant at the population level for Steller's and spectacled eiders. FMP 4.2 would suspend the groundfish fisheries and would have no effect on eiders through mortality.

- **Persistent Past Effects**. Past sources of mortality that may continue to have an effect on these species include sport hunting and subsistence harvest in Russia and Alaska, incidental take in Russian and Alaskan coastal fisheries, oil spills and other marine pollution that causes physiological stress and reduces survival rates, lead shot poisoning on the nesting grounds, and collisions with vessels and other structures. Incidental take in the BSAI and GOA groundfish fisheries appears to have been very rare for Steller's eider. Both species have been afforded protection through the ESA.

- **Reasonably Foreseeable Future External Effects**. All of the mortality factors listed above in persistent past effects are likely to continue in the future. Conservation concerns focus on preventing potential impacts in critical habitat areas.

- **Cumulative Effects**. The groundfish fisheries are not likely to contribute to direct mortality of spectacled eiders, so no cumulative effect is identified for that species under FMP 4.2. However, there is potential for expansion of the groundfish fishery into spectacled eider critical habitat under FMP 4.1. The effects from this expansion are considered insignificant. Decreased adult survival rates appear to have driven the past population decline of Steller's eiders. Known sources of direct human-caused mortality of Steller's eider, including very rare incidental take in the groundfish fisheries, do not appear to account for the past population decline in Alaska. However, several indirect factors may be contributing to decreased adult survival rates, including climate-induced changes in habitat, concentration of predators around nesting areas due to nearby human habitation, and pollution of nearshore waters from chronic and periodic sources of petroleum products (USFWS 2003a). Since the Alaska breeding population of Steller's eiders has declined dramatically in the past and has not recovered, and because several human-induced sources of mortality have been identified as potential contributing factors to this decline, including the potential for contributions to pollution and vessel collisions from the groundfish fisheries as managed under FMP 4.1, the cumulative effects of mortality on Steller's eiders are considered significant adverse at the population level.

Changes in Food Availability

The abundance of marine invertebrate species important to the spectacled and Steller's eiders, including bivalves, snails, crustaceans, and polychaete worms, could potentially be affected by disturbance to their benthic habitat. These effects will be discussed below. Although other factors external to the fisheries may influence the abundance and distribution of eider prey, the groundfish fisheries contribute minimally to these potential effects under FMP 4.1. The cumulative effects on eider prey availability from bycatch of all fisheries is considered insignificant. Under FMP 4.2, the groundfish fishery would be suspended, and there would be no effects on eider prey. Therefore, no cumulative effects on prey availability are identified for eiders.

<u>Benthic Habitat</u>

- **Direct/Indirect Effects**. Bottom trawls, and to a lesser extent pelagic trawls and pot gear, disrupt benthic habitats that support the prey of eiders. Under FMP 4.1, the groundfish fishery has the potential to be displaced into eider critical habitat areas. The overall effects of FMP 4.1 on eiders through potential changes in benthic habitat are considered unknown. The groundfish fishery would be suspended under FMP 4.2, and there would be no effects on eiders through benthic habitat.

- **Persistent Past Effects**. Benthic habitats important to spectacled and Steller's eiders have been affected by various trawl and pot fisheries for many years and include nearshore as well as offshore fisheries. The magnitude and longevity of the effects of these different types of fisheries have only begun to be investigated, so it is unclear what or where habitat effects are persistent, especially in regard to the indirect effects on prey species important to eiders. Natural sources of benthic habitat disruption, such as strong ocean currents, ice scouring, and foraging by gray whales and walrus, may have persistent effects in certain areas. Climate change and ocean temperature fluctuations may also play a role in altering the benthic environment.

- **Reasonably Foreseeable Future External Effects**. All future fisheries that use bottom contact fishing gear in areas used by eiders are likely to affect benthic habitat to some extent. Natural sources of benthic habitat disruption will continue.

- **Cumulative Effects**. While the groundfish fisheries are predicted to have little spatial overlap with spectacled and Steller's eider habitat under FMP 4.1, the interaction of all human-caused and natural disturbances on benthic habitat important to eiders has not been examined with respect to their population declines in the past. The cumulative effects of benthic habitat disruptions and changes over the years as they relate to the food web important to eiders are therefore considered to be unknown. Under FMP 4.2, the groundfish fishery would be suspended, so there would be no cumulative effects on eiders through benthic habitat.

4.8.8 Marine Mammals Alternative 4 Analysis

4.8.8.1 Western Distinct Population Segment of Steller Sea Lions

FMP 4.1 – Direct/Indirect Effects

<u>Incidental Take/Entanglement in Marine Debris</u>

Catch levels are reduced to extremely low levels relative to the baseline under FMP 4.1. Incidental takes of all marine mammals would decrease under FMP 4.1. Even under the baseline level of groundfish fisheries, takes and entanglements incidental to fishing activities are much less than PBR and are thus considered to be insignificant at the population level to the western distinct population segment (western population) of the Steller sea lion. Substantially reduced levels of incidental take under FMP 4.1 would not affect the rate of population recovery and are therefore considered insignificant.

Fisheries Harvest of Prey Species

Changes in the fishing mortality rate for Steller sea lion prey species were calculated using output from the multi-species management model which projected catch rates for the various FMPs. The estimated fishing mortality rates expected to occur under each FMP management regime were compared to the baseline fishing mortality rate in order to apply the significance criteria established in Table 4.1-6 for determining the effects on marine mammal populations. The baseline fishing mortality rates for the individual BSAI and GOA groundfish fisheries, the fishing mortality rates projected to occur under each FMP, and the relative difference between the baseline and FMP fishing mortality rates are shown in Table 4.5-61.

Under FMP 4.1, (F) of EBS pollock is expected to decrease by an average of 76 percent relative to the comparative baseline. According to the significance criteria for effects on marine mammals, the change in the harvest of this key Steller sea lion prey species is rated significant. The harvest of EBS pollock under the FMP 4.1 management regime meets the criteria of a significantly beneficial effect to Steller sea lions relative to the baseline condition.

The fishing mortality rate of GOA pollock is expected to decrease by an average of 78 percent relative to the comparative baseline over the next five years under FMP 4.1. This change in F is significantly beneficial under the FMP 4.1 scenario at the population level for Steller sea lions. Fishing mortality rates are not calculated for Aleutian Islands pollock as there was no directed Aleutian Islands pollock fishery under the baseline condition. There is no change in the projected catch of Aleutian Islands pollock between the baseline and FMP 4.1; therefore, effects of Aleutian Islands pollock harvests are deemed to be insignificant to Steller sea lions at the population level for this FMP.

Under FMP 4.1, the BSAI Pacific cod fishing mortality rate is expected to decrease by 71 percent. This change is determined to be significantly beneficial to Steller sea lions according to the criteria established in Table 4.1-6. Under FMP 4.1, the GOA Pacific cod fishing mortality rate is expected to decrease by 73 percent. This change is determined to be significantly beneficial to Steller sea lions. Changes in Aleutian Islands Atka mackerel harvest are expected to be significantly beneficial to Steller sea lions with decreases in F of 81 percent under FMP 4.1 relative to the baseline.

Little difference is expected relative to the baseline and among the FMPs for harvest of other, non-target species that are prey for Steller sea lions (e.g., cephlapods and forage fish such as capelin). Changes in the harvest of these species under the various FMPs were determined to be insignificant to Steller sea lions. The reduced combined harvest of Steller sea lion prey species under FMP 4.1 is expected to result in significantly beneficial population-level effects for the western population of Steller sea lions (Table 4.8-5).

Spatial/Temporal Concentration of the Fishery

Relative to the baseline, FMP 4.1 offers substantially more temporal and spatial protection from the effects of groundfish fisheries on Steller sea lions. FMP 4.1 was determined to have significantly beneficial effects for the western population of Steller sea lions in regards to the spatial/temporal concentration of the fishery.

Disturbance

FMP 4.1 is expected to result in decreased disturbance to the western population of Steller sea lions relative to the baseline. Since the effects of disturbance are insignificant under the baseline condition, they would also be insignificant at the population level under FMP 4.1 management scenarios.

Cumulative Effects

The past/present effects on the western population of Steller sea lion are described in Section 3.8.1 (Table 3.8-1). The effects considered in this analysis are listed in Table 4.8-5. Representative direct effects used in this analysis include mortality and disturbance. Major indirect effects are availability of prey and spatial/temporal concentration of the fisheries.

Mortality

- **Direct/Indirect Effects**. With regard to incidental take, FMP 4.1 is not likely to result in significant changes to the population trajectory of the western population of Steller sea lions, so it is considered insignificant.

- **Persistent Past Effects.** Substantial mortality of Steller sea lions did not occur in the fisheries until after the 1950s. The take of Steller sea lions was substantial after this time with over 20,000 animals believed to have been incidentally killed in the foreign and JV groundfish fisheries from 1966 to 1988, although data from this period are not complete (Perez and Loughlin 1991). In the BSAI groundfish trawl fisheries, incidental take has declined from about 20 per year in the early 1990s to an average of 7.8 sea lions per year from 1996 to 2000. Steller sea lions are also taken incidentally in state-managed nearshore salmon gillnet fisheries and halibut longline fisheries with an estimated 14.5 sea lion takes per year in the PWS drift gillnet fisheries (Wynne *et al*. 1992). Two cases of illegal shooting were prosecuted in the Kodiak area in 1998 involving two Steller sea lions from the western population (Angliss *et al*. 2001). It is thought that shooting used to be a significant source of mortality prior to ESA listing. The subsistence harvest in the western population has decreased over the last ten years from 547 to 171 animals per year (1992 to 1998) (Angliss *et al*. 2001). Commercial harvest of sea lions for hides and meat occurred prior to 1900 and likely depleted local populations. Over a nine year period, 1963 to 1972, more than 45,000 Steller sea lion pups were taken for commercial purposes (Merrick *et al.* 1987). Predation by transient killer whales and sharks has always contributed to the natural mortality of Steller sea lions but the numbers of sea lions taken and the relative contribution of this factor to the recent population decline and lack of recovery is currently under investigation (Matkin *et al.* 2001, Matkin *et al.* 2003, Springer *et al.* 2003).

- **Reasonably Foreseeable Future External Effects.** Incidental take in the state-managed fisheries, such as salmon gillnet fisheries, will continue in the foreseeable future, but the numbers of Steller sea lions will likely be relatively low (less than ten per year). Entanglement in fishing gear and intentional shootings would be expected to continue at a level similar to the baseline condition. Predation will continue to contribute to natural mortality but climate change and regime shifts would not be expected to have direct effects on mortality of Steller sea lions.

- **Cumulative Effects.** Cumulative effects of mortality are based on the contribution of internal effect of the groundfish fishery and external effects. These cumulative effects are considered significantly adverse, since the overall human-caused mortality approaches or exceeds the PBR for this population, and the species is listed as endangered under the ESA due to the severe decline of the species. The contribution of the groundfish fisheries is very small in comparison to the total human-caused mortality and, under the baseline conditions, is not considered to cause jeopardy to this population under the ESA (NMFS 2001b).

Prey Availability

- **Direct/Indirect Effects**. The reduced combined harvest of Steller sea lion prey species under FMP 4.1 is expected to result in significantly beneficial population-level effects to Steller sea lions.

- **Persistent Past Effects.** Past effects on key prey species of Steller sea lions include harvest of species that are targeted or taken as bycatch by the GOA groundfish fisheries and parallel fisheries in State of Alaska waters, partially overlapping with other state-managed fisheries. These species were targeted in the past foreign and JV groundfish fisheries. There is substantial evidence that nutritional stress played an important role in the rapid decline of the western population of Steller sea lions during the late 1970s and 1980s and one hypothesis is that the combined fisheries, perhaps in conjunction with climate and oceanographic fluctuations, greatly reduced the availability of forage fish to Steller sea lions. NMFS issued a number of BiOps since 1991 that analyzed the key issue as to whether the groundfish fisheries were contributing to the decline of sea lion populations or causing adverse impacts to their critical habitat but most of the focus was on the western population. A recent Steller sea lion BiOp and EIS explore this subject in great depth (NMFS 2001b).

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries such as salmon and herring are expected to continue in future years in a generally similar manner to the baseline conditions. New fisheries in state or federal waters are not anticipated. Climate change or regime shifts were identified as potentially having effects on availability of prey, but the direction or magnitude of these changes is difficult to predict. Climate-induced change has been a suspected cause in the decline of the western population of Steller sea lions.

- **Cumulative Effects.** Cumulative effects of prey availability were based on both internal and external effects. The significantly beneficial rating of the internal effects on prey availability in the groundfish fisheries results from extensive area closures under MPAs for sea lion prey species and the no-take reserves under this FMP. When added to the external factors, the cumulative effects were determined to result in a population-level effect to the western population of the Steller sea lion and are considered significantly beneficial.

Spatial/Temporal Concentration of Prey

- **Direct/Indirect Effects.** Relative to the baseline, FMP 4.1 offers substantially more temporal and spatial protection from the effects of groundfish fisheries on Steller sea lions. FMP 4.1 was determined to have significantly beneficial effects on Steller sea lions with regard to the spatial/temporal concentration of the fishery.

- **Persistent Past Effects.** Past effects of spatial/temporal harvest of prey were identified for foreign, JV, federal, and domestic groundfish fisheries and state-managed fisheries for salmon and herring. Past changes in the groundfish harvest have dispersed the fishing effort in time and space in order to minimize effects on Steller sea lions. Minimizing the competitive overlap between the fisheries and Steller sea lions is the primary focus of sea lion protective measures, which are expanded under FMP 4.1.

- **Reasonably Foreseeable Future External Effects.** The reasonably foreseeable future factors, external to the groundfish fisheries, that could affect the spatial/temporal harvest of Steller sea lion prey would be state-managed salmon and herring fisheries which remove Steller sea lion prey during the spring and summer months. These fisheries are expected to be managed in a similar manner to recent years. No new state or federal fisheries are anticipated at this time.

- **Cumulative Effects.** Cumulative effects of the spatial/temporal harvest of prey on Steller sea lions were considered conditionally significant beneficial based on the significant beneficial effects of the groundfish fisheries under FMP 4.1. This rating is conditional on whether the actual decrease in concentration of the groundfish fisheries would result in improvements to prey fields to the extent that beneficial population-level effects occur and also whether the location of MPAs and no take reserves are in areas critical to Steller sea lion foraging success.

Disturbance

- **Direct/Indirect Effects.** FMP 4.1 is expected to result in decreased disturbance to Steller sea lions relative to the baseline. However, because the effects of disturbance are insignificant under the baseline condition they would be insignificant at the population level under FMP 4.1.

- **Persistent Past Effects.** Past effects of disturbance were identified from foreign, JV, and domestic groundfish fisheries in the BSAI and GOA and state-managed fisheries. Past disturbances from commercial harvest, intentional shooting, and subsistence harvest were identified. General vessel traffic and disturbance of prey fields from fishing gear have regularly occurred in the past.

- **Reasonably Foreseeable Future External Effects.** Future sources of disturbance were identified as state-managed salmon and herring fisheries and general fishing and non-fishing vessel traffic in Steller Sea lion foraging areas. Subsistence harvest was identified as a continuing source of disturbance to Steller sea lions. Levels of disturbance from external sources are expected to be similar to baseline conditions.

- **Cumulative Effects.** Cumulative effects of disturbance on Steller sea lions are considered insignificant because they are either decreased from or similar to the baseline condition and population-level effects are unlikely.

Direct/Indirect Effects FMP 4.2

Under FMP 4.2, the groundfish fisheries would be essentially closed until specific fisheries were certified to have no adverse effects on the environment. The potential impacts to marine mammals would therefore be even less than described under FMP 4.1 but the conclusions regarding direct/indirect effects for incidental take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 4.2 are the same as described under FMP 4.1.

Cumulative Effects

Since the groundfish fisheries would be essentially closed under FMP 4.2, the cumulative effects for mortality, prey availability, spatial and temporal concentration of the fishery, and disturbance would all be dominated by the same persistent past and external factors discussed under FMP 4.1. Since the contribution of the groundfish fisheries to all of these effects is also greatly reduced relative to the baseline condition under FMP 4.1, the cumulative effects conclusions are the same as discussed under FMP 4.1.

4.8.8.2 Eastern Distinct Population Segment of Steller Sea Lions

Direct/Indirect Effects FMP 4.1

Incidental Take/Entanglement in Marine Debris

Catch levels are reduced to extremely low levels relative to the baseline under FMP 4.1. Incidental take of all marine mammals, including the eastern distinct population segment (eastern population) of Steller sea lions, would decrease under FMP 4.1. Even under the baseline conditions, takes and entanglements incidental to fishing activities are considered insignificant to the eastern population of Steller sea lions at the population level. Reducing these takes to even further would also be considered insignificant to the population.

Fisheries Harvest of Prey Species

The fishing mortality rate of GOA pollock is expected to decrease by an average of 78 percent relative to the comparative baseline over the next five years under FMP 4.1. This change in F is significantly beneficial under the FMP 4.1 scenario at the population level of Steller sea lions. Under FMP 4.1, the GOA Pacific cod fishing mortality rate is expected to decrease by 73 percent. This change is determined to be significantly beneficial to Steller sea lions. The combined harvest of prey species from the eastern population of Steller sea lions under FMP 4.1 is therefore expected to be substantially less than the baseline condition and is considered to be significantly beneficial.

Spatial/Temporal Concentration of the Fishery

Relative to the baseline, FMP 4.1 offers substantially more temporal and spatial protection from the effects of groundfish fisheries on Steller sea lions. However, since the eastern population of Steller sea lions has been increasing steadily over the past 20 years and food availability does not appear to be limiting their population recovery, it is unlikely that these additional protection measures would improve their access to prey to the extent that population-level effects would occur. While the spatial/temporal measures under FMP 4.1 could be considered beneficial, they are unlikely to result in substantial changes to the baseline condition and are therefore considered insignificant at the population-level for the eastern population of Steller sea lions.

Disturbance

FMP 4.1 is expected to result in decreased disturbance to Steller sea lions relative to the baseline. However, because the effects of disturbance are insignificant under the baseline conditions they would also be insignificant at the population level under FMP 4.1.

Cumulative Effects

The past/present effects on the eastern population of Steller sea lions in southeast Alaska are described in Section 3.8.1 (Table 3.8-1). The effects considered in this analysis are listed in Table 4.8-5. Representative direct effects used in this analysis include mortality and disturbance. Major indirect effects are availability of prey and spatial/temporal concentration of the fisheries.

Mortality

- **Direct/Indirect Effects.** With regard to incidental take and entanglement, FMP 4.1 is not likely to result in significant changes to the population trajectory of the eastern population of Steller sea lions. No Steller sea lions from the eastern population have been taken incidental to groundfish fisheries from 1995 to 1999 (Angliss *et al*. 2001).

- **Persistent Past Effects.** It is thought that shooting was once a significant source of mortality prior to listing the Steller sea lion as threatened under the ESA. NMFS Alaska Enforcement Division has successfully prosecuted two cases of illegal shooting involving four sea lions from the eastern population (Angliss *et al*. 2001). It is not known to what extent illegal shooting continues in the eastern population, but stranding of sea lions with bullet holes still occurs. Predator control programs associated with mariculture facilities in British Columbia account for a mean of 44 animals killed per year from the eastern population (Angliss, *et al*. 2001). The subsistence harvest in the eastern population of Steller sea lions is very slight and subject to an average of only two sea lions taken per year from southeast Alaska (1992-1997) (Angliss *et al*. 2001). Commercial harvest of sea lions for hides and meat occurred prior to 1900 and likely depleted some local populations. Over a nine year period, 1963 to 1972, more than 45,000 Steller sea lion pups were taken for commercial purposes (Merrick *et al.* 1987). The proportion taken from the eastern population is unknown. Intentional shooting of Steller sea lions, other than in subsistence hunts, became illegal after the species was listed as threatened under the ESA in 1990. Steller sea lions are incidentally taken in low numbers by commercial fisheries other than groundfish fisheries, including some state-managed salmon drift and set gillnet fisheries and the salmon troll fishery in southeast Alaska (mean of 1.25 and 0.2 respectively) (Angliss and Lodge 2002). Small numbers of sea lions from the eastern population are taken outside of southeast Alaska in groundfish fisheries (0.45 per year in Washington, Oregon, and California) and set gillnet fisheries in Northern Washington State (0.2 per year) (Angliss *et al*. 2001). The PBR for this population is 1,396 and current human caused mortality is 45.5, substantially less than ten percent of the PBR.

- **Reasonably Foreseeable Future External Effects.** Incidental take in the state-managed fisheries such as salmon gillnet and troll fisheries will continue in the foreseeable future but the numbers of Steller sea lions will likely remain relatively low (less than ten per year). Groundfish fisheries in

Washington, Oregon, and California and salmon set gillnets fisheries will continue to take small numbers from this population. Entanglement and intentional shootings would also be expected to continue. Pollution is likely more of a factor for this population due to the closer association with population centers. Climate change and regime shifts would not be expected to have direct effects on mortality of Steller sea lions.

- **Cumulative Effects.** Cumulative effects of mortality are based on the contribution of the groundfish fishery and external mortality effects. These effects are considered insignificant since the overall human-caused mortality does not approach the PBR for this population. Although this population is listed as threatened under the ESA, the population has been increasing over the last 20 years. The contribution of the groundfish fisheries is very small in comparison to the total human-caused mortality and does not jeopardize the species under the ESA (NMFS 2001b).

Effects of Prey Availability

- **Direct/Indirect Effects.** Only groundfish fisheries in the GOA would be expected to have a potential effect on the eastern population of Steller sea lions. The decreased harvest of Steller sea lion prey species under FMP 4.1 is considered significantly beneficial according to the significance criteria but is unlikely to have population-level effects.

- **Persistent Past Effects.** Past effects on key prey species of Steller sea lions include harvest of species that are targeted or taken as bycatch by the GOA groundfish fisheries and parallel fisheries in state waters, and partial overlap with other state-managed fisheries. These species were targeted in the past foreign and JV groundfish fisheries. NMFS issued a number of BiOps since 1991 that analyzed the key issue of whether the groundfish fisheries were contributing to the decline of Steller sea lion populations or causing adverse impacts to their critical habitat but most of the focus was on the western population. The most recent Steller sea lion BiOp and EIS (NMFS 2001b) explores this subject in great depth.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries such as salmon and herring are expected to continue in future years in a similar manner to the baseline condition. New fisheries in state or federal waters are not anticipated. Climate change or regime shifts were identified as potentially having adverse effects on availability of prey but the direction and magnitude of these changes are difficult to predict. Climate-induced change has been suspected in the decline of the western population of Steller sea lions, but effects of climate change or regime shifts on the eastern population are largely unknown.

- **Cumulative Effects.** The cumulative effects of prey availability on the eastern population of the Steller sea lion are considered to be insignificant at the population level. The eastern population of Steller sea lions has been increasing steadily over the last 20 years so prey availability is not considered to be limiting the recovery of the population. Decreased harvest levels under FMP 4.1 would therefore be unlikely to result in population-level effects.

Spatial/Temporal Concentration of the Fishery

- **Direct/Indirect Effects.** Spatial/temporal fishing measures in FMP 4.1 offer substantially greater temporal and spatial protection to Steller sea lions from the effects of groundfish fisheries. However, while the spatial/temporal measures under FMP 4.1 could be considered beneficial, they are unlikely to result in population-level effects for the eastern population of Steller sea lions, which have been increasing under the baseline conditions, and are therefore considered insignificant.

- **Persistent Past Effects.** Past effects of spatial/temporal harvest of prey were identified for foreign, JV, federal and domestic groundfish fisheries, and state-managed fisheries for salmon and herring. Past changes in the groundfish harvest have dispersed the fishing effort in time and space in order to minimize effects on Steller sea lions. Minimizing the competitive overlap between the fisheries and Steller sea lions is the primary focus of the baseline Steller sea lion protection measures.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries such as salmon set and drift gillnet fisheries and salmon troll fisheries and herring fisheries are expected to continue in future years in a similar manner to the baseline condition.

- **Cumulative Effects.** Cumulative effects for the spatial and temporal harvest of prey from both internal effects of the groundfish fishery and external effects such as state-managed fisheries would be reduced from the baseline condition, under which the population has increased steadily, and are therefore considered insignificant for the eastern population of Steller sea lions.

Disturbance

- **Direct/Indirect Effects.** The effects of disturbance on Steller sea lions under FMP 4.1 are expected to decrease relative to the baseline. However, because the effects of disturbance are insignificant under the baseline condition, they would also be insignificant under FMP 4.1.

- **Persistent Past Effects.** Past disturbance was identified for foreign, JV, federal domestic groundfish fisheries, and state-managed salmon and herring fisheries. General vessel traffic has contributed to the disturbance level for this population. Intentional shooting has likely been a disturbance factor in past years.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries and vessel traffic will likely continue in the future at a level similar to the baseline condition. Disturbance from subsistence harvest is not an issue for this population.

- **Cumulative Effects.** The cumulative effect of disturbance from both internal and external sources would be reduced from the baseline condition, under which the population has increased steadily, and is therefore considered insignificant for the eastern population of Steller sea lions.

Direct/Indirect Effects FMP 4.2

Under FMP 4.2, the groundfish fisheries would be essentially closed until specific fisheries were certified to have no adverse effects on the environment. The potential impacts to marine mammals would therefore be even less than described under FMP 4.1 but the conclusions regarding direct/indirect effects for incidental take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 4.2 are the same as described under FMP 4.1.

Cumulative Effects

Since the groundfish fisheries would be essentially closed under FMP 4.2, the cumulative effects for mortality, prey availability, spatial and temporal concentration of the fishery, and disturbance would all be dominated by the same persistent past and external factors discussed under FMP 4.1. Since the contribution of the groundfish fisheries to all of these effects is also greatly reduced relative to the baseline condition under FMP 4.1, the cumulative effects conclusions are the same as discussed under FMP 4.1.

4.8.8.3 Northern Fur Seals

Direct/Indirect Effects FMP 4.1

Incidental Take/Entanglement in Marine Debris

Since fishing effort is greatly reduced relative to the baseline under FMP 4.1, incidental takes of northern fur seal would be expected to decrease under FMP 4.1. Under the baseline conditions, takes and entanglements associated with fishing activities are thought to be insignificant to fur seals at the population level. Reducing these takes even further would also be considered to have insignificant effects on the population trajectory of fur seals.

Fisheries Harvest of Prey Species

Under FMP 4.1, the F of EBS pollock is expected to decrease by an average of 76 percent relative to the comparative baseline. According to the significance criteria for effects on marine mammals, the change in the harvest of northern fur seal prey species is considered to be significantly beneficial.

Catches of squid and small schooling fish (e.g., fish designated in the forage fish assemblage) in the groundfish fisheries of the BSAI and GOA are low, generally less than 1,000 mt per year. While precise biomass estimates for these groups do not exist, the exploitation rate on these groups in the groundfish fisheries is thought to be very low. For instance, squid biomass in the Bering Sea may be as large as 4 million mt, based on marine mammal food habits, daily ration, and abundance data (Sobolevsky 1996). Similarly, with respect to small schooling fishes, consumption of capelin in the GOA by arrowtooth flounder alone may be as large as 300,000 mt per year (Livingston 1994). Assuming that these crude projections of squid and capelin biomass at least approximate the order of magnitude of the true population levels, then the fisheries removals would amount to only a fraction of one percent of those populations. Fisheries for pollock and Pacific cod do not target fish younger than three years of age (Ianelli *et al.* 1999, Dorn *et al.* 1999, Thompson and Dorn 1999, Thompson and Zenger 1994, Fritz 1996). Catches of pollock smaller than 30 centimeters (cm) are small, and thought to be only one to four percent of the number of one- and two-year olds each year in the EBS and GOA (Fritz 1996).

Therefore, while fisheries do harvest prey of northern fur seals (i.e., pollock and Pacific cod), competition due to the harvest rates of those species may vary depending on the size range consumed by northern fur seals. The overall catch of juvenile pollock has tended to be low in recent years and the degree to which adult pollock occur in the northern fur seal diet is not certain. While the potential overlap with fisheries may be moderated by these factors, effects on northern fur seals may yet exist, the relevance of which is not reflected by estimates of biomass removals over large geographical areas.

The overall harvest of northern fur seal prey species is rated conditionally significant beneficial under the FMP 4.1. Population-level effects are plausible if commercially sized pollock are a substantial component of fur seal diet. This rating is conditional on whether the decreased level of pollock harvest in the groundfish fisheries under FMP 4.1 results in increased prey resources such that fur seals are impacted at the population level.

<u>Spatial/Temporal Concentration of the Fishery</u>

The effects of the spatial/temporal concentration of the fisheries under the baseline conditions were rated conditionally significant adverse for northern fur seals in the Steller sea lion SEIS (NMFS 2001b). Relative to the baseline, FMP 4.1 offers substantially more temporal and spatial protection from the effects of groundfish fisheries on the prey fields of northern fur seals, including the establishment of MPAs and no-take reserves. FMP 4.1 was therefore determined to have significantly beneficial effects on northern fur seals in regards to the spatial/temporal concentration of groundfish fisheries.

<u>Disturbance</u>

FMP 4.1 is expected to result in decreased disturbance to northern fur seals relative to the baseline. However, because the effects of disturbance are insignificant under the baseline conditions they would also be insignificant at the population level under FMP 4.1.

Cumulative Effects

A summary of the effects of the past/present with regard to the northern fur seal is presented in Section 3.8.2 (Table 3.8-2). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. The effects considered in this analysis are listed in Table 4.8-5. Representative direct effects used in this analysis include mortality and disturbance. Indirect effects include availability of prey and spatial/temporal concentration of the fisheries.

<u>Mortality</u>

- **Direct/Indirect Effects.** Incidental take and entanglements of northern fur seals would decrease under 4.1, but would continue to be insignificant to the population trajectories due to the low level of mortalities attributed to incidental take and entanglements in fishing gear.

- **Persistent Past Effects.** Effects of past mortality on fur seal populations include commercial harvest of young males up to 1985, harvest of females between 1956 and 1968, incidental take in the JV fisheries, foreign fisheries, and annual subsistence harvest on the Pribilof Islands. Commercial harvest of fur seals peaked in 1961 with over 126,000 animals, but was halted in 1985. The harvest of female fur seals on the Pribilof Islands, as many as 300,000 between 1956 and 1968, likely contributed to the decline of the population in the late 1970s and early 1980s (York and Kozloff 1987). This precipitous decline resulted in its depleted status under the MMPA. Entanglements may have contributed significantly to declining trends of the population during the late 1970's (Fowler, 1987). Since the cessation of commercial harvest in 1985, fur seal numbers have steadily declined (NMFS 1993 and Angliss and Lodge 2002). The contribution of the earlier harvest of fur seals to the subsequent declines is uncertain since it has been nearly 20 years since the commercial harvest was ended. Subsistence harvest has been one of the major contributors to fur seal mortality in recent years. From 1986 to 1996, the average annual subsistence take was 1,605 from St. Paul and St. George Islands. From 1995 to 2000, this average take dropped to 1,340 seals per year, which represents about eight percent of the PBR for this species.

- **Reasonably Foreseeable Future External Effects.** These effects include incidental take from foreign fisheries outside the U.S. EEZ where fur seals are widely dispersed. State-managed fisheries take small numbers of fur seals including the PWS drift gillnet fishery, Alaska Peninsula and Aleutian Island salmon gillnet fisheries, and the Bristol Bay salmon fisheries (Angliss *et al*. 2001). Subsistence will continue to be a major source of mortality in the future but is limited to the Pribilof Islands; however, levels of take are expected to be well below ten percent of the PBR for this species. Short-term and long-term climate change is not considered a major mortality factor for this species.

- **Cumulative Effects.** Cumulative effects of mortality from internal and external factors are considered insignificant because of the size of the fur seal population in relation to existing levels of take, which are well below the PBR of this species. The contribution of the groundfish fisheries is very small and approaches zero.

Availability of Prey

- **Direct/Indirect Effects.** The decreased harvest of northern fur seal prey species under FMP 4.1 was determined to be conditionally significant beneficial relative to the baseline.

- **Persistent Past Effects.** Effects of past harvest of prey are primarily from the foreign and JV fisheries and state and federal domestic fisheries in the BSAI. There has been no concern with regard to displaced/increased fishing effort encroaching into nearshore areas of the Pribilof Islands and resulting in increased overlap with fur seal foraging areas. The proportion of the total June-October pollock harvest in fur seal foraging habitat increased from an average of 40 percent in 1995-1998 to 69 percent in 1999-2000 (NMFS 2001b). There is particular concern for the potential impact of this increased fishing pressure on lactating females from St. George Island where catch rates were consistently higher in areas used by females from St. Paul (Robson *et al*. 2004). Climate and oceanic fluctuations are suspected in past changes to the abundance and distribution of prey.

- **Reasonably Foreseeable Future External Effects.** Effects on prey availability for northern fur seals in the future are considered for State-managed salmon and herring fisheries in nearshore areas. Climate effects are largely unknown, but could potentially have adverse effect on the availability of prey.

- **Cumulative Effects.** Cumulative effects of prey availability have been identified from the internal contribution of the groundfish fisheries, external effects on prey from other fisheries, and possibly long-term climate change. This cumulative effect is considered conditionally significant beneficial and is conditional on whether reduced pollock catches under FMP 4.1 would increase the available pollock for northern fur seal to the extent that beneficial population-level effects occur.

<u>Spatial/Temporal Concentration of Harvest</u>

- **Direct/Indirect Effects.** FMP 4.1 was determined to have significantly beneficial effects on northern fur seals in regards to the spatial/temporal concentration of groundfish fisheries.

- **Persistent Past Effects.** Effects of past harvest of prey occurred in the foreign and JV fisheries and the state and federal domestic fisheries in the BSAI. There has been concern with regard to displaced/increased fishing effort encroaching into nearshore areas of the Pribilof Islands and resulting in increased overlap with fur seal foraging areas. The proportion of the total June-October pollock catch in fur seal foraging habitat increased from an average of 40 percent in 1995-1998 to 69 percent in 1999-2000 (NMFS 2001b). There is particular concern for the potential impact of this increased fishing pressure on lactating females from St. George Island where catch rates were consistently higher than in areas used by females from St. Paul Island (Robson *et al.* 2004).

- **Reasonably Foreseeable Future External Effects.** Effects of the spatial/temporal harvest of prey species occur primarily in the foreign and federal domestic fisheries outside the EEZ, due to the extensive range of the fur seal when they are away from their breeding rookeries. State-managed fisheries have very limited overlap with fur seal prey. Climate change was identified as a potential factor in spatial/temporal effects on prey.

- **Cumulative Effects.** Cumulative effects of the spatial/temporal harvest of prey were based on the presence of internal and external factors and likely to result in substantial improvements in the availability of forage fish to northern fur seals. Since the concentration of fisheries under the baseline conditions may have contributed to past population declines, reductions in competition for localized resources could have population-level effects and are considered significantly beneficial to northern fur seal populations.

<u>Disturbance</u>

- **Direct/Indirect Effects.** FMP 4.1 is expected to result in decreased disturbance to northern fur seals relative to the baseline. However, because the effects of disturbance are insignificant under the baseline conditions they would be insignificant at the population level under FMP 4.1.

- **Persistent Past Effects.** Disturbance of fur seals in the past included commercial groundfish harvest by JV fisheries, foreign and federal domestic fisheries, state-managed fisheries and, to a lesser extent, the subsistence harvest of fur seals on the Pribilof Islands. It is unknown whether these past activities persist, but ongoing fishing activities continue and result in some level of disturbance to fur seals in the BSAI region.

- **Reasonably Foreseeable Future External Effects.** Future external disturbance effects on fur seals were identified for State-managed fisheries and subsistence activities on the Pribilof Islands. No new State of Alaska or Federal fisheries are expected within the range of the northern fur seal.

- **Cumulative Effects.** The cumulative effects of disturbance from internal and external factors are considered insignificant to northern fur seals because there is little information indicating an adverse effect at a population level.

Direct/Indirect Effects FMP 4.2

Under FMP 4.2, the groundfish fisheries would be essentially closed until specific fisheries were certified to have no adverse effects on the environment. The potential impacts to marine mammals would therefore be even less than described under FMP 4.1 but the conclusions regarding direct/indirect effects for incidental take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 4.2 are the same as described under FMP 4.1.

Cumulative Effects

Since the groundfish fisheries would be essentially closed under FMP 4.2, the cumulative effects for mortality, prey availability, spatial and temporal concentration of the fishery, and disturbance would all be dominated by the same persistent past and external factors discussed under FMP 4.1. Since the contribution of the groundfish fisheries to all of these effects is also greatly reduced relative to the baseline condition under FMP 4.1, the cumulative effects conclusions are the same as discussed under FMP 4.1.

4.8.8.4 Harbor Seals

FMP 4.1 – Direct/Indirect Effects

Incidental Take/Entanglement in Marine Debris

Since fishing effort is greatly reduced relative to the baseline under FMP 4.1, incidental takes of harbor seals would be expected to decrease under FMP 4.1. Under the baseline conditions, takes and entanglements associated with fishing activities are thought to be insignificant to harbor seals at the population level. Reducing these takes even further would also be considered to have insignificant effects on the population trajectory of harbor seals.

Fisheries Harvest of Prey Species

Under FMP 4.1, the fishing mortality rate of EBS pollock is expected to decrease by an average of 76 percent relative to the comparative baseline. According to the significance criteria for effects on marine mammals, the change in the harvest of this key harbor seal prey species is rated significantly beneficial.

The fishing mortality rate of GOA pollock is expected to decrease by an average of 78 percent relative to the comparative baseline over the next five years under FMP 4.1. This change in F is significantly beneficial under the 4.1 scenario at the population level for harbor seals. Fishing mortality rates are not calculated for Aleutian Islands pollock, as there was no directed Aleutian Islands pollock fishery under the baseline conditions. There is no change in the projected catch of Aleutian Islands pollock between the baseline and FMP 4.1; therefore, effects of Aleutian Islands pollock harvests are deemed to be insignificant to harbor seals at the population level for FMP 4.1.

Under FMP 4.1, the BSAI Pacific cod fishing mortality rate is expected to decrease by 71 percent. This change is determined to be significantly beneficial to harbor seals according to the criteria established in Table 4.1-6. Under FMP 4.1, the GOA Pacific cod fishing mortality rate is expected to decrease by 73 percent. This change is determined to be significantly beneficial to harbor seals. Changes in Aleutian Islands Atka mackerel harvest are expected to be significantly beneficial to harbor seals with decreases in F of 81 percent under FMP 4.1 relative to the baseline.

Little difference is expected relative to the baseline for harvest of other, non-target species that are prey for harbor seals under the FMP 4.1 management regime (e.g., cephlapods and forage fish such as capelin). Changes in the harvest of these species under FMP 4.1 were determined to be insignificant to harbor seals. The combined harvest of harbor seal prey species under FMP 4.1 is expected to be significantly beneficial to harbor seals relative to the baseline.

Spatial/Temporal Concentration of the Fishery

Relative to the baseline, FMP 4.1 offers substantially more temporal and spatial protection from the effects of groundfish fisheries on harbor seals and was determined to have significantly beneficial effects on harbor seals by substantially reducing potential impacts on their prey fields.

Disturbance

FMP 4.1 is expected to result in decreased disturbance to harbor seals relative to the baseline. However, because the effects of disturbance are insignificant under the baseline conditions they would also be insignificant at the population level under FMP 4.1.

Cumulative Effects

A summary of the effects of the past/present with regards to harbor seals is presented in Section 3.8.4 (Table 3.8-4). The effects considered in this analysis are listed in Table 4.8-5. Representative direct effects used in this analysis include mortality and disturbance. Indirect effects include availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** Incidental take of all marine mammals, including harbor seals, would decrease under FMP 4.1 but would still be insignificant to the population trajectories of marine mammals due to the low level of mortalities attributed to incidental take and entanglement in fishing gear.

- **Persistent Past Effects.** Residual effects on local populations from State of Alaska predator control programs (1950s to 1972) and commercial hunts (1963 to 1972) may still occur in some areas, although there are no data on these factors. Foreign and JV groundfish fisheries in the 1960s and 1970s have likely contributed to some level of direct harbor seal mortality from entanglement in gear, but based on the near shore distribution of harbor seals, there was likely minimal direct interaction and mortality is believed to have been very low. From 1990 to 1996, minimum estimates of harbor seals taken incidentally in groundfish gear in the Bering Sea were four per year and less than one per year in the GOA. In southeast Alaska, four harbor seals are estimated to be killed each year on longlines. Harvest of harbor seals for subsistence purposes is likely the highest cause of anthropogenic mortality for this species, since the cessation of commercial harvests in the early 1970s. Between 1992 and 1998, the state-wide harvest of harbor seals from all stocks ranged between 2,546 and 2,854 animals, the majority of which were taken in southeast Alaska (Wolfe and Hutchinson-Scarbrough 1999). Subsistence harvest of Bering sea stock of harbor seals approximately 161 animals, 42 percent of PBR for this species. For the GOA stock, the subsistence harvest is approximately 91 percent of the PBR for this stock. For the southeast stock, harvest is approximately 83 percent of PBR.

- **Reasonably Foreseeable Future External Effects.** Incidental take of harbor seals in state-managed fisheries such as salmon set and drift gillnet fisheries would be expected to continue at its present low rate. Subsistence take is expected to continue to be the greatest source of human-controlled mortality with a relatively high percentage of the PBR in both the GOA and southeast Alaska stock and a lower take in the BSAI region. Climate change is likely not a factor in the direct mortality of harbor seals although there would likely be indirect effects.

- **Cumulative Effects.** Cumulative effects of mortality are based on internal effects of the groundfish fishery and external sources such as subsistence and state-managed fisheries. Total human-caused mortality is expected to be below the PBR for all stocks of harbor seals and is considered insignificant.

Availability of Prey

- **Direct/Indirect Effects.** The combined harvest of harbor seal prey species under FMP 4.1 is expected to result in significantly beneficial population-level effects to harbor seals.

- **Persistent Past Effects.** Availability of prey for harbor seals in the past has likely been affected by foreign and JV fisheries, Federal domestic groundfish fisheries and state-managed salmon and herring fisheries, since the fish targeted by these fisheries are also prey of the harbor seal. Climate change/regime shift could possibly have been a factor in fluctuations in prey availability in the past.

- **Reasonably Foreseeable Future External Effects.** State-managed salmon and herring fisheries are identified as having potential adverse effects on harbor seal prey availability. Climate change/regime shift will continue to be a contributing factor although the effects can be either beneficial or adverse, depending on direction and magnitude of the change.

- **Cumulative Effects.** Cumulative effects of prey availability were based on internal effects of the groundfish fisheries and external factors. These effects were determined to likely result in population-level effects based on the substantial decrease in harvest of harbor seal prey species in the groundfish fisheries and are considered significantly beneficial.

Spatial/Temporal Concentration of the Fishery

- **Direct/Indirect Effects.** FMP 4.1 offers substantially more temporal and spatial protection from the effects of groundfish fisheries on harbor seals relative to the baseline and is considered to have significantly beneficial effects on harbor seals.

- **Persistent Past Effects.** Effect of groundfish harvest in the past has likely occurred from overlap of harbor seal prey species, fish targeted, and areas fished by the foreign and JV fisheries in the BSAI as well as the State of Alaska and federal fisheries.

- **Reasonably Foreseeable Future External Effects.** Future effects on spatial/temporal harvest were considered for the state-managed fisheries in nearshore areas such as salmon and herring. Since these fisheries generally occur in the nearshore areas in comparison to groundfish fisheries, overlap is more pronounced. Effects of climate change/regime shifts on prey species abundance and distribution are likely in the foreseeable future.

- **Cumulative Effects.** Cumulative effects of spatial/temporal harvest of prey were based on internal effects of the groundfish fisheries and external effect of other fisheries. These effects were determined to be significantly beneficial based on a significantly beneficial rating assigned to the internal effect of the FMP for extensive areas closures, MPAs for prey species, and no take reserves. These measures would be likely to substantially reduce potential impacts on the prey fields of harbor seals and therefore have beneficial population level effects.

Disturbance

- **Direct/Indirect Effects.** The effects of disturbance on harbor seals are considered to be insignificant at the population level.

- **Persistent Past Effects.** Disturbance of harbor seals in the past included commercial groundfish fisheries harvest by JV fisheries, foreign and federal domestic fisheries, commercial harvest, State of Alaska predator control programs, and to a lesser extent, the subsistence harvest of harbor seals. It is unknown whether these past activities have persistent effects but the ongoing fishing activities and subsistence do continue to result in some level of disturbance to harbor seal.

- **Reasonablely Foreseeable Future Effects.** State-managed fisheries, general vessel traffic, and subsistence activities would be expected to continue to create some level of disturbance to harbor seals in the foreseeable future.

- **Cumulative Effects.** Cumulative effects of disturbance were based on the presence of both internal and external sources of disturbance. Since there is little to indicate that harbor seals have suffered any adverse effects from the baseline level of disturbance, reduced levels of disturbance under FMP 4.1 are unlikely to have population-level effects and are therefore considered insignificant.

Direct/Indirect Effects FMP 4.2

Under FMP 4.2, the groundfish fisheries would be essentially closed until specific fisheries were certified to have no adverse effects on the environment. The potential impacts to marine mammals would therefore be even less than described under FMP 4.1 but the conclusions regarding direct/indirect effects for incidental take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 4.2 are the same as described under FMP 4.1.

Cumulative Effects

Since the groundfish fisheries would be essentially closed under FMP 4.2, the cumulative effects for mortality, prey availability, spatial and temporal concentration of the fishery, and disturbance would all be dominated by the same persistent past and external factors discussed under FMP 4.1. Since the contribution of the groundfish fisheries to all of these effects is also greatly reduced relative to the baseline condition under FMP 4.1, the cumulative effects conclusions are the same as discussed under FMP 4.1.

4.8.8.5 Other Pinnipeds

Direct/Indirect Effects FMP 4.1

Incidental Take/Entanglement in Marine Debris

Since fishing effort is greatly reduced relative to the baseline under FMP 4.1, incidental takes of other pinnipeds would be expected to decrease under FMP 4.1. Under the baseline conditions, takes and entanglements associated with fishing activities are thought to be insignificant to other pinnipeds at the population level. Reducing these takes even further would also be considered to have insignificant effects on the population trajectory of other pinnipeds.

Fisheries Harvest of Prey Species

Due to limited overlap in prey species taken (see section 4.5.8.5), the effects of groundfish fisheries harvest under FMP 4.1 are determined to be insignificant to all pinnipeds in this group except northern elephant seal. The diet of northern elephant seals in the GOA is unknown; however, the species is known to be a deep diver. This behavior suggests that their foraging may be partitioned by depth from most groundfish fishing activities. The effects of groundfish harvests on prey species for northern elephant seals are therefore considered to be unknown.

Spatial/Temporal Concentration of the Fishery

Due to the limited potential for competitive overlap to occur between pinnipeds included in this section and the groundfish fisheries, the spatial/temporal concentrations of the fisheries are expected to be inconsequential to animals in this category under FMP 4.1.

Disturbance

FMP 4.1 is expected to result in decreased disturbance to pinnipeds relative to the baseline. However, because the effects of disturbance are insignificant under the baseline conditions they would also be insignificant at the population level under FMP 4.1.

Cumulative Effects

A summary of the effects of the past/present with regards to other pinnipeds is presented in Section 3.8.2 and Sections 3.8.5 through 3.8.9 (Table 3.8-3 and Tables 3.8-5 through 3.8-9). The predicted direct/indirect effects of the groundfish fishery under FMP 4.1 are described above (Table 4.8-5). Cumulative effects are summarized in Table 4.5-66.

Mortality

- **Direct/Indirect Effects.** Incidental take of pinnipeds would decrease under FMP 4.1 relative to the baseline and would be insignificant.

- **Persistent Past Effects.** Past external effects on the populations of pinniped include low levels of incidental take in the foreign, JV, and domestic groundfish fisheries and low levels of take in the State-managed fisheries. Spotted seal incidental mortality in groundfish fisheries is one per year between 1995 and 1999 (Angliss and Lodge 2002). For bearded seal, the BSAI groundfish fisheries take an average of 0.6 per year. The Bristol Bay salmon drift gillnet fishery from 1990-1993 indicated 14 mortalities and 31 injuries of bearded seals. No mortalities of ringed seals have been observed in the last ten years in the BSAI groundfish (Angliss *et al*. 2001). For ribbon seal incidental take, the Bering Sea trawl fishery had one take in 1990, one in 1991, and one in 1997. An average of 86 elephant seals are taken each year in various gillnet fisheries from California to Washington. Incidental take included one in the Bering Sea trawl fishery in 1990, two in the GOA trawl fishery in 1990, and three in the GOA longline fishery in 1990. One juvenile elephant seal, originally misidentified as a bearded seal, was taken in the Bering Sea trawl fishery in 1991 (Angliss *et al*. 2001). Of the 17 Pacific walrus that were caught each year in groundfish trawl fisheries in the EBS between 1990 and 1997, over 80 percent were already decomposed (Gorbics *et al*. 1998). Subsistence is the major human-cause external factor for morality. Subsistence annual harvest rates include 5,265 spotted seal, 6,788 bearded seal, 100 ribbon seal, 9,567 ringed seal, 1,000 walrus and zero elephant seal.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries will likely continue to take very small numbers of seals in this group. Subsistence take of these marine mammals will likely continue at a similar rate to the baseline conditions.

- **Cumulative Effect.** The combined effects of mortality within the other pinniped group resulting from internal effects of the groundfish fisheries and external effects, such as subsistence harvest, are considered insignificant. For spotted, ringed, bearded, and ribbon seals, PBRs cannot be calculated. Walrus take is below PBR and population level effects are unlikely. Elephant seal populations are expanding so overall mortality is considered insignificant. Contributions of the groundfish fisheries to overall mortality is very small.

Abundance of Prey

- **Direct/Indirect Effects.** Except for elephant seals, where the amount of prey overlap is unknown, there is very little overlap of species taken in the groundfish fisheries with prey of the pinnipeds in this group and the effects of fisheries harvest on prey species are determined to be insignificant under FMP 4.1.

- **Persistent Past Effects.** Past effects on spotted seal prey include foreign, JV, and domestic groundfish fisheries and state-managed fisheries for salmon and herring. For the other ice seals, elephant seals, and walrus, no persistent past effects were identified due to minimal overlap with commercial fisheries.

- **Reasonably Foreseeable Future External Effects.** Future effects were identified for state-managed fisheries for the spotted seal. Climate change may be either a beneficial factor or adverse factor for the ice seals due to the extent of ice cover in the Bering Sea and effect on abundance and distribution of prey.

- **Cumulative Effects.** The cumulative effect of all fisheries on the abundance of prey for pinnipeds is considered insignificant for all species. Spotted seals have some overlap of prey with the groundfish fisheries but the harvest of prey by the fisheries is not expected to have population level effects. The amount of groundfish fishery overlap with elephant seals is unknown but, since the elephant seal population is expanding, food does not appear to be limiting so cumulative effects on prey availability are considered insignificant. The amount of prey overlap with the other pinniped species is very limited and is considered insignificant for all species in this group.

Spatial/Temporal Concentration of Fisheries

- **Direct/Indirect Effects.** The effects from spatial/temporal concentrations of the fisheries are expected to be insignificant for pinnipeds in this category under FMP 4.1.

- **Persistent Past Effects.** Persistent past effects on spotted seals include foreign, JV, and domestic groundfish fisheries and State of Alaska-fisheries. For other species, no past effects are identified.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries within the range of spotted seals would be expected in the future in a manner similar to the baseline conditions. Future effects of spatial/temporal concentration of fisheries on ice seals and walrus would not be expected.

- **Cumulative Effects.** The spatial/temporal concentration of the groundfish fishery and all other fisheries is considered to have an insignificant cumulative effect on pinniped prey due to limited seasonal overlap. Population-level effects are unlikely for any of the species in this group.

Disturbance

- **Direct/Indirect Effects.** FMP 4.1 is expected to result in decreased disturbance to pinnipeds relative to the baseline. However, because the effects of disturbance are insignificant, under the baseline conditions they would also be insignificant.

- **Persistent Past Effects.** Past sources of disturbance of spotted seals have come from the foreign, JV, and federal domestic groundfish fisheries in the BSAI and state-managed fisheries for salmon. Overlap of fisheries is minimal for most of species. The primary source of external disturbance to the other pinniped category would be related to subsistence harvest.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries could be expected to continue at a level similar to the baseline conditions. Disturbance from subsistence harvest activities in future years would be expected to remain similar to the baseline conditions.

- **Cumulative Effects.** Cumulative effects of disturbance were based on both internal and external effects. These cumulative effects are found to be insignificant for all species based on very limited overlap with the fisheries and the lack of evidence that disturbance results in population-level effects for any of these species.

Direct/Indirect Effects FMP 4.2 – Other Pinnipeds

Under FMP 4.2, the groundfish fisheries would be essentially closed until specific fisheries were certified to have no adverse effects on the environment. The potential impacts to marine mammals would therefore be even less than described under FMP 4.1 but the conclusions regarding direct/indirect effects for incidental take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 4.2 are the same as described under FMP 4.1.

Cumulative Effects

Since the groundfish fisheries would be essentially closed under FMP 4.2, the cumulative effects for mortality, prey availability, spatial and temporal concentration of the fishery, and disturbance would all be dominated by the same persistent past and external factors discussed under FMP 4.1. Since the contribution of the groundfish fisheries to all of these effects is also greatly reduced relative to the baseline condition under FMP 4.1, the cumulative effects conclusions are the same as discussed under FMP 4.1.

4.8.8.6 Transient Killer Whales

Direct/Indirect Effects FMP 4.1

Incidental Take/Entanglement in Marine Debris

Since fishing effort is greatly reduced relative to the baseline under FMP 4.1, incidental takes of transient killer whales would be expected to decrease under FMP 4.1. Under the baseline conditions, takes and entanglements associated with fishing activities are thought to be insignificant to transient killer whales at the population level. Reducing these takes even further would also be considered to have insignificant effects on the population trajectory of transient killer whales.

Fisheries Harvest of Prey Species

The diet of transient killer whales consists of marine mammals. Since the groundfish fisheries kill very few marine mammals through incidental take, the direct effects of groundfish fisheries on the abundance of transient killer whale prey species are determined to be insignificant under FMP 4.1.

Spatial/Temporal Concentration of the Fishery

The spatial/temporal concentration of the groundfish fisheries does not directly affect the distribution of marine mammals. Therefore, the direct effects of the fisheries on transient killer whale prey are determined to be insignificant under FMP 4.1.

Disturbance

FMP 4.1 would likely result in decreased disturbance to transient killer whales relative to the baseline. However, because the effects of disturbance are insignificant under the baseline conditions they would also be insignificant at the population level under FMP 4.1.

Cumulative Effects

The past/present effects on transient killer whales are described in Section 3.8.22 (Table 3.8-22). The effects considered in this analysis are listed in Table 4.5-66. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** Incidental takes of transient killer whales would decrease under FMP 4.1 and would be insignificant.

- **Persistent Past Effects.** Mortality has been documented in the JV fisheries, domestic groundfish fisheries, state-managed fisheries, and intentional shootings. Past incidental take in the groundfish fisheries is less than two animals per year, but it is not known if these animals were transients or residents. In addition to mortalities caused by entanglement, killer whales are susceptible to injury or mortality through vessel strikes. One killer whale was reported to be killed when it struck the propeller of a BSAI groundfish trawl vessel in 1998 (Angliss and Lodge 2002). The EVOS resulted in the loss of half of the individual killer whales from the AT1 transient group in PWS (Matkin *et al.* 1999). This distinct group of whales is being evaluated for recognition as a separate stock and protection as a depleted stock under the MMPA. Contaminant levels in whales in this group were found to be many times higher than other killer whales (Matkin *et al.* 1999).

- **Reasonably Foreseeable Future External Effects**. Mortality from external factors is identified for other state-managed fisheries, intentional shooting, and marine pollution, particularly bioaccumulating compounds such as PCBs and DDT (Matkin *et al.* 2001).

- **Cumulative Effects.** Cumulative effects of mortality resulting from internal effects of the groundfish fisheries and external factors are determined to be insignificant. The exception to this finding is in the AT1 transient group in PWS. The cumulative effects of mortality on this group were determined to be significantly adverse due to the past external effects of the EVOS and their subsequent population decline.

<u>Prey Availability</u>

- **Direct/Indirect Effects.** Since the groundfish fisheries kill very few marine mammals through incidental take, the direct effects of groundfish fisheries on the abundance of transient killer whale prey species are determined to be insignificant.

- **Persistent Past Effects.** Since marine mammals are the primary prey of transient killer whales, all of the factors that have been identified as affecting the abundance or distribution of cetaceans, pinnipeds, and sea otters are pertinent in this context. These factors include commercial and subsistence harvest, intentional shootings, incidental take in all fisheries, marine pollution, climate change, and regime shifts. In addition, there is the potential for past indirect effects of fisheries on the abundance of Steller sea lions, fur seals, and harbor seals, all of which are important prey species for transient killer whales. Declines in harbor seals in PWS after the EVOS could have affected the AT1 group of transient killer whales through their food supply (Matkin *et al.* 1999).

- **Reasonably Foreseeable Future External Effects.** Future external effects on prey species important to transient killer whales, primarily marine mammals, would include state-managed fisheries to a small extent and subsistence harvest of the various marine mammals.

- **Cumulative Effects.** The cumulative effects on different marine mammal species are varied, with some populations declining substantially while others increase. Although some individual whales may specialize on particular prey species, the ability of these top predators to switch prey and forage over vast areas is believed to decrease the importance of any one species or stock of marine mammal prey. The overall availability of prey does not appear to be having population level effects on transient killer whales and therefore the cumulative effect is considered insignificant.

Spatial/Temporal Concentration of the Fishery

- **Direct/Indirect Effects.** The spatial/temporal concentration of the groundfish fisheries does not directly affect the distribution of marine mammals. Therefore, the direct effects of the fisheries on transient killer whale prey are determined to be insignificant.

- **Persistent Past Effects.** All persistent past effects that have been identified for cetaceans, pinnipeds, and sea otters are pertinent in this context. These factors include the potential contribution of the spatial/temporal concentration of past fisheries to have caused localized depletion of prey for Steller sea lions, harbor seals, and northern fur seals with consequent population-level effects on those species.

- **Reasonably Foreseeable Future External Effects.** The future spatial/temporal concentration of external fisheries could have indirect effects on the abundance and distribution of marine mammals that are important prey for transient killer whales.

- **Cumulative Effects.** The cumulative effects of the spatial/temporal concentration of fisheries on different marine mammal species result in changes to the abundance and distribution of prey to transient killer whales. Since transient killer whales. are able to switch prey and forage over vast areas, the potential localized depletion of any one species or stock of marine mammal prey is unlikely to have population level effects on the killer whales. The cumulative effect of the spatial and temporal harvest of fish from all fisheries does not appear to be having population level effects on transient killer whales and is therefore considered insignificant.

Disturbance

- **Direct/Indirect Effects.** Levels of disturbance to transient killer whales are expected to be similar to baseline conditions and are expected to be insignificant.

- **Persistent Past Effects.** Some level of disturbance has likely occurred from foreign, JV, and domestic groundfish fisheries, and state-managed fisheries. Vessel traffic external to the fisheries has contributed to overall disturbance of these animals. Effects of the level of disturbance on transient killer whales are largely unknown.

- **Reasonably Foreseeable Future External Effects.** External effects of state-managed fisheries and other vessel traffic on disturbance will likely occur in future years at a level similar to the baseline.

- **Cumulative Effects.** Cumulative effects of disturbance to transient killer whales are not likely to result in any population-level effects and are therefore considered insignificant.

Direct/Indirect Effects FMP 4.2

Under FMP 4.2, the groundfish fisheries would be essentially closed until specific fisheries were certified to have no adverse effects on the environment. The potential impacts to marine mammals would therefore be even less than described under FMP 4.1 but the conclusions regarding direct/indirect effects for incidental

take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 4.2 are the same as described under FMP 4.1.

Cumulative Effects

Since the groundfish fisheries would be essentially closed under FMP 4.2, the cumulative effects for mortality, prey availability, spatial and temporal concentration of the fishery, and disturbance would all be dominated by the same persistent past and external factors discussed under FMP 4.1. Since the contribution of the groundfish fisheries to all of these effects is also greatly reduced relative to the baseline condition under FMP 4.1, the cumulative effects conclusions are the same as discussed under FMP 4.1.

4.8.8.7 Other Toothed Whales

FMP 4.1 – Direct/Indirect Effects

Incidental Take/Entanglement in Marine Debris

Since fishing effort is greatly reduced relative to the baseline under FMP 4.1, incidental takes of other toothed whales would be expected to decrease under FMP 4.1. Under the baseline conditions, takes and entanglements associated with fishing activities are thought to be insignificant to other toothed whales at the population level. Reducing these takes even further would also be considered to have insignificant effects on the population trajectory of other toothed whales.

Fisheries Harvest of Prey Species

The effects of the groundfish fisheries under FMP 4.1 on the toothed whales are largely constrained by differences between their prey and the fisheries harvest targets. FMP 4.1 is not expected to increase the level of interactions relative to the baseline for the endangered sperm whale or non ESA-listed toothed whales and is therefore determined to be insignificant at the population level for all species.

Spatial/Temporal Concentration of the Fishery

Groundfish fisheries have little competitive overlap with toothed whales (see Section 4.5.8.7). Changes to the spatial/temporal concentration of the fisheries under FMP 4.1 are expected to have insignificant effects on toothed whales at the population level.

Disturbance

FMP 4.1 is expected to result in decreased disturbance to endangered sperm whales and other toothed whales relative to the baseline. However, because the effects of disturbance are insignificant under the baseline conditions they would also be insignificant at the population level under FMP 4.1.

Cumulative Effects

The past/present effects on the other toothed whale group are described in Sections 3.8.19 through 3.8.21 and Section 3.8.23 to 3.8.25 (Tables 3.8-19 through 3.8-25). The effects considered in this analysis are listed in Table 4.5-68. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** Incidental take of toothed whales would decrease under FMP 4.1 and is considered insignificant.

- **Persistent Past Effects.** Persistent past effects on species within the other toothed whale group include incidental take and entanglement in foreign, JV, Federal domestic groundfish fisheries and State-managed fisheries, and subsistence hunting of beluga whales. The decline of the Cook Inlet beluga population is thought to have been the result of subsistence harvests, which ranged from 21 to 123 animals per year between 1993 and 1998. Only one beluga was harvested in 2001 by hunters from the Native Village of Tyonek and one beluga was harvested in 2002 by the Cook Inlet community hunters. Belugas are incidentally taken during the State-managed salmon gillnet fisheries in Bristol Bay and Cook Inlet with one beluga reported taken from the eastern Bering stock in 1996 and seven reported taken in Bristol Bay in 2000. In the BSAI and GOA groundfish fisheries, no mortality or serious injuries to belugas have been observed. Harbor porpoise have not been taken in the observed groundfish fisheries over a ten year period between 1990 to 1998 (Angliss *et al*. 2001). Salmon gillnet fisheries in southeast Alaska take approximately three individuals per year. Dall porpoise mean annual mortality was 6.0 for the Bering Sea groundfish trawl fishery, 1.2 for the GOA groundfish trawl fishery, and 1.6 for the Bering Sea groundfish longline fishery. The Alaska Peninsula/Aleutian Island salmon drift gillnet fishery has a higher take of Dall's Porpoise with an estimated 28 porpoises in one year (1990). Thousands of Pacific white-sided dolphins were killed annually between 1978 and 1991 in the high seas driftnet fisheries, which no long occur (Angliss *et al*. 2001). One Pacific white-sided dolphin was taken in the BSAI trawl fishery and one in the BSAI longline fishery during the same time span (Angliss *et al*. 2001). State-managed salmon gillnet fisheries take approximately two dolphins per year.

  Approximately 258,000 sperm whales in the North Pacific were harvested by commercial whalers between 1947 and 1987, with high counts in 1968 when 16,357 sperm whales were harvested, after which the population were severely depleted. Sperm whale interactions with longline fisheries operating in the GOA are known to occur and may be increasing in frequency. Sperm whales have been known to prey on sablefish caught on commercial longline gear in the GOA. Only three entanglements have been reported in the GOA longline fishery.

  For killer whales, the combined mortality from the observed groundfish fisheries was 1.4 whales per year (Angliss *et al*. 2001). While it is most likely that whales interacting with fisheries are from resident pods (since they eat fish), no genetic testing has been done on whales incidentally taken in the groundfish fisheries to ascertain whether they were from resident or transient stocks.

For beaked whales (Baird's, Cuvier's, or Stejneger's), no incidental takes or entanglements in BSAI and GOA groundfish trawl, longline, and pot fisheries have been documented (Hill and DeMaster 1999).

- **Reasonably Foreseeable Future External Effects.** Foreign fisheries outside the U.S. EEZ and State-managed fisheries were identified as potential effects in the futures. Several of these species range outside of BSAI and GOA during the winter months. Subsistence takes of some beluga whales would be expected to continue similar to the baseline conditions. Other species are not taken for subsistence purposes.

- **Cumulative Effects.** Cumulative effects of mortality resulting from internal and external factors are considered insignificant for all non-ESA listed species due to the low level of incidental take in the groundfish fisheries and limited external human-caused mortality.

  For the endangered sperm whale, the cumulative effect was also considered insignificant because the very low level of incidental take in the groundfish fisheries and very limited human-caused mortality from external sources is not expected to delay the recovery of sperm whale populations.

Prey Availability

- **Direct/Indirect Effects.** The groundfish fishery under FMP4.1 is not expected to increase the level of competitive interactions for toothed whale prey from the baseline condition and is therefore considered to have insignificant effects on toothed whale prey.

- **Persistent Past Effects.** Although this group preys on a wide variety of fish species, past effects on the availability of prey for this group are identified for fisheries in general and include the foreign, JV, and Federal domestic groundfish fisheries and the State-managed fisheries for salmon and herring. The diversity of diet in this whale group results in limited overlap for most species with the possible exception of sperm whales and resident killer whales.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries were identified as an external factor having a potential effect on prey for these species in the future. Climate and regime shift are also identified but the direction and magnitude of these effects are difficult to predict.

- **Cumulative Effects.** The ability of these whale species to forage over wide areas and on a variety of prey species moderates any potential impacts from fisheries competition. Cumulative effects on prey availability were identified for this group, including a very limited contribution from the groundfish fishery, but the degree of fishery harvest and bycatch of prey important to these whale species is not expected to have population-level effects on any species, including the endangered sperm whale, and is therefore considered insignificant.

Spatial/Temporal Concentrations of the Fisheries

- **Direct/Indirect Effects.** The groundfish fisheries have little competitive overlap with toothed whales; therefore, changes to the spatial/temporal concentration of the fisheries is expected to result in effects that are insignificant to sperm whales and other toothed whales at the population level.

- **Persistent Past Effects.** The spatial/temporal concentration of foreign, JV, and domestic groundfish fisheries and the State-managed fisheries are believed to have had minimal effects on the abundance and distribution of toothed whale prey.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries are expected to continue in a similar manner as the under the baseline conditions. Effects of future fishing activities on toothed whale prey are expected to be minimal.

- **Cumulative Effects.** The ability of toothed whales to forage over wide areas and on a variety of prey species moderates any potential impacts from localized depletion of prey from the spatial/temporal concentration of fisheries. Cumulative effects on prey abundance and distribution, including a very limited contribution from the groundfish fishery, are not expected to have population-level effects on any species, including the endangered sperm whale, and are therefore considered insignificant.

Disturbance

- **Direct/Indirect Effects.** Disturbance from the groundfish fishery under FMP 4.1 on sperm whale and other toothed whale populations is determined to be insignificant at the population level.

- **Persistent Past Effects.** Past potential disturbance effects on species in this group were identified for foreign, JV, and Federal domestic groundfish fisheries; however, there is little indication of an adverse effect from this level of disturbance. General vessel traffic likely also contributes to disturbance to these species.

- **Reasonably Foreseeable Future External Effects.** Increases in the general marine vessel traffic and continued fishing activity in the state-managed fisheries were identified as potential sources of disturbance.

- **Cumulative Effects.** The cumulative effect of disturbance from both internal and external factors is found to be insignificant for endangered sperm whales and other toothed whale species based on the lack of evidence that disturbance has a population-level effect for any of these species. For sperm whales, there is growing evidence that the whales are attracted to fishing vessels as reliable and easy sources of food.

Direct/Indirect Effects FMP 4.2 – Other Toothed Whales

Under FMP 4.2, the groundfish fisheries would be essentially closed until specific fisheries were certified to have no adverse effects on the environment. The potential impacts to marine mammals would therefore be even less than described under FMP 4.1 but the conclusions regarding direct/indirect effects for incidental

take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 4.2 are the same as described under FMP 4.1.

Cumulative Effects

Since the groundfish fisheries would be essentially closed under FMP 4.2, the cumulative effects for mortality, prey availability, spatial and temporal concentration of the fishery, and disturbance would all be dominated by the same persistent past and external factors discussed under FMP 4.1. Since the contribution of the groundfish fisheries to all of these effects is also greatly reduced relative to the baseline condition under FMP 4.1, the cumulative effects conclusions are the same as discussed under FMP 4.1.

4.8.8.8 Baleen Whales

Direct/Indirect Effects FMP 4.1

Incidental Take/Entanglement in Marine Debris

Since fishing effort is greatly reduced relative to the baseline under FMP 4.1, incidental takes of baleen whales would be expected to decrease under FMP 4.1. Under the baseline conditions, takes and entanglements associated with fishing activities are thought to be insignificant to baleen whales at the population level. Reducing these takes even further would also be considered to have insignificant effects on the population trajectory of baleen whales.

Fisheries Harvest of Prey Species

The effects of groundfish fisheries under FMP 4.1 are considered insignificant to baleen whales in regards to harvest of prey species due to the lack of competitive overlap in species targeted by each (see Section 4.5.8.8).

Spatial/Temporal Concentration of the Fishery

Groundfish fisheries have little competitive overlap with baleen whales forage species. Changes to the spatial/temporal concentration of the fisheries under FMP 4.1 are expected to result in effects that are insignificant to baleen whales at the population level.

Disturbance

FMP 4.1 is expected to result in decreased disturbance to baleen whales relative to the baseline. However, because the effects of disturbance are insignificant under the baseline conditions they would also be insignificant at the population level.

Cumulative Effects

The past/present effects on the baleen whale group are described in Section 3.8.11 through 3.8.18 (Tables 3.8-11 through 3.8-18). The effects considered in this analysis are listed in Table 4.5-69.

Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** The reduced level of takes and entanglements of baleen whales projected to occur under the FMP 4.1 is considered insignificant at the population level for all species.

- **Persistent Past Effects.** Commercial whaling in the last century has had lingering effects on most of the baleen whales in this group with the possible exception of the minke whale. These include endangered blue whales, fin whales, sei whales, humpback whales, northern right whale and the non-ESA-listed gray whales and right whales. A full discussion of the effects of commercial whaling is presented in Section 3.8.

- **Reasonably Foreseeable Future External Effects.** Foreign fisheries outside the EEZ and State-managed fisheries are expected to continue to take small numbers of baleen whales in the coming years. Entanglements in fishing gear will continue to effect baleen whales throughout their ranges. Subsistence for gray whales and bowhead will continue to be the largest source of human-caused mortality.

- **Cumulative Effects.** Cumulative effects of mortality resulting from internal effects of the fishery and contributions from external factors are considered conditionally significant adverse for fin, humpback, and northern right whales due to past effects on their population, potential for interactions with fisheries, and their endangered status. Right whales are very rare so even one human-caused mortality could be considered significant. Given the overlap of their preferred habitat with the BSAI fisheries, the chances of future adverse interactions with fishing gear are more than negligible. The adverse rating for these three species is conditional on whether future take or entanglement substantially affects their rates of recovery. Cumulative effects are found to be insignificant for the endangered blue, bowhead, and sei whales. These species rarely interact with the fisheries so population-level effects are not anticipated. Mortality is also considered insignificant for non-ESA-listed minke and gray whales. Population-level effects are not expected for either of these species.

Prey Availability

- **Direct/Indirect Effects.** The effects of FMP 4.1 are determined to have an insignificant effect on baleen whale species in regards to harvest of prey species due to the lack of competitive overlap in species targeted by each.

- **Persistent Past Effects.** Past effects on availability of prey were not identified due to the lack of competitive overlap in prey species targeted.

- **Reasonably Foreseeable Future External Effects.** Future effects were identified as state-managed fisheries such as herring, which are preyed on by humpback whales and fin whales. Other species would not be directly affected through their prey.

- **Cumulative Effects.** Cumulative effects of prey availability on baleen whale species are not anticipated on a population level for any of the species in this group primarily due to the limited overlap of prey species with fisheries. The effects are considered insignificant for all species.

Temporal and Spatial Concentration of the Fishery

- **Direct/Indirect Effects.** Due to limited overlap of prey species taken, changes to the spatial/temporal concentration of the fisheries under FMP 4.1 are expected to have insignificant effects on baleen whales at the population level.

- **Persistent Past Effects.** Persistent past effects of temporal and spatial concentrations of the fisheries were not identified.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries would be expected to continue to contribute some degree of effect on several species in the baleen whales group.

- **Cumulative Effects.** Cumulative effects on the spatial and temporal concentration of harvest of baleen whale prey resulting from internal effects of the fishery and contributions from external factors are considered insignificant for endangered and non-ESA listed species in this group due to the limited overlap of prey species within the fisheries.

Disturbance

- **Direct/Indirect Effects.** FMP 4.1 is expected to result in decreased disturbance to endangered and non-ESA-listed baleen whales, but the effects are considered insignificant at the population level.

- **Persistent Past Effects.** Some level of disturbance has likely occurred from foreign, JV, and domestic groundfish fishing and State-managed fisheries along with general vessel traffic. For some species such as the gray and bowhead whales, subsistence activities have contributed to disturbance of these animals.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries and general vessel traffic from recreational boating and whale watching to commercial vessels would be expected to continue in future years as well as subsistence activities.

- **Cumulative Effects.** Cumulative effects of disturbance resulting from internal and external sources are determined to be similar to the baseline condition and not likely to result in a population-level effect for any of the species in this group. Therefore, the cumulative effect is considered to be insignificant for both endangered and non ESA-listed baleen whales.

Direct/Indirect Effects FMP 4.2

Under FMP 4.2, the groundfish fisheries would be essentially closed until specific fisheries were certified to have no adverse effects on the environment. The potential impacts to marine mammals would therefore be even less than described under FMP 4.1 but the conclusions regarding direct/indirect effects for incidental

take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 4.2 are the same as described under FMP 4.1.

Cumulative Effects

Since the groundfish fisheries would be essentially closed under FMP 4.2, the cumulative effects for mortality, prey availability, spatial and temporal concentration of the fishery, and disturbance would all be dominated by the same persistent past and external factors discussed under FMP 4.1. Since the contribution of the groundfish fisheries to all of these effects is also greatly reduced relative to the baseline condition under FMP 4.1, the cumulative effects conclusions are the same as discussed under FMP 4.1.

4.8.8.9 Sea Otters

Direct/Indirect Effects FMP 4.1

<u>Incidental Take/Entanglement in Marine Debris</u>

Since fishing effort is greatly reduced relative to the baseline under FMP 4.1, incidental takes of sea otters would be expected to decrease under FMP 4.1. Under the baseline conditions, takes and entanglements associated with fishing activities are thought to be insignificant to sea otters at the population level. Reducing these takes even further would also be considered to have insignificant effects on the population trajectory of sea otters.

<u>Fisheries Harvest of Prey Species</u>

Given the minor importance of groundfish in their diet (see Section 4.5.8.9), fisheries removals under FMP 4.1 are expected to be substantially reduced relative to the baseline condition but the effects on prey availability to otters are considered insignificant at the population level.

<u>Spatial/Temporal Concentration of the Fishery</u>

Because of the habitat preference of sea otters for shallow areas, they do not overlap spatially with groundfish fisheries. Therefore, the effects of the spatial/temporal concentrations of the fisheries under FMP 4.1 are insignificant for sea otters.

<u>Disturbance</u>

FMP 4.1 may result in decreased disturbance to sea otters relative to the baseline. However, because the effects of disturbance are insignificant under the baseline conditions they would also be insignificant at the population level under FMP 4.1.

Cumulative Effects

The past/present effects on the sea otter are described in Section 3.8.10 (Table 3.8-10). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. This analysis seeks to provide an overall assessment of the species' population level response to its environment as it is influenced by the groundfish fishery. The effects considered in this analysis are listed in Table 4.5-70. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects**. The effects of incidental take and entanglement on sea otters under FMP 4.1 are considered insignificant.

- **Persistent Past Effects.** Commercial exploitation for pelts had a huge impact on sea otters dating from the mid-1700s to the late 1800s, causing them to become nearly extinct (Bancroft 1959, Lensink 1962). Alaska Natives have hunted sea otters for pelts and meat throughout history. Current harvest levels represent nine percent of PBR for the southwestern stock, 15 percent of PBR for the southcentral stock, and 35 percent of PBR for southeast stock (USFWS 2002a, 2002b and 2002c). Oils spills, such as the EVOS, can result in substantial mortality of sea otters. Sea otter numbers have declined dramatically from the Alaska Peninsula to the Bering Sea, and this stock is being considered for listing under the ESA.

- **Reasonably Foreseeable Future External Effects.** Low levels of incidental take in commercial and subsistence fisheries, subsistence hunting, and periodic mortalities from oil spills are likely to continue in the future. Population-level effects from transient killer whale predation may continue in the southwest Alaska stock, depending on the recovery of alternate prey and behavior of whales.

- **Cumulative Effects.** The cumulative effects of mortality from all sources are different for different stocks of sea otters. The populations of the southeast and southcentral stocks of sea otters appear to be stable or increasing and are not expected to have additional mortality pressures in the future. These stocks are considered to have insignificant cumulative effects from mortality. The rapid decline of the southwest Alaska stock does not appear to be the result of food shortages, disease, or toxic contamination and is likely the result of increased predation by killer whales following the collapse of their preferred sea lion prey population in the 1980s (Estes *et al*. 1998). Since the mechanism(s) of the population decline is still under investigation, the cumulative effect on the southwest stock is considered to be conditionally significant adverse through mortality.

Prey Availability

- **Direct/Indirect Effects.** The effects of harvest of key prey species in groundfish fisheries under FMP 4.1 are determined to be insignificant for sea otters.

- **Persistent Past Effects.** The groundfish fisheries have had little effect on the availability of prey in the past due to the limited overlap in prey species of the sea otter and the fish targeted by the groundfish fisheries. There is some minor overlap in State-managed crab fisheries and sea otter prey.

- **Reasonably Foreseeable Future External Effects.** State-managed crab fisheries that take crab from shallow waters were identified as external effects. The overlap primarily occurs in inshore areas or offshore areas with relatively shallow water.

- **Cumulative Effects.** Effects on prey availability were determined to be cumulative based on both internal effects of the groundfish fisheries and external factors as in the crab fisheries. These cumulative effects are determined to be insignificant due to the very limited overlap of these fisheries and the sea otter forage species and not likely to have population-level effects.

<u>Spatial/Temporal Concentration of the Fisheries</u>

- **Direct/Indirect Effects.** The effects of the spatial/temporal concentrations of the fisheries under FMP 4.1 are insignificant for sea otters.

- **Persistent Past Effects.** The limited spatial overlap of groundfish fisheries and other fisheries in the past have limited their interaction with sea otter prey. Past effects of spatial/temporal concentration have likely been in very specific areas and associated with State-managed crab fisheries.

- **Reasonably Foreseeable Future External Effects.** State-managed crab fisheries are likely to continue into the future at a level similar to the baseline conditions.

- **Cumulative Effects.** The cumulative effect of the spatial/temporal harvest of prey in the internal and external fisheries is considered to be insignificant due their limited spatial overlap with sea otter habitat. These fisheries are unlikely to have population-level effects.

<u>Disturbance</u>

- **Direct/Indirect Effects.** Levels of disturbance under FMP 4.1 are expected to be similar to the baseline and are therefore considered to be insignificant.

- **Persistent Past Effects.** Past effects of disturbance are primarily related to some minor disturbance by vessel traffic from fisheries and other vessels and disturbance associated with subsistence harvest of sea otters.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries are expected to continue at a level similar to the baseline. Commercial vessel traffic within sea otter habitat in future years would be expected to be similar the baseline.

- **Cumulative Effects.** Cumulative effects of disturbance on sea otters are considered insignificant and are unlikely to result in any population-level effects. The contribution of the groundfish fishery to the overall cumulative effect is minor.

Direct/Indirect Effects FMP 4.2

Under FMP 4.2, the groundfish fisheries would be essentially closed until specific fisheries were certified to have no adverse effects on the environment. The potential impacts to marine mammals would therefore be even less than described under FMP 4.1 but the conclusions regarding direct/indirect effects for incidental take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 4.2 are the same as described under FMP 4.1.

Cumulative Effects

Since the groundfish fisheries would be essentially closed under FMP 4.2, the cumulative effects for mortality, prey availability, spatial and temporal concentration of the fishery, and disturbance would all be dominated by the same persistent past and external factors discussed under FMP 4.1. Since the contribution of the groundfish fisheries to all of these effects is also greatly reduced relative to the baseline condition under FMP 4.1, the cumulative effects conclusions are the same as discussed under FMP 4.1.

4.8.9 Socioeconomic Alternative 4 Analysis

Alternative 4 represents a highly precautionary approach to managing fisheries under scientific uncertainty. This section contains both quantitative and qualitative assessments of select economic and social effects of FMP 4.1 and FMP 4.2.

4.8.9.1 Harvesting and Processing Sectors

The model and analytical framework used in the analysis of the effects of FMP 4.1 on the harvesting and processing sectors are described in Section 4.1.7.

Model projections of ex-vessel value and product value for this FMP are based on 2001 prices and product mixes. Because FMP 4.1 results in large reductions in catches of pollock and Pacific cod for both catcher vessels and catcher processors, actual prices might be expected to increase as a result of a reduction in the quantity of fish and the subsequent product supplied. The extent to which prices would increase depends on demand elasticities. Due to the presence of a large number of substitutes for Alaska groundfish products, the demand for these products is believed to be relatively elastic. In other words, prices for groundfish products are unlikely to be substantially influenced by changes in harvests. Also, ex-vessel prices are determined by negotiations between individual processors on one side and either bargaining associations for catcher vessels or individual fishermen on the other side. Ex-vessel prices may not behave as one might expect in a competitive market. Actual prices will ultimately depend on the relative bargaining power of harvesters and processors.

Historically, the product quality and prices for headed and gutted cod have often been higher for Pacific cod caught with fixed gear. Therefore, the elimination of the trawl fisheries and the expansion of the fixed-gear fisheries might be expected to increase the prices of headed and gutted Pacific cod. The use of product prices that are not gear-specific could underestimate the total product value for FMP 4.1 and would overstate the reduction in product value due to this FMP bookend. There is not a similar problem with ex-vessel value projections because gear-specific ex-vessel prices were used.

However, the assumption of constant prices and product mix may also result in bias in the opposite direction if a decline in catch quality puts downward pressure on average prices. This FMP would result in large shifts in catch both spatially and temporally relative to the comparative baseline. It is reasonable to assume that, subject to regulatory constraints, harvesters target catch in areas and time periods that maximize its value either by increasing the value (quality) of the fish or by decreasing the harvesting cost or both. If catch quality is lower, prices received are lower and total gross revenue is affected. The model projections for FMP 4.1 may understate the actual impact since 2001 ex-vessel prices are used to calculate ex-vessel value.

It is also possible that catch estimates from the model projections may be overstated. If catch rates are reduced substantially due to the spatial/temporal shift of harvests, it may not be possible or cost-effective for the fleet to take the full projected catch. Moreover, the concentration of fishing effort in the areas that remain open may lead to localized depletion of stocks and a decline in catch per unit of effort over the long-term. The model projections do not reflect these possibilities and therefore may overstate ex-vessel value and product value by overstating the quantity of catch.

It should also be noted that the model projections indicate that catches of Pacific cod do not decline significantly under this FMP. This projection is believed to be erroneous and an artifact of the way in which the model apportions catch between catcher vessels and catcher processors. The model redistributes a significant amount of catch from longline catcher processors to pot catcher vessels. In reality, such a reapportionment would not be expected to occur. Therefore, the model output overstates catcher vessel catches and understates catcher processor catches.

Finally, it is important to note that this analysis assumes that the no-take MPA established under this FMP bookend only apply to the groundfish fisheries. Non-groundfish fisheries would be allowed to be prosecuted within the borders of the marine protected areas subject to current regulations. However, it is possible that the no-take concept would be applied more broadly to include fisheries not managed under the groundfish FMPs. For example, the area closures could be applied in federal waters so as to prohibit crab fisheries in the BSAI, salmon fisheries in the southeast GOA, Bering Sea scallop fisheries, and halibut fisheries. It is also possible that the area closures could extend into State of Alaska waters if the state chose to implement complementary measures. The broader application of no-take marine protected areas would magnify the adverse economic impacts described in this analysis. In particular, small vessels that participate in non-groundfish fisheries may experience a larger decrease in revenues than what is projected in this analysis, as these vessels may be unable to travel beyond the boundaries of the area closures.

The net impact of upward and downward bias in projections of ex-vessel value and product value is difficult to determine; however, we expect that model projections of ex-vessel value and product value are likely to understate the adverse impact of FMP 4.1 on these variables. Whether the bias in projections is high or low, we expect large reductions in ex-vessel value and product value to occur under FMP 4.1 relative to the comparative baseline.

Table 4.8-6 summarizes projected impacts of FMP 4.1 on the harvesting and processing sectors. The numbers in the table reflect the 5-year average of outcomes projected for 2003 to 2007. Under FMP 4.1, there would be significant decreases in the harvest of groundfish species as a result of a large projected decrease in the TAC. The 5-year mean estimate of groundfish wholesale product value is about $0.5 billion, a 64 percent decrease when compared to the baseline.

The 5-year mean estimate of the pollock harvest is 1,035,000 mt (71 percent) lower than the comparative baseline. Pacific cod harvest are expected to decrease by 126,000 mt (58 percent), and harvest of species in the A-R-S-O species aggregation as a whole are predicted to decrease by 109,000 mt (74 percent). Only flatfish harvests do not change significantly in comparison to the comparative baseline. Total groundfish payments to labor are expected to decrease by 64 percent, and groundfish employment will decrease by about 6,000 FTE positions.

4.8.9.1.1 Catcher Vessels

Direct/Indirect Effects of FMP 4.1

Groundfish Landings By Species Group

A comparison of the 5-year average of outcomes projected for the 2003 to 2007 period to 2001 catcher vessel conditions reveals that the large decrease in groundfish TAC that occurs under FMP 4.1 will cause retained catches of all groundfish species to significantly decline (see the earlier discussion regarding the erroneous model projections of Pacific cod catches for this FMP).

Ex-Vessel Value

As a result of the overall decrease in retained catch, the total ex-vessel value of groundfish landed by catcher vessels is expected to decrease significantly relative to the comparative baseline. Fixed-gear catcher vessels are expected to experience a less dramatic decline in groundfish ex-vessel value in comparison to classes of trawl catcher vessels because of the measure in FMP 4.1 that prohibits trawling in all fisheries that can be prosecuted with other gear types. In effect, this measure represents an allocation of groundfish TAC to users of fixed gear. Nevertheless, the decrease in the TAC for Pacific cod is expected to cause the ex-vessel value of fixed-gear catcher vessels to decline significantly.

Employment and Payments to Labor

Groundfish employment and payments to labor by all classes of catcher vessels are expected to decrease significantly under FMP 4.1. Most of the decrease in employment and payments to labor is incurred by the three classes of AFA-eligible trawl catcher vessels and fixed-gear catcher vessels 33 to 59 ft in length.

Impacts on Excess Capacity

Because FMP 4.1 would result in a large decrease in the quantity of catch and products from the groundfish fisheries, it is expected to generally lead to significantly higher excess capacity in the harvesting sector. However, the impacts of FMP 4.1 on excess capacity will vary by vessel class. Vessels using trawl gear will see a significant increase in excess capacity because of the reapportionment of Pacific cod to fixed gear. For fixed-gear vessels, the FMP measures are expected to have both adverse and beneficial effects in terms of harvest capacity. The reapportionment of Pacific cod to fixed-gear vessels will reduce excess capacity. However, the decrease in the TAC will cause a decline in the overall catches of fixed-gear catcher vessels.

To control capacity in the groundfish fisheries, FMP 4.1 includes all current measures that address overcapacity, including the LLP, the sablefish longline fishery IFQ program; the cooperatives established in the BSAI pollock fishery under the AFA, and the western Alaska CDQ program. In addition, FMP 4.1 would implement effort-based measures (also referred to as input-based methods) to further control fishing capacity. These effort-based measures may include limits on trips, gear size, vessel size or vessel horsepower or seasonal exclusive area registration. All effort-based measures attempt to control capacity by directly regulating the character, amount or usage of various fishing inputs. Gear and vessel restrictions limit the type or quantity of those particular inputs. Seasonal exclusive area registration prohibits individual fishing units from operating outside a specified area each season, thereby restricting where inputs can be used. Trip limits restrict the extent to which inputs can be used by imposing a catch ceiling for an individual fishing trip. Trip limits are often accompanied by a limit on the frequency of landings, which restricts the duration of use of inputs.

Obviously such measures would have to be associated with a restriction on the number of fishermen, otherwise it is clear that no control is placed on total potential effort. The number of participants in the Alaska groundfish fisheries is currently capped by the LLP. The LLP also limits the number of vessels that can use fixed gear. Even if the number of fishermen is restricted, effort-based measures do little towards mitigating the race for fish, and fishermen will continue to have an incentive to fish harder in order to maintain or increase their share of the TAC. Moreover, while the measures considered here can severely restrict the type, amount or use of fishing inputs, experience in fisheries worldwide shows that, given time to adjust, fishermen will often find ways of increasing their fishing effort by substituting inputs that are not controlled.

Average Costs

FMP 4.1 is expected to a have a significantly adverse impact on the average costs of many fishing operations. The closure of sea lion critical habitat to trawling, establishment of no-take marine protected areas, and the TAC component of FMP 4.1 would lower harvest rates for most classes of catcher vessels. Consequently, average costs per unit of catch for catcher vessels can be expected to increase substantially under FMP 4.1 because of the reduction in the overall level of production resulting from lower catches. Many costs are fixed (e.g., loan repayments, general office and accounting expenses and insurance costs); and are not reduced with the level of production. These costs would be allocated to a smaller amount of product, raising the average cost per unit of product.

Additionally, the redistribution of fishing effort to fixed gear vessels may lead to grounds congestion, increased gear conflicts, increased fishing costs and reduced gross revenue for these vessels. For example, grounds crowding with pots and longline gear occurred in the halibut and sablefish fisheries prior to the implementation of the IFQ program.

The spatial displacement of fishing effort resulting from implementation of FMP 4.1 would be substantial for some catcher vessels. These changes can be expected to lead to increased operating costs since vessels will have to travel farther to reach open areas and will likely be required to fish in less productive areas in some cases. The greatest impact would be on smaller trawl and fixed-gear vessels because of their more limited fishing range.

It is reasonable to assume that, subject to regulatory constraints, harvesters target catch with the gear that maximizes its value either by increasing the quality of the fish or by decreasing the harvesting costs, or both. For example, bottom trawl gear and fixed gear are actively used in the BSAI and GOA Pacific cod fisheries. The fixed-gear cod fishery is an economically viable fishery; however, the feasibility and cost of having it completely replace the bottom trawl cod fishery is not known. The information required to compare harvesting costs by gear is unavailable. However, to the extent that the historical fishing gear was used because it has the lowest cost per unit of catch, the replacement of several bottom trawl fisheries with fixed-gear fisheries would increase cost per unit of catch.

The effort-based methods implemented under FMP 4.1 to control harvesting and processing capacity would impose additional costs on fishermen. In general, these methods are designed to increase the cost of producing effort for individual fishing units by prohibiting certain cost-effective ways of operating (Anderson 1989). To adjust to these imposed inefficiencies, fishermen will continue to increase their outlays on doing whatever is permitted to maintain or increase their share of the catch. These permitted adjustment costs may include expenditures not only on vessel and gear improvements or storing fish on board longer, but also on reequipping their vessels to make them usable in other fisheries (Scott 1979).

The expanded observer coverage, scale and VMS requirements would also impose additional operating costs on fishery participants. In addition to the cost of paying for additional observers (expected to be about $355 per deployment day, not including food costs), some smaller vessels may have difficulty in providing berths for observers.

Fishing Vessel Safety

FMP 4.1 is expected to result in a significant reduction in safety for the fishing vessels that remain active. While the large decrease in the groundfish TAC may reduce the number of active vessels and thereby decrease the number of persons at risk, it is likely that the decrease in catches will encourage vessel owners to reduce crew size in an effort to compensate for reduced earnings. Reductions in crew size, in turn, may increase the risk of vessel accidents. Both the closure of sea lion critical habitat to trawling and the establishment of no-take marine protected areas would result in vessels fishing farther from port and possibly in more hazardous areas. The adverse effects would be more extreme for smaller vessels. In addition, effort-based measures such as gear and vessel restrictions may require fishermen to employ smaller vessels, thereby decreasing fishing safety. Moreover, effort-based measures to control overcapacity require fishermen to use inefficient fishing methods and do little to reduce their impulse to intensify their fishing operations by, for example, operating farther from shore or in areas and seasons with more hazardous weather conditions.

Cumulative Effects of FMP 4.1

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect. The persistent past effects on catcher vessels are presented in detail in Section 3.9 (Table 3.9-125) and the predicted direct/indirect effects are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish ex-vessel value, employment, payments to labor, excess capacity, average costs, and fishing vessel safety. Table 4.8-6 summarizes this cumulative effects analysis.

Groundfish Landings By Species Group

- **Direct/Indirect Effects**. Significantly adverse effects are expected under FMP 4.1 due to the decrease in harvest.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1 under FMP 1.

- **Cumulative Effects**. Given the current downward trends in the commercial salmon and crab fisheries, the predicted change in retained harvests under FMP 4.1 is expected to result in significantly adverse cumulative effects. The significant reduction in harvest levels will further exacerbate the cumulative effects of reductions in other fisheries. Groundfish landings by species will be reduced resulting in significantly adverse cumulative effects.

Ex-Vessel Value

- **Direct/Indirect Effects.** The total ex-vessel value of groundfish landed by catcher vessels is expected to result in significantly adverse effects under FMP 4.1.

- **Persistent Past Effects.** The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** Overall reductions in groundfish catch is likely to dramatically decrease ex-vessel value for fixed-gear vessels while a less dramatic decline is likely for trawl vessels. Decreases in ex-vessel value in other fisheries such as salmon and crab may continue to occur, thereby exacerbating the cumulative effects of FMP 4.1. Changes in revenue streams that affect the ability of communities to provide municipal services, fund capital projects, borrow money, and retire or service debt have the greatest potential for cumulative effects on landing tax revenues from non-groundfish fisheries (such as salmon, crab, and halibut). During recent years, state municipal revenue sharing, power cost equalization and contributions to education programs have been decreasing. Given the potential of these conditions to contribute to decreased levels of harvest under FMP 4.1, cumulative effects ex-vessel value on are expected to be significantly adverse.

Employment and Payments to Labor

- **Direct/Indirect Effects**. Significantly adverse effects are projected for employment and payments to labor.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. Overall reductions in other fisheries such as salmon and crab, and the fact that many fishermen often rely on participation in multiple fisheries, significantly adverse cumulative effects are anticipated for FMP 4.1. The projected decrease in employment (60 percent) for the groundfish fisheries under this FMP will intensify the adverse effects experienced in other fisheries. While other economic activities and other sources of municipal and state revenue have the potential to mitigate these effects by providing other employment opportunities, many rural Alaska villages rely so heavily on fishing that other such options for earning income are not always available. This is particularly true if the economy and government spending are down. Thus, the reductions in harvesting under FMP 4.1 are expected to result in significantly adverse cumulative effects.

Impacts on Excess Capacity

- **Direct/Indirect Effects**. Changes in excess capacity are likely to be significantly adverse under FMP 4.1.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. Historical expansions in fishing capacity followed by reductions in harvest levels and product value have resulted in persistent adverse effects on excess capacity. Excess capacity has not only been a problem in the groundfish fishery but exists in other fisheries as well. The number of fishing permits would be greatly reduced under FMP 4.1 but the number of vessels would remain high, resulting in many vessels sitting idle, not permitted to fish. The dramatic reductions in harvest levels under FMP 4.1 combined with the persistent past effects of overcapacity are projected to result in significantly adverse cumulative effects on excess capacity. (For details refer to the Overcapacity Paper in Appendix F-8).

Average Costs

- **Direct/Indirect Effects**. Significantly adverse effects are expected to occur for average costs under FMP 4.1.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. Average costs in the groundfish fisheries are often associated or shared with other fisheries. Fixed costs are somewhat independent of the fisheries in that loan payments and general office and accounting expenses remain at a certain amount while ex-vessel value and product value are variable. Depending on area closures or the fixed or variable costs in other fisheries, when considered in combination with average costs in the groundfish fishery, cumulative effects may result. Should costs in other fisheries increase or decrease, vessels that are dependent on multiple fisheries are often sensitive to these changes. Although the overall reductions in TAC under FMP 4.1 may reduce costs, the increases in closure areas and the collective pressure of fixed costs are such that significantly adverse cumulative effects are anticipated.

Fishing Vessel Safety

- **Direct/Indirect Effects**. Significantly adverse effects are predicted under FMP 4.1.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. Vessel safety is primarily a function of the race for fish, and of distance to fishing areas and sea conditions relative to vessel size. The extent of closures proposed under FMP 4.1 are likely to increase the risk to the few vessels still permitted to harvest, as they may have to travel much greater distances to harvest fish. Significantly adverse cumulative effects are predicted under FMP 4.1.

4.8.9.1.2 Catcher Processors

Direct/Indirect Effects of FMP 4.1

Groundfish Landings By Species Group

A comparison of the 5-year average of outcomes projected for the 2003-2007 period to 2001 catcher processor conditions reveals that the large decrease in groundfish TAC that occurs under FMP 4.1 will cause catches of all groundfish species except flatfish to decline significantly.

Groundfish Gross Product Value

Groundfish employment and payments to labor by all classes of catcher processors are expected to decrease significantly under FMP 4.1.

Employment and Payments to Labor

As a result of the decrease in catch, the overall wholesale product value of groundfish processed by catcher processors is expected to decrease significantly relative to the comparative baseline. All classes of catcher processors would experience a significant decline in product value. Notwithstanding the model projection that flatfish catches will remain relatively stable compared to the baseline, the head-and-gut trawl catcher processors that focus on flatfish are expected to experience a significant decline in product value because of the reapportionment of Pacific cod to fixed-gear vessels. Moreover, fixed-gear catcher processors are expected to experience a significant decline in product value despite the reapportionment because of the overall reduction in the TAC.

Product Quality and Product Utilization Rate

A conditionally significant decrease in product quality is expected under this FMP relative to the comparative baseline. The additional area closures that are implemented under FMP 4.1 are expected to cause product quality to decline, but the intensity of this effect and the probability of its occurrence are uncertain. It is reasonable to assume that, subject to regulatory constraints, harvesters target catch in areas that maximizes its value either by increasing the quality of the fish or by decreasing the harvesting cost or both. Consequently, a measure that prohibits vessels from using historical fishing grounds may result in a decline in product quality (e.g., fish may be smaller or a less uniform size). In contrast, FMP 4.1 is expected to result in a conditionally significant increase in product utilization rates relative to the comparative baseline. The extension of improved retention and utilization regulations to all target fisheries is expected to result in an increase in product utilization. Moreover, the large decrease in catch that occurs under FMP 4.1 provides a strong incentive for processors to use the fish that are harvested to the fullest possible extent. However, the intensity of this effect and the probability of its occurrence are uncertain.

Excess Capacity

As with catcher vessels, FMP 4.1 is predicted to generally lead to significantly higher excess capacity.

Average Costs

As with catcher vessels, FMP 4.1 is predicted to generally lead to significantly higher average costs. The closure of sea lion critical habitat to trawling, establishment of no-take marine protected areas, and the TAC component of FMP 4.1 would lower harvest rates for catcher processors and consequently, average costs per unit of catch can be expected to increase substantially under FMP 4.1. Perhaps more importantly the overall reduction in TACs will reduce average costs. Many costs are fixed (e.g., loan repayments, general office and accounting expenses and insurance costs) and are not reduced with the level of production. These costs would be allocated to a smaller amount of product, raising the average cost per unit of product.

The extension of improved retention and utilization regulations to all target fisheries is expected to have a significantly adverse economic impact on all head-and-gut trawl catcher processors by decreasing gross revenues and/or increasing operating costs. The flatfish discard rates of these vessels are high in fisheries that target flatfish and in fisheries in which flatfish are caught incidentally. To the extent that the race for fish allows it, head-and-gut trawl catcher processors may offset the lost revenues or additional costs experienced under IR/IU regulations by taking additional fishing trips. However, the number of profitable trips vessels can make may be limited by seasonal decreases in fish quality and/or roe content that lower ex-vessel prices. Smaller head-and-gut trawl catcher processors may be disproportionately affected by IR/IU regulations, as they are more likely constrained by hold space during a fishing trip, their processing capacity is more limited, and their slower speed restricts their ability to increase revenue by taking additional trips.

The expanded observer coverage and scale and VMS requirements would also impose additional operating costs on fishery participants. In addition to the cost of paying for additional observers (expected to be about $355 per deployment day, not including food costs), some smaller vessels may have difficulty in providing berths for observers. A motion-compensated platform scale would cost between $6,000 and $12,000. In addition, smaller (less than 200 ft. LOA) at-sea processors may have insufficient space in which to install scales without considerable reconfiguration or removal of existing processing equipment (J. Gauvin, Groundfish Forum, pers. comm., December 2003.). The current list price of a VMS unit is about $2,000.

Fishing Vessel Safety

As with catcher vessels, FMP 4.1 is expected to result in a significant reduction in fishing vessel safety relative to the comparative baseline.

Cumulative Effects of FMP 4.1

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect. The persistent past effects on catcher vessels are presented in detail in Section 3.9 (Table 3.9-125) and the predicted direct/indirect effects are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish ex-vessel value, employment, payments to labor, excess capacity, average costs, and fishing vessel safety. For a summary of the cumulative effects analysis, please refer to Table 4.8-6.

Groundfish Landings By Species Group

- **Direct/Indirect Effects**. Significantly adverse effects are expected under FMP 4.1due to the decrease in harvest.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to an increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1 under FMP 1.

- **Cumulative Effects**. As with catcher vessels, given the current downward trends in the commercial salmon and crab fisheries, the predicted change in retained harvests under FMP 4.1 is expected to result in significantly adverse cumulative effects. The significant reduction in harvest levels will further exacerbate the cumulative effects of reductions in other fisheries. Groundfish Landings by Species will be reduced resulting in significantly adverse cumulative effects.

Groundfish Gross Product Value

- **Direct/Indirect Effects**. The total gross product value of groundfish landed by catcher processors is expected to result in significantly adverse effects under FMP 4.1.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. As with catcher vessels, during recent years, state municipal revenue sharing, power cost equalization, and contributions to education programs have been decreasing. This often causes communities to rely on fish taxes for municipal revenue which may affect gross product value. The decreased level of harvest under FMP 4.1 is significant enough that reductions in harvest combined with increased municipal pressure will result in significantly adverse cumulative effects on gross product value, particularly for fixed-gear processors due to the reduction in TAC.

Employment and Payments to Labor

- **Direct/Indirect Effects**. Significantly adverse effects are projected for employment and payments to labor.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. Similar to catcher vessels, the overall reductions in other fisheries such as salmon and crab, contribute to the decrease in harvest levels under FMP 4.1. The projected decrease in employment (65 percent) for the groundfish fisheries under this FMP will exacerbate the adverse effects experienced in other fisheries. While other economic activities and other sources of municipal and state revenue have the potential to mitigate these effects by providing other employment opportunities, many rural Alaska villages rely so heavily on fishing that other such options for earning income are not always available. This is particularly true in smaller villages and if the economy and government spending are down. Thus, the reductions in harvesting under FMP 4.1 are expected to result in significantly adverse cumulative effects.

Product Quality and Product Utilization Rate

- **Direct/Indirect Effects**. Conditionally significant adverse effects are likely for product quality, but conditionally significant beneficial effects for product utilization rates are expected under FMP 4.1 relative to the baseline.

- **Persistent Past Effects**. For details on persistent past effects, please refer to the beginning of Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed under the Section 4.5.9.1.

- **Cumulative Effects**. Advances in technology have improved product quality and utilization for various fisheries throughout the world. The end of the race for fish has also made significant differences in product quality and utilization, however, any continuation of this harvest strategy in fisheries may hinder some of these improvements. Improvements in product quality might be expected in the future; however, the increased number of closure areas under FMP 4.1 may jeopardize some of the quality gained through better handling and techniques by the greater distances vessels may have to travel to harvest fish. Thus, conditionally significant adverse effects are predicted for product quality and significantly beneficial cumulative effects are projected for product utilization rate under FMP 4.1.

Impacts on Excess Capacity

- **Direct/Indirect Effects**. Changes in excess capacity are likely to be significantly adverse under FMP 4.1.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. Historical expansions in fishing capacity followed by reductions in harvest levels and product value have resulted in persistent adverse effects on excess capacity. Excess capacity has not only been a problem in the groundfish fishery but exists in other fisheries as well. The number of fishing permits would be greatly reduced under FMP 4.1 but the number of catcher processors would remain high, especially in the short-term. The dramatic reductions in harvest levels under FMP 4.1 combined with the persistent past effects of overcapacity are projected to result in significantly adverse cumulative effects on excess capacity. (For details please refer to the Overcapacity Paper in Appendix F-8).

Average Costs

- **Direct/Indirect Effects**. Significantly adverse effects are expected to occur for average costs under FMP 4.1.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. As with catcher vessels, average costs in for catcher processors are often associated or shared with other fisheries and include fixed and variable costs. Depending on area closures or the fixed or variable costs in other fisheries, when considered in combination with the increase in closure areas and reduced harvest rates under FMP 4.1 in the groundfish fishery, significantly adverse cumulative effects are likely. Should costs in other fisheries increase or decrease, catcher processors in the groundfish fishery may experience fewer or greater impacts to average costs.

Fishing Vessel Safety

- **Direct/Indirect Effects**. Significantly adverse effects are predicted under FMP 4.1.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. Vessel safety is primarily a function of the race for fish, and of distance to fishing areas and sea conditions relative to vessel size. The extent of closures proposed under FMP 4.1 are likely to increase the risk catcher processors, as they may have to travel much greater distances to harvest fish. Significantly adverse cumulative effects are predicted under FMP 4.1.

4.8.9.1.3 Inshore Processors and Motherships

Direct/Indirect Effects FMP 4.1

Groundfish Landings By Species Group

A comparison of the 5-year average of outcomes projected for the 2003 to 2007 period to 2001 inshore processor and mothership conditions reveals the large decrease in groundfish TAC that occurs under FMP 4.1 will cause catches of all groundfish species to decline significantly (see the earlier discussion regarding the erroneous model projections of Pacific cod catches for this FMP).

Groundfish Gross Product Value

As a result of the decrease in catch, the overall wholesale product value of groundfish processed by inshore processors and motherships is expected to decrease significantly relative to the comparative baseline. The economic impact of this decrease in groundfish product value would differ across processing facilities depending on the extent to which plants process other types of fish and shellfish resources, such as salmon, crab, halibut, and other finfish. For example, under FMP 4.1, the value of groundfish products produced by southcentral Alaska inshore plants would decline significantly but the decrease in total wholesale value of all fish and shellfish processed by these plants may not be significant. In contrast, groundfish represents a large portion of the wholesale production value of Bering Sea pollock shore plants. Under FMP 4.1, the decline in groundfish production value for these plants would result in a significant reduction in their total (groundfish and non-groundfish) wholesale value.

A significant decline in groundfish product value is also expected for southeast Alaska shore plants, Alaska Peninsula and Aleutian Islands shore plants, and Kodiak shore plants. This decline reflects the dependence of these processors on groundfish harvested in sea lion critical habitat or no-take marine protected areas.

Employment and Payments to Labor

Groundfish employment and payments to labor by all classes of inshore processors and motherships are expected to decrease significantly under FMP 4.1. Most of the decrease in employment and payments to labor is incurred by Bering Sea shore plants.

Product Quality and Product Utilization Rate

A significant decrease in product quality is expected under this FMP relative to the comparative baseline. The additional area closures that are implemented under FMP 4.1 may cause product quality to decline. It is reasonable to assume that, subject to regulatory constraints, harvesters target catch in areas that maximizes its value either by increasing the quality of the fish or by decreasing the harvesting cost or both.

Consequently, a measure that prohibits vessels from using historical fishing grounds may result in a decline in product quality (e.g., fish may be smaller or a less uniform size). In addition, Pacific cod and Alaska pollock are fragile fish whose quality deteriorates rapidly the longer the time between harvest and processing. Consequently, any factors that will increase the length of time to processing will lower the quality of the product produced. To the extent that FMP 4.1 results in catcher vessels traveling farther distances from (inshore) processors, and thereby lengthening the time between harvest and processing, the quality of surimi, fillets, and roe will be adversely affected.

In contrast, FMP 4.1 is expected to result in a conditionally significant increase in product utilization rates relative to the comparative baseline. The large decrease in catch that occurs under FMP 4.1 provides a strong incentive for processors to use the fish that are harvested to the fullest possible extent. However, both the intensity of this effect and the probability of its occurrence are uncertain.

Excess Capacity

As a result of the large decrease in groundfish catches, FMP 4.1 is predicted to generally lead to significantly higher excess capacity in both the harvesting and processing sectors, but some exceptions are expected. For example, those processing plants, such as southcentral Alaska inshore plants and floating inshore plants, that are only marginally dependent on groundfish may not experience a significantly higher excess capacity. This leads to direct/indirect effects ratings of insignificant/significantly adverse for excess capacity under FMP 4.1.

Average Costs

As a result of the large decrease in groundfish catches, FMP 4.1 is predicted to lead to significantly higher average costs. The overall amount of target species delivered to processors would decrease substantially. Average costs will increase because of the reduction in the overall level of production resulting from lower catches. Many costs are fixed (e.g., loan repayments, general office and accounting expenses and insurance costs) and will not change with the level of production. These costs would be allocated to a smaller amount of product, thereby raising the average cost per unit of product. The increase will be larger for those processors that are most dependent on groundfish. As average costs per unit of production rise, it is possible that they would exceed the value of production and lead to a shutdown or permanent closing of some processing plants and motherships.

Variable costs may also be increased under FMP 4.1. The reduction in supply of fish is likely to put upward pressure on ex-vessel prices. If spatial shifting of production raises average costs for catcher vessels, inshore plants and motherships may face increased pressure to pay higher prices for fish. The extent to which processors versus catcher vessels would absorb increased harvesting costs and be able to demand higher prices as total supply declines will depend on their relative bargaining power as well as price elasticities of the products made from the fish. However, increased ex-vessel prices are likely, and this could substantially raise variable costs of production for processors that have to purchase fish.

Cumulative Effects of FMP 4.1

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect. The persistent past effects on catcher vessels are presented in detail in Section 3.9 (Table 3.9-125) and the predicted direct/indirect effects are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish ex-vessel value, employment, payments to labor, excess capacity, average costs, and fishing vessel safety (see Table 4.8-6 for a summary of the cumulative effects).

<u>Groundfish Landings By Species Group</u>

- **Direct/Indirect Effects**. Significantly adverse effects are expected under FMP 4.1 due to the decrease in harvest.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1 under FMP 1.

- **Cumulative Effects**. As with catcher processors, given the current downward trends in the commercial salmon and crab fisheries, the predicted change in retained harvests under FMP 4.1 is expected to result in significantly adverse cumulative effects. The significant reduction in harvest levels will further exacerbate the cumulative effects of reductions in other fisheries. Groundfish Landings by Species will be reduced resulting in significantly adverse cumulative effects.

<u>Groundfish Gross Product Value</u>

- **Direct/Indirect Effects**. The total gross product value of groundfish landed by inshore processors and motherships is expected to result in significantly adverse effects under FMP 4.1.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. As with catcher processors, during recent years, state municipal revenue sharing, power cost equalization, and contributions to education programs have been decreasing. This often causes communities to rely on fish taxes for municipal revenue which may affect gross product value. The decreased level of harvest under FMP 4.1 is significant enough that reductions in harvest combined with increased municipal pressure will result in significantly adverse cumulative effects on gross product value, particularly for fixed-gear processors due to the reduction in TAC.

Employment and Payments to Labor

- **Direct/Indirect Effects**. Significantly adverse effects are projected for employment and payments to labor.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. Similar to catcher processors, the overall reductions in other fisheries such as salmon and crab, contribute to the decrease in harvest levels under FMP 4.1. The projected decrease in employment (60 percent) for the groundfish fisheries under this FMP will exacerbate the adverse effects experienced in other fisheries. While other economic activities and other sources of municipal and state revenue have the potential to mitigate these effects by providing other employment opportunities, many rural Alaska villages rely so heavily on fishing that other such options for earning income are not always available. This is particularly true in smaller villages and if the economy and government spending are down. Thus, the reductions in harvesting under FMP 4.1 are expected to result in significantly adverse cumulative effects.

Product Quality and Product Utilization Rate

- **Direct/Indirect Effects**. Conditionally significant adverse effects are likely for product quality but conditionally significant beneficial effects for product utilization rates are expected under FMP 4.1 relative to the baseline.

- **Persistent Past Effects**. For details on persistent past effects, please refer to the beginning of Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed under the Section 4.5.9.1.

- **Cumulative Effects**. Advances in technology have improved product quality and utilization for various fisheries throughout the world. The end of the race for fish has also made significant differences in product quality and utilization, however, any continuation of this harvest strategy in fisheries may hinder some of these improvements. Improvements in product quality might be expected in the future; however, the increased number of closure areas under FMP 4.1 may jeopardize some of the quality gained through better handling and techniques due to the greater distances vessels may have to travel to harvest fish. The reduction in harvest levels under this FMP are likely to cause processors to maximize unit utilization rate as there may be much fewer fish to process. Thus, conditionally significant adverse effects are predicted for product quality but conditionally significant beneficial cumulative effects are projected for product utilization rate under FMP 4.1.

Impacts on Excess Capacity

- **Direct/Indirect Effects**. Changes in excess capacity are likely to be significantly adverse or insignificant under FMP 4.1.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. Historical expansions in fishing capacity followed by reductions in harvest levels and product value have resulted in persistent adverse effects on excess capacity. Excess capacity has not only been a problem in the groundfish fishery but exists in other fisheries as well. The number of fishing permits would be greatly reduced under FMP 4.1 but the number of catcher processors would remain high, especially in the short-term. The dramatic reductions in harvest levels under FMP 4.1 combined with the persistent past effects of overcapacity are projected to result in significantly adverse cumulative effects on excess capacity. (For details refer to the Overcapacity Paper in Appendix F-8).

Average Costs

- **Direct/Indirect Effects**. Significantly adverse effects are expected to occur for average costs under FMP 4.1.

- **Persistent Past Effects**. The persistent past effects include: foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. The combination of these factors has contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects.** The future external effects include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects**. As with catcher vessels, average costs in for catcher processors are often associated or shared with other fisheries and include fixed and variable costs. Depending on area closures or the fixed or variable costs in other fisheries, when considered in combination with the increase in closure areas and reduced harvest rates under FMP 4.1 in the groundfish fishery, significantly adverse cumulative effects are likely. Should costs in other fisheries increase or decrease, catcher processors in the groundfish fishery may experience fewer or greater impacts to average costs.

Direct/Indirect Effects of FMP 4.2

FMP 4.2 would suspend the harvest of groundfish until more information is known on the impacts of fishing on the environment. Only fisheries certified by NOAA Fisheries to have no significantly adverse effects on the environment would be authorized to operate in the EEZ off Alaska.

During the period in which groundfish fisheries are suspended, all revenue from the fisheries would be reduced by 100 percent from the baseline case under this FMP. Approximately $1.5 billion in product value is projected to be foregone if no fisheries are certified by 2004. About 11,300 FTE positions are projected to be lost if no fisheries are certified by that year.

Under this FMP, all 917 catcher vessels, 89 catcher processors, 3 motherships and 3 floating inshore plants that were active in the Alaska groundfish fisheries in 2001 would be displaced until fisheries are certified. This suspension is expected to have a significantly adverse effect on the catches of all groundfish species, groundfish ex-vessel value and product value, groundfish employment and payments to labor, excess capacity, product quality, product utilization rates, and average costs. In the absence of the groundfish fisheries, fishing vessel safety is expected to significantly improve.

While boats across and within various vessel classes differ in their dependence on groundfish fisheries, the suspension of the groundfish fisheries is expected to have an adverse economic effect on the average boat in all the vessel classes. AFA-eligible trawl catcher vessel classes generated more than 85 percent of their annual ex-vessel value (gross revenue) from groundfish in 2001, while pot catcher vessels generated only about 10 percent of their total gross revenue from groundfish. From this perspective, impacts of the suspension of the groundfish fisheries are likely to be much greater for vessels that are more dependent on groundfish. This effect is also true for processors (both catcher processors and inshore plants and motherships) who are heavily dependent on groundfish harvests. However, vessel classes that catch relatively small quantities of groundfish and processors who process small quantities of groundfish may still be significantly adversely affected. For instance, a study by Northern Economics, Inc. (1999) on the importance of salmon to the Aleutians East Borough showed that many fixed-gear catcher vessels 33-59 ft in length that use seine gear in salmon fisheries and fixed gear for groundfish are only marginally profitable. Loss of revenue from either groundfish or salmon is likely to push a number of these vessels and processors toward bankruptcy.

Cumulative Effects of FMP 4.2

Displaced fishermen could either shift to different fisheries or tie up their vessels. Those displaced fishermen who successfully shift to other fisheries are likely to recover some portion of the revenue previously generated from fishing for groundfish. However, it is probable that displaced vessel owners will have difficulty relocating their operations given the limited access programs that have been implemented in State of Alaska fisheries and other U.S. fisheries. Thus, the effect on processors will be similar due to the reduction in groundfish harvest overall. Moreover, while some vessels and processors are already outfitted to participate in non-groundfish fisheries, other boat owners or processors may not be capable of shifting into other fisheries without substantial additional capital outlays. It is also likely that some fishermen or processors may face increased costs and uncertain markets if they are forced to shift their operations away from the communities in which they live.

Given that opportunities for displaced fishermen and processors to recover their lost harvest and income would be limited, it is likely that some displaced fishermen would be forced to sell out or retire. It is uncertain how active the Alaska, nationwide or world market is for the types of vessels, gear and other investment capital used in the groundfish fisheries. However, it is possible that the Alaska market for these assets could quickly be flooded. Suspension of the groundfish fisheries would likely depress the immediate resale market for fishing equipment and vessels as well as diminish the long-term investment value of the vessels owned by displaced fishermen who opt to continue fishing. The same fate is possible for processors who rely heavily on groundfish harvests. This could create an economic hardship for those fishermen or processors who are relying on money earned from selling their fishing assets to supplement their retirement funds.

Transfer of effort from groundfish to non-groundfish fisheries could also indirectly create economic hardship in the form of reduced profitability for those already engaged in non-groundfish fisheries. The majority of fisheries in Alaska and other areas of the U.S. are fully utilized. If fishermen in Alaska groundfish fisheries were to shift their effort to other fisheries, catch per unit of effort and individual harvest for non-groundfish fishermen would likely decline due to the intensified fishing pressure on fish stocks. Lower individual catches would mean a decrease in the incomes of part-time and full-time commercial fishermen and possibly a reduction in the non-market value of the recreational fishing experience to the sport anglers who participate in non-groundfish fisheries.

See Table 4.8-6 for a summary of the cumulative effects on catcher vessels, catcher processors and inshore processors and motherships under FMP 4.2.

4.8.9.2 Regional Socioeconomic Effects

The predicted direct and indirect effects of the groundfish fishery under FMP 4.1 and FMP 4.2 are described below. The past/present effects on regions that participate in the groundfish fishery are described in Section 3.9 (and summarized in Table 3.9-126) and below; these regions (illustrated in Figures 3.9-9 through 3.9-13) include the Aleutian Islands/Alaska Peninsula (comprised of the Aleutians East Borough and the Aleutians West Census Area, which includes the communities of Unalaska, Nikolski, Atka, Adak and the Pribilof Islands), Kodiak Island (Kodiak Island Borough, which includes the City of Kodiak) southcentral Alaska (the Kenai Peninsula Borough, Matanuska-Susitna Borough, Municipality of Anchorage, and the Valdez-Cordova Census Area, which includes the PWS region), southeast Alaska (all of the southeastern part of the state, from Yakutat Borough to Dixon Entrance), Washington inland waters (all counties bordering Puget Sound and the Strait of Juan de Fuca), and Oregon coast (Lincoln, Tillamook, and Clatsop counties, the three northernmost Oregon coastal counties). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case (Table 4.8-6).

Due to the linkages of potential effects on regions that participate in the groundfish fishery to changes in harvest and processing levels under each of the policy alternatives and illustrative FMP bookends, the direct and indirect effects of each alternative are based on an economic model that distributes potential effects to each of the participating regions. The indicators used to assess potential regional effects include the following:

- In-Region Processing and Related Effects;
- Regionally Owned At-Sea Processors;
- Extra-regional Deliveries of Regionally Owned Catcher Vessels;
- In-region Deliveries of Regionally Owned Catcher Vessels; and
- Total Direct, Indirect, and Induced Labor Income and FTEs.

As discussed earlier, these indicators also reflect changes in other important regional characteristics such as secondary economic activity associated with the support of fishing, state and municipal revenue generated by fishing, and indirectly population, to the extent that it is related to employment opportunities. For more information on the economic model used to assess direct and indirect regional effects, see analysis for FMP 1 and Section 4.1.7 of the document.

Direct/Indirect Effects of FMP 4.1

Alternative 4 represents a highly precautionary approach, in which TAC is reduced, or in the case of FMP 4.2, eliminated until fishing activity is determined not to have significantly adverse effects. Additional management measures related to bycatch, protection of prohibited species, and habitat protection, including closures by gear types, are applied. Under FMP 4.1, in general there is a strong net overall decrease in fishery socioeconomic indicator values over baseline conditions for all regions. For example, total value of processing sales decreases by about 64 percent over baseline conditions, while total processing and harvesting related income and employment decrease by 64 and 61 percent, respectively, for all regions combined. The decreases are large (and significant) for each of the regions. The overall regional level (and individual community level) impacts will ultimately be based on the relative dependency of the locally operating (or owned) fishing sector components on the groundfish fishery, and, in turn, the dependency of local community and regional economies on the commercial fishing in overall. While there are a number of exceptions, in general the economies of Alaska Peninsula and Aleutian Islands communities (and the region as a whole) are less diversified into non-fishery related activity (and therefore more vulnerable at a higher level) than those seen in other Alaska regions, and particularly those of southcentral and southeast Alaska (with Kodiak in between). The following subsections provide a region-by-region summary of change under FMP 4.1 as compared to the baseline.

Alaska Peninsula and Aleutian Islands. Under FMP 4.1, total in-region groundfish processing value would decrease by 62 percent (with decreases in both the BSAI portion and GOA portion of the total). In region processing associated labor income and FTE jobs would also decrease by 62 percent. Regionally owned at-sea processing value (and associated payments to labor and FTEs) would decline sharply in percentage terms, but this is a very small sector in this region, with negligible impact on a regional basis. The value of extra-regional and in-region deliveries by regionally owned catcher vessels would decrease by 61 and 58 percent, respectively. Catcher vessel payments to labor and FTE jobs associated with extra-regional deliveries would decrease by about 61 and 65 percent respectively. For in-region deliveries, catcher vessel payments to labor and FTEs would decrease by about 58 and 59 percent, respectively, but for both extra-regional and in-region catcher vessel deliveries, the absolute values for this region are relatively small. With respect to the relative importance of the different sectors to net regional impacts, the in-region processing related activity accounts for the vast majority of fishery associated labor income and FTEs, so the decrease seen in processing values would be disproportionately important in relation to changes seen in the other sectors. (Further, in-region processing value may be taken as a proxy for regionally important municipal and borough revenues generated by local fish taxes.) The total regional direct, indirect, and induced labor income would decrease by about 62 percent and FTE employment would also decrease by about 62 percent under this FMP (from a base of $226 million in labor income and 4,796 FTEs). Under FMP 4.1, the Alaska Peninsula and Aleutian Islands region would experience significantly adverse impacts on the local sector level, the regional level, and the community level for all of the substantially engaged communities.

In addition to the profound adverse regional and community social impacts that would result from loss of revenues, economic opportunities and employment under from this FMP, the location of marine reserves may further disadvantage specific communities in this as well as other regions. Especially impacted would be communities with small vessel fleets with more limited options in terms of alternate areas to fish due to limited range (and a lack practical ability to switch between major gear types and fisheries).

Kodiak Island. Total in-region groundfish processing value would decrease by 64 percent (with a lower value for GOA; BSAI values are not a significant portion of the regional total). Associated labor income and FTE jobs would also decrease by 64 percent. Regionally owned at-sea processing value would decline by 77 percent (with the vast majority of the decline attributable to changes in BSAI values), and associated labor income and FTEs would decline by 79 and 75 percent, respectively. (In this region under baseline conditions, in-region processing accounts for about three-quarters of the combined processing total value of sales and regionally owned at-sea processing accounts for about one-quarter of the total; labor income and FTEs distribution between these processing sectors follow a similar pattern.) The value of extra-regional deliveries by regionally owned catcher vessels would decrease by 19 percent and the value of in-region deliveries by regionally owned catcher vessels would decrease 55 percent. Catcher vessel payments to labor and FTE jobs associated with extra-regional deliveries would decrease by about 19 and 20 percent respectively. For in-region deliveries, catcher vessel payments to labor and FTEs would decrease by about 55 and 57 percent, respectively, but over a smaller base than seen for extra-regional deliveries. On a regional basis, catcher vessel activity is a relatively more important component of fishery associated labor income and FTEs than was seen in the Alaska Peninsula/Aleutian Islands region, but processing activity still dominates these categories in the regional totals. The total regional direct, indirect, and induced labor income would decrease by about 62 percent and FTE employment would decrease by about 57 percent under this FMP (from a base of $66 million in labor income and 1,600 FTEs). In the Kodiak Island region under FMP 4.1, significantly adverse impacts would occur at the local sector level. The city and region of Kodiak is somewhat less vulnerable to community and regional level impacts than is the case in the Alaska Peninsula and Aleutian Islands region and communities, due to greater size and economic diversity along with a lesser degree of dependence on groundfish per se, but there would be adverse impacts felt at the community and regional level (and within the commercial fishing sector of the economy, groundfish dependency is as important in Kodiak as it is in the Alaska Peninsula and Aleutian Islands region).

Southcentral Alaska. Total in-region groundfish processing value would decrease by 29 percent (all attributable to GOA decreases). Associated labor income and FTE jobs would also decrease by 29 percent. Regionally owned at-sea processing value would decrease by 62 percent (with relatively large decreases in BSAI values and smaller declines in GOA values), and associated labor income and FTEs both decreasing by 62 percent. (In this region under baseline conditions, in-region processing accounts for about four-fifths of the combined processing total value of sales and regionally owned at-sea processing accounts for about one-fifth of the total; labor income follows a similar pattern, but FTE employment is somewhat more heavily weighted toward the at-sea sector.) The value of extra-regional and in-region deliveries by regionally owned catcher vessels would decrease by 49 and 36 percent, respectively. Catcher vessel payments to labor and FTE jobs associated with extra regional deliveries would decrease by about 49 and 54 percent, respectively. For in-region deliveries, catcher vessel payments to labor and FTEs would decrease by about 36 and 40 percent, respectively. In this region, catcher vessel associated FTE jobs far surpass processing FTEs in the regional totals, but payments to labor for processing still surpass those for catcher vessels. Processing labor income figures for this region should be treated with caution, however, as the model tends to overstate actual payments due to the relative proportion of high value species processed. The total regional direct, indirect, and induced labor income would decrease by about 39 percent and FTE employment would decrease about 44 percent (from a base of $23 million in labor income and 567 FTEs). Under FMP 4.1, significantly adverse impacts would accrue to local sectors within the southcentral Alaska region. No significant impacts would be felt at the regional level, and community level impacts would tend to be attenuated by the relative size and economic diversity of the engaged communities. Overall, groundfish dependency is substantially lower for southcentral entities than for those in the Alaska Peninsula and Aleutian Islands region as well as the Kodiak Island region.

Southeast Alaska. Total in-region groundfish processing value would decrease by 88 percent (all attributable to GOA decreases). Associated labor income and FTE jobs would also decrease by 88 percent (but both are relatively low values). Regionally owned at-sea processing value would decrease by 94 percent (with decreases in both BSAI and GOA values), and associated labor income and FTEs both decreasing by 94 percent. (In this region under baseline conditions, in-region processing accounts for about seven-tenths of the combined processing total value of sales and regionally owned at-sea processing accounts for about three-tenths of the total; labor income follows a similar pattern, but FTE employment is somewhat more heavily weighted toward the at-sea sector.) The value of extra-regional and in-region deliveries by regionally owned catcher vessels would decrease by 25 and 88 percent, respectively. Catcher vessel payments to labor associated with extra regional deliveries would decrease by about 25 percent and FTE jobs would decrease by 23 percent. For in-region deliveries, catcher vessel payments to labor and FTEs would both decrease by about 88 percent. For this region, catcher vessel FTE employment far outpaces processing related employment, but payments to labor for processing still outpace those for catcher vessels. Processing labor income figures for this region should be treated with caution, however, as the model tends to overstate actual payments due to the relative proportion of high value species processed. The total regional direct, indirect, and induced labor income would decrease by about 77 percent and FTE employment would decrease by about 70 percent (from a base of $34 million in labor income and 879 FTEs). FMP 4.1 would have significantly adverse impacts on local sectors in the southeast Alaska region. In general, regional and community level impacts would be less pronounced than the output data might otherwise suggest, given the lower degree of dependency on groundfish than seen in some of the other Alaska regions, but impacts would still be felt at the community level for some of the smaller communities in the region that are relatively heavily engaged in the fishery.

Washington Inland Waters. Total in-region groundfish processing value changes are negligible on a regional basis due to low baseline values and small changes from the baseline. Associated labor income and FTE jobs would decrease by 29 percent, but their overall low value render these changes not significant. Regionally owned at-sea processing value would decrease by 67 percent (with decreases in both BSAI and GOA values, although GOA values are comparatively very small), and associated labor income and FTEs would decrease by 67 and 64 percent, respectively. The value of extra-regional and in-region deliveries by regionally owned catcher vessels would both decrease by 64 percent. Catcher vessel payments to labor and FTE jobs associated with extra regional deliveries would decrease by about 64 and 40 percent, respectively. For in-region deliveries, catcher vessel payments to labor and FTEs would decrease by about 64 and 22 percent, respectively. In this region, processing dominates the regional labor income and FTE employment totals when compared to analogous catcher vessel figures, but it is important to note that catcher vessel totals are still far higher for this region than for any other. The total regional direct, indirect, and induced labor income would decrease by about 66 percent and FTE employment would decrease by about 64 percent (from a base of $557 million in labor income and 10,316 FTEs). Under FMP 4.1, impacts to local sectors would be adverse and significant. Community level impacts would not be significant, given the nature of the concentration of the sectors in the greater Seattle metropolitan area.

Oregon Coast. Total in-region groundfish processing value changes are zero, along with associated labor income and FTE jobs, as there is no activity under baseline conditions or under this FMP. Similarly, there are no regionally owned at-sea processors under baseline conditions or foreseen under this FMP, so all processing values, labor income, and FTE job values are zero. The value of extra-regional deliveries by regionally owned catcher vessels would decrease by 64 percent, and associated labor income and FTE jobs would decrease 64 and 40 percent, respectively. There is no in-region activity by catcher vessels owned in this region, so all values for product, labor income, and FTE jobs are zero under both baseline conditions and this FMP. The total regional direct, indirect, and induced labor income would decrease by about 64 percent and FTE employment would decrease by about 54 percent (from a base of $15 million in labor income and 318 FTEs). Under FMP 4.1, Oregon coast catcher vessels would experience significantly adverse impacts, but regional and community level impacts would be less than significant, given the scale and diversity of the local economies and communities.

Cumulative Effects of FMP 4.1

For a summary of the direct/indirect and cumulative ratings see Table 4.8-6.

In-Region Processing and Related Effects

- **Direct/Indirect Effects**. For FMP 4.1, direct/indirect effects are considered significantly adverse for the Alaska Peninsula/Aleutian Islands and Kodiak Island regions, conditionally significant adverse for the southcentral Alaska and southeast Alaska regions and insignificant for the Washington inland waters and Oregon coast regions.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. For more detail, refer to the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities. Other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. For more detail, refer to the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Cumulative Effects**. Under FMP 4.1, cumulative effects on in-region processing and related characteristics, such as municipal revenue and secondary economic development, are conditionally significant adverse for the four Alaska regions (Alaska Peninsula/Aleutian Islands, Kodiak Island, southcentral Alaska, and southeast Alaska). The influence of external factors is adverse for many of the in-region processors based in Alaska and their associated regions. Trends in multi-species fisheries and other sources of municipal and state revenue, primarily due to the continued crab closures, downturn in salmon and reductions in state and municipal revenue, result in adverse effects on in-region processing and municipal revenue. For the Washington inland waters and Oregon coast regions, direct/indirect effects are insignificant, and there are no reasonably foreseeable events that would have a significant contribution, resulting in a finding of insignificant cumulative effect.

Regionally Owned At-Sea Processors

- **Direct/Indirect Effects**. Under FMP 4.1, direct/indirect effects are considered insignificant for the Alaska Peninsula/Aleutian Islands (negligible regional ownership) and Oregon coast (no regional ownership, and significantly adverse for the Kodiak Island, southcentral Alaska, southeast Alaska, and Washington inland waters regions.

- **Persistent Past Effects** The persistent past effects include trends and developments in fisheries, and to a lesser extent, trends in state and municipal revenue. For more detail see the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. For more detail, see the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Cumulative Effects**. Under FMP 4.1, direct/indirect effects are insignificant or significantly adverse. Within southcentral Alaska, Washington inland waters, and Oregon coast regions, fisheries are a small part of the regional economies and effects are dwarfed by other trends. Cumulative effects for these regions are insignificant. Adverse trends in other fisheries (particularly salmon) and reductions on municipal revenue, decrease regional labor income and employment benefits, particularly in the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska regions. Cumulative effects for these regions are conditionally significant adverse.

<u>Extra-Regional Deliveries of Regionally Owned Catcher Vessels</u>

- **Direct/Indirect Effects**. Under FMP 4.1, direct and indirect effects are significantly adverse for all regions.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. Catcher vessels are affected by changes that have occurred in the groundfish industry related to allocation and AFA sideboards, and by their participation in multi-species fisheries, particularly salmon, crab, and halibut. For more detail, see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities. Other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all alternatives; for more detail see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects**. Under FMP 4.1, direct/indirect effects significantly adverse for all six regions. Within southcentral Alaska, Washington inland waters, and Oregon coast regions, fisheries are a small part of the regional economies and effects are dwarfed by other trends. Cumulative effects for these regions are insignificant. Adverse trends in other fisheries (particularly salmon) and reductions on municipal revenue, decrease regional labor income and employment benefits, particularly in the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska regions. Cumulative effects for these regions are conditionally significant adverse.

In-Region Deliveries of Regionally Owned Catcher Vessels

- **Direct/Indirect Effects**. Under FMP 4.1, direct/indirect effects are considered significantly adverse for all regions except the Oregon coast (no in-region deliveries), which is insignificant.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. For more detail, see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects**. Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all alternatives; for more detail see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects**. Under FMP 4.1, the direct/indirect effects conditionally significant adverse for five of the six regions, and insignificant for one. Given the size and diversity of regional economies, in southcentral Alaska, Washington inland waters, and the Oregon coast, adverse external effects are offset and cumulative effects are insignificant. The significant decrease in extra-regional deliveries to the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska, in conjunction with adverse external effects related to other fisheries and revenue sharing results in a conditionally significant adverse cumulative effect for these three regions.

Total Direct, Indirect, and Induced Labor Income and FTEs

- **Direct/Indirect Effects**. Under FMP 4.1, direct/indirect effects on labor income and employment are significantly adverse for all six regions.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, trends in state and municipal revenue, and public infrastructure and facility projects. Fishing is a major component of income and employment in many small Alaskan coastal communities. Federal, state, and local revenue has funded public infrastructure and facility projects that generate income and employment in many regions and communities. For more detail, see the discussion of persistent past effects under in-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities. other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all alternatives. For more detail, see the discussion of persistent past effects under in-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects**. Under FMP 4.1 direct/indirect effects on labor income and employment are significantly adverse for all regions. Within southcentral Alaska, Washington inland waters, and

Oregon coast regions, fisheries are a small part of the regional economies and effects are dwarfed by other trends. Cumulative effects for these regions are insignificant. Adverse trends in other fisheries (salmon and crab) and reductions on municipal revenue, decrease regional labor income and employment benefits, particularly in the Alaska Peninsula/Aleutian Islands, Kodiak Islands, and southeast Alaska regions. Cumulative effects for the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska regions are conditionally significant adverse.

Direct/Indirect Effects of FMP 4.2

Under this FMP, the commercial harvest of groundfish would be suspended for an indeterminate period of time until it can be determined that fishing activities are not having a significantly adverse effect on sustainable fisheries, habitat, and the ecosystem. The regional impacts of the discontinuation of the fishery would be immediate, adverse, and significant for all regions in all categories of effects.

Cumulative Effects of FMP 4.2

For a summary of the direct/indirect and cumulative ratings see Table 4.8-6.

In-Region Processing and Related Effects

- **Direct/Indirect Effects**. For FMP 4.2, the indeterminate cessation in fishing would result in significantly adverse direct/indirect effects for all regions, except for the Oregon coast region, which has no in-region processing and is insignificant. Refer to the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. For more detail, refer to the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities. Other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. For more detail, refer to the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Cumulative Effects**. Under FMP 4.2, significantly adverse direct/indirect effects would combine with adverse trends in multi-species fisheries (crab closures, downturn in salmon fishery) and other sources of municipal and state revenue, resulting in significantly adverse cumulative effects for the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska regions. Although the direct/indirect effects would be significantly adverse for the participants in the fishery in southcentral Alaska and Washington inland waters regions, because of the diversity of regional economies, the cumulative effects would be insignificant. For the Oregon coast region, direct/indirect effects are insignificant, and there are no reasonably foreseeable future events that would have a significant contribution, resulting in a finding of insignificant cumulative effect.

Regionally Owned At-Sea Processors

- **Direct/Indirect Effects**. For FMP 4.2, the indeterminate cessation in fishing would result in significantly adverse direct/ indirect effects for all regions, except for the Oregon coast, which has no at-sea processing and is insignificant. Refer to the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects**. The persistent past effects include trends and developments in fisheries, and to a lesser extent, trends in state and municipal revenue. For more detail see the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. For more detail, see the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Cumulative Effects**. Under FMP 4.2, significantly adverse direct/indirect effects would combine with adverse trends in multi-species fisheries (crab closures, downturn in salmon fishery) and other sources of municipal and state revenue, resulting in significantly adverse cumulative effects for the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska regions. Although the direct/indirect effects would be significantly adverse for the participants in the fishery in southcentral Alaska and Washington inland waters regions, because of the diversity of regional economies, the cumulative effects would be insignificant. For the Oregon coast region, direct/indirect effects are insignificant, and there are no reasonably foreseeable future events that would have a significant contribution, resulting in a finding of insignificant cumulative effect.

Extra-Regional Deliveries of Regionally Owned Catcher Vessels

- **Direct/Indirect Effects**. For FMP 4.2, the indeterminate cessation in fishing would result in significantly adverse direct/indirect effects for all regions. See the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. Catcher vessels are affected by changes that have occurred in the groundfish industry related to allocation and AFA sideboards, and by their participation in multi-species fisheries, particularly salmon, crab, and halibut. For more detail, see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities. Other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all alternatives; for more detail see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects**. Under FMP 4.2, significantly adverse direct/indirect effects would combine with adverse trends in multi-species fisheries (crab closures, downturn in salmon fishery) and other sources of municipal and state revenue, resulting in significantly adverse cumulative effects for the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska regions. Although the direct/indirect effects would be significantly adverse for the participants in the fishery in southcentral Alaska, Washington inland waters, and Oregon coast regions, because of the diversity of regional economies, the cumulative effects would be insignificant.

<u>In-Region Deliveries of Regionally Owned Catcher Vessels</u>

- **Direct/Indirect Effects**. For FMP 4.2, the indeterminate cessation in fishing would result in significantly adverse direct/ indirect effects for all regions, except for the Oregon coast, which has no in-region deliveries and is insignificant. See the previous section for a more detailed discussion of direct/ indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. For more detail, see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects**. Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all alternatives; for more detail see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects**. Under FMP 4.2, significantly adverse direct/indirect effects would combine with adverse trends in multi-species fisheries (crab closures, downturn in salmon fishery) and other sources of municipal and state revenue, resulting in significantly adverse cumulative effects for the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska regions. Although the direct/indirect effects would be significantly adverse for the participants in the fishery in southcentral Alaska and, Washington inland waters regions, because of the diversity of regional economies, the cumulative effects would be insignificant. For the Oregon coast region, direct/indirect effects are insignificant, and there are no reasonably foreseeable future events that would have a significant contribution, resulting in a finding of insignificant cumulative effect.

<u>Total Direct, Indirect, and Induced Labor Income and FTEs</u>

- **Direct/Indirect Effects.** For FMP 4.2, the indeterminate cessation in fishing would result in significantly adverse direct/ indirect effects for all regions. See previous section for a more detailed discussion of direct/ indirect effects.

- **Persistent Past Effects**. The persistent past effects include trends and developments in fisheries, trends in state and municipal revenue, and public infrastructure and facility projects. Fishing is a major component of income and employment in many small Alaskan coastal communities. Federal, state, and local revenue has funded public infrastructure and facility projects that generate income and employment in many regions and communities. For more detail, see the discussion of persistent past effects under in-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects**. Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities. other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all alternatives. For more detail, see the discussion of persistent past effects under in-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects**. Under FMP 4.2, significantly adverse direct/indirect effects would combine with adverse trends in multi-species fisheries (crab closures, downturn in salmon fishery) and other sources of municipal and state revenue, resulting in significantly adverse cumulative effects for the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska regions. Although the direct/indirect effects would be significantly adverse for the participants in the fishery in southcentral Alaska, Washington inland waters, and Oregon coast regions, because of the diversity of regional economies, the cumulative effects would be insignificant.

4.8.9.3 Community Development Quota Program

The predicted direct and indirect effects of the groundfish fishery under FMP 4.1 and FMP 4.2 are described below. The past/present effects on CDQ are described in Section 3.9 and below (Table 3.9-126). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. The representative indicator used in this analysis is allocation of catch to CDQ groups. It should be noted that allocation reflects potential revenue to CDQ groups, and indirectly the potential funds that are available for approved economic development activities in CDQ communities (Table 4.8-6).

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

The CDQ program would continue in its present structure under FMP 4.1, but the steep declines in the overall fishery would be mirrored by similarly steep declines in CDQ royalties, employment, and income. As with the rest of the regions participating in the fishery, impacts to the CDQ region would be significantly adverse.

The CDQ region would also experience significantly adverse social impacts under FMP 4.2. While the multi-species CDQ program would continue, this would allow royalties, income, and employment levels to continue at only a fraction of the level seen under baseline conditions.

Cumulative Effects of FMP 4.1 and FMP 4.2

For a summary of the direct/indirect and cumulative ratings see Table 4.8-6.

- **Direct/Indirect Effects**. The direct/indirect effects on the CDQ program under FMP 4.1 and FMP 4.2 are significantly adverse.

- **Persistent Past Effects**. The past/present effects on the CDQ program for groundfish fisheries include establishment of CDQ program; FMP amendments that further added or defined CDQ in 1992,1995,1996, and 1998; establishment of multi-species CDQ programs, and persistent limitations on economic development and associated employment activities. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects**. Other fisheries, other economic development activities, other sources of municipal and state revenue all have the potential to affect the CDQ program adversely or beneficially. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Cumulative Effects**. Under FMP 4.1 and FMP 4.2, a cumulative effect is identified for the CDQ Program, and the effect is judged to be significantly adverse. Impacts to the CDQ region would be significantly adverse due to declines in CDQ royalties, employment and income.

4.8.9.4 Subsistence

The predicted direct and indirect effects of the groundfish fishery under FMP 4.1 and FMP 4.2 are described below. The past/present effects on subsistence are described in Section 3.9 and below (Table 3.9-126). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. The representative indicators used in this analysis are other fisheries such as foreign JV, domestic, and state-managed fisheries, other economic development activities, sport and personal use, and long-term climate change and regime shift (Table 4.8-6).

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

Potential impacts to subsistence fall into four main categories: subsistence use of groundfish, subsistence use of Steller sea lions, subsistence use of salmon in western Alaska and bycatch in the groundfish fisheries, and indirect impacts on other subsistence activities, including loss of income that would be otherwise directed toward subsistence pursuits and the loss of access to commercial fishing vessels and gear that would be otherwise be available for joint production opportunities. Under this FMP, commercial fishery activity is sharply reduced, but it is not clear that this would have direct beneficial or adverse impacts on the subsistence groundfish fishing conditions in relation to the subsistence fishery that is occurring under baseline conditions, but it is assumed that any change would not be large enough to reach significant levels. Steller sea lion populations are expected to benefit under this FMP due to a beneficial effect on pelagic forage availability. This would be a conditionally significant beneficial benefit for Steller sea lion subsistence activities, with the condition being that Steller populations would need to increase to point where subsistence activities substantially benefit through a reduction in effort needed for hunting success and/or the perceived recovery of the Steller population fostered a substantial increase in subsistence activity. Salmon bycatch would be reduced under this FMP, however, current information does not allow a determination that the level of bycatch reduction would result in significant increases in salmon returns to subsistence fishery areas. Therefore, while reduction in salmon bycatch would be generally beneficial for subsistence salmon fisheries, current data do not suggest that these benefits would rise to the level of significance. Catcher vessel activity and labor income are anticipated to decline sharply under this FMP, therefore it is expected that adverse indirect impacts to subsistence through a decline in income or joint production opportunities will occur.

It is not clear whether subsistence related groundfish fishing would experience direct impacts under FMP 4.2. Local groundfish availability may increase with the elimination of the commercial groundfish fishery, but the magnitude of this increase is unknown and the effect of this increase on subsistence activity is unknown. Given the relatively low level of groundfish subsistence use, it is assumed that any direct increase groundfish subsistence likely under this FMP would be insignificant. Steller sea lion populations are expected to benefit under this FMP due to a beneficial effect on pelagic forage availability. This would be a conditionally significant beneficial benefit for Steller sea lion subsistence activities, with the condition being that Steller populations would need to increase to point where subsistence activities substantially benefit through a reduction in effort needed for hunting success and/or the perceived recovery of the Steller population fostered a substantial increase in subsistence activity. Salmon bycatch would be eliminated under this FMP. This would result in a conditionally significant beneficial benefit for salmon subsistence fisheries, with the condition being that as a result of bycatch elimination salmon returns increased significantly to subsistence salmon fishery areas. Indirect impacts to subsistence in the form of loss of income and the loss of joint production opportunities would occur, and are considered significantly adverse.

Cumulative Effects of FMP 4.1 and FMP 4.2

The predicted direct and indirect effects of the groundfish fishery under FMP 4.1 and FMP 4.2 are described above. The past/present effects on subsistence are described in Section 3.9. This section will assess the potential for these effects to interact with other reasonably foreseeable future events and activities in the cumulative case. Representative indicators used in this analysis are the same as those used in the direct/indirect analysis and include subsistence use of groundfish, subsistence use of Steller sea lions, subsistence use of salmon, and indirect impacts on other subsistence activities such as income and joint production opportunities. For a summary of the direct/indirect and cumulative ratings see Table 4.8-6.

<u>Subsistence Use of Groundfish</u>

- **Direct/Indirect Effects**. Under FMP 4.1, commercial fishery activity is sharply reduced, but it is not clear that this would have direct beneficial or adverse impacts on the subsistence groundfish fishing conditions in relation to the subsistence fishery that is occurring under baseline conditions, but it is assumed that any change would not be large enough to reach significant levels. Under FMP 4.2 it is not clear whether subsistence related groundfish fishing would experience direct impacts under this FMP. Local groundfish availability may increase with the elimination of the commercial groundfish fishery, but the magnitude of this increase is unknown and the effect of this increase on subsistence activity is unknown. Given the relatively low level of groundfish subsistence use, it is assumed that any direct increase groundfish subsistence likely under this FMP would be insignificant.

- **Persistent Past Effects**. Foreign JV, domestic, and state-managed fisheries have decreased populations of some species of groundfish used for subsistence. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects**. Other fisheries and long-term climate change have a potential to adversely contribute to subsistence use of the groundfish fisheries. Economic development and sport and personal use are not likely to adversely contribute to subsistence use of the groundfish fisheries. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Cumulative Effects**. Under FMP 4.1 and FMP 4.2, a cumulative effect is identified for subsistence use of groundfish, and the effect is judged to be insignificant. Under FMP 4.1 commercial fishery activities are sharply reduced and under FMP 4.2 subsistence groundfish harvest in federal waters fishing is suspended. The cumulative effects could be adverse, but not enough to have significant indirect impacts to subsistence. The external impacts of economic development activities and sport and personal use of groundfish are not likely to contribute adversely to the groundfish fisheries. However, other state-managed fisheries could have adverse impacts to the subsistence use of groundfish due to the direct competition for the same species, but those impacts are not considered to be significant. The long-term climate change could adversely effect groundfish stocks.

Subsistence Use of Steller Sea Lions

- **Direct/Indirect Effects**. Under FMP 4.1 Steller sea lion populations are expected to benefit due to a beneficial effect on pelagic forage availability. This would be a conditionally significant beneficial benefit for Steller sea lion subsistence activities, with the condition being that Steller populations would need to increase to point where subsistence activities substantially benefit through a reduction in effort needed for hunting success and/or the perceived recovery of the Steller population fostered a substantial increase in subsistence activity. Under FMP 4.2 Steller sea lion populations are expected to benefit due to a beneficial effect on pelagic forage availability. This would be a conditionally significant beneficial benefit for Steller sea lion subsistence activities, with the condition being that Steller populations would need to increase to point where subsistence activities substantially benefit through a reduction in effort needed for hunting success and/or the perceived recovery of the Steller population fostered a substantial increase in subsistence activity.

- **Persistent Past Effects**. The past/present effects on subsistence use of Steller sea lions include the following: a long-term decline in population of Steller sea lions due to a number of factors; a long-term decline in relative importance of marine mammals in local diets; commercial groundfish fishing taking prey species utilized by Steller sea lions; and Steller sea lion protection measures designed to assist in population recovery instituted in 2000. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects**. Other fisheries, economic development, and long-term climate change have a potential to adversely contribute to Steller sea lions subsistence activities. Sport and personal use is not likely to adversely contribute to subsistence use of Steller sea lions. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Cumulative Effects**. Under FMP 4.1 and FMP 4.2, a cumulative effect is identified for subsistence use of Steller sea lions and the effect is judged to be conditionally significant beneficial. The reduction of open fisheries under FMP 4.1 and the closure of fisheries under FMP 4.2 could have a beneficial impact on Steller population levels.

Subsistence Use of Western Alaskan Salmon and Bycatch in the Groundfish Fishery

- **Direct/Indirect Effects**. Under FMP 4.1, salmon bycatch would be reduced, however, current information does not allow a determination that the level of bycatch reduction would result in significant increases in salmon returns to subsistence fishery areas. Therefore, while reduction in salmon bycatch would be generally beneficial for subsistence salmon fisheries, current data do not suggest that these benefits would rise to the level of significance. Under FMP 4.2 salmon bycatch would be eliminated under this FMP. This would result in a conditionally significant beneficial benefit for salmon subsistence fisheries, with the condition being that as a result of bycatch elimination salmon returns increased significantly to subsistence salmon fishery areas.

- **Persistent Past Effects**. The past/present effects on subsistence use of salmon include the following: utilization for subsistence since pre-contact times; and Area M closures implemented to decrease intercept of salmon. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects**. Other fisheries, other economic development activities and long-term climate change and regime shift could all adversely contribute to salmon subsistence activities. Sport and personal use is not likely to adversely contribute to salmon subsistence activities. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Cumulative Effects**. Under FMP 4.1, a cumulative effect is identified for subsistence use of salmon, and is judged to be insignificant. The reduction in salmon bycatch is offset by external effects that adversely affect subsistence use of salmon. Under FMP 4.2 a cumulative effect is identified for subsistence use of salmon and the effect is judged to be conditionally significant beneficial. Given the poor stock status of salmon runs in western Alaska, decreasing bycatch in BSAI and GOA could help to restore stock and improve recovery.

Indirect Impacts on Other Subsistence Activities

- **Direct/Indirect Effects**. Under FMP 4.1, catcher vessel activity and labor income are anticipated to decline sharply, therefore it is expected that significantly adverse indirect impacts to subsistence through a decline in income or joint production opportunities will occur. Under FMP 4.2 indirect impacts to subsistence in the form of loss of income and the loss of joint production opportunities would occur.

- **Persistent Past Effects**. The past/present effects on the indirect impacts on other subsistence activities include joint production as a part of local groundfish and other commercial fishery development from the outset; and income from fishing used for investment in subsistence is similar to use of income from other activities. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects**. Other fisheries, other economic development activities, and long-term climate change and regime shift could all adversely or beneficially contribute to indirect subsistence activities. Sport and personal use is not likely to adversely contribute to indirect impacts on other subsistence activities. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Cumulative Effects**. Under FMP 4.1 and FMP 4.2 a cumulative effect is identified for subsistence use of salmon and the effect is judged to be significantly adverse. Under FMP 4.1 income, catcher vessel activity, and joint production opportunities are adversely affected by reduced fishing activities. Under FMP 4.2 income, catcher vessel activity, and joint production opportunities are eliminated.

4.8.9.5 Environmental Justice

The predicted direct and indirect effects of the groundfish fishery under FMP 4.1 and FMP 4.2 are described below. The past/present effects on Environmental Justice are described in Section 3.9 (Table 3.9-126) and below. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. The external factors used in this analysis are other fisheries such as foreign, domestic, and state-managed fisheries; other economic development activities; other sources of municipal/state revenue; and long-term climate change and regime shift (Table 4.8-6).

Direct/Indirect Effects of FMP 4.1

Potential impacts that drive Environmental Justice issues include employment/municipal revenue and taxes in communities with significant percentages of special populations (Alaska Native and minority processing workforce); revenue to Native-owned catcher vessels; revenue to Native-owned catcher processors; subsistence activities associated with groundfish, Steller sea lion, and salmon; and the loss of income from fishing that would be otherwise directed toward subsistence pursuits and the loss of access to commercial fishing vessels and gear that would otherwise be available for joint production opportunities. The regions that could experience potential impacts include the Alaska Peninsula and Aleutian Islands, Kodiak Island, southcentral Alaska, southeast Alaska, Washington inland waters, Oregon coast, the CDQ regions, and western Alaska communities that harvest salmon for subsistence purposes.

Alaska Peninsula and Aleutian Islands. As described in existing conditions, this region encompasses a number of groundfish fishing communities, of which several have predominantly Alaska Native populations. Also as described under existing conditions, the in-region processing workforce is predominantly a minority population. in-region processing employment would decrease below baseline conditions by about 2,131 jobs; therefore, this loss of jobs in a region with predominantly minority populations engaged in the processing industry would result in a marked Environmental Justice impact. Total in-region groundfish processing value would decrease from $464 million to $178 million. Decreased in-region processing value would correspond to reduced municipal revenue and taxes to the local communities and would therefore result in associated Environmental Justice impacts for those communities with substantial minority populations. In this region the ownership and crews of the catcher vessels are assumed to tend to mirror the demographic composition of populations of the home port communities, so local fleets from at least a few communities in this region are likely to be owned and crewed by Alaska Native residents. Under this FMP bookend, the total value of catcher vessel operations would decrease as would corresponding labor income and employment; therefore, an Environmental Justice impact would likely result.

Kodiak Island. As described in existing conditions, groundfish processing and catcher vessel activity in this region is highly concentrated in the City of Kodiak. Although the city is ethnically diverse, it does not have a predominantly Alaska Native population as do some of the groundfish fishing communities in the Alaska Peninsula/Aleutian Islands region. However, as described under existing conditions, the in-region processing workforce is predominantly a minority population. in-region processing employment would decrease over baseline conditions by about 367 jobs; therefore, an Environmental Justice impact would result. Total in-region groundfish processing value would decrease from $81 million to $29 million. Decreased in-region processing value would correspond to reduced municipal revenue and taxes to the City and the Kodiak Island Borough, but given local and regional demographics, this is not likely to be an Environmental Justice issue. Ownership and crews of the catcher vessels are assumed to mirror the demographic composition of populations of the City of Kodiak itself, and therefore the local fleet associated population is not likely to be predominantly Alaska Native (or comprised of other identified minority populations). Under this FMP bookend, the total value of catcher vessel operations would decrease as would corresponding labor income and employment, but given demographic assumptions, this is unlikely to be an Environmental Justice issue.

Southcentral Alaska. As described in existing conditions, Environmental Justice concerns are much less salient in this region than in the Alaska Peninsula/Aleutian Islands or Kodiak Island regions. The communities most directly engaged in the groundfish fishery, particularly with respect to the processing sector, are largely non-Native communities, and have relatively large populations and diversified economic opportunities. Further, there is a relatively low level of groundfish related processing employment overall. Catcher vessel related employment is assumed to mirror community demographics, and thus it is unlikely that Environmental Justice issues will be associated with any employment change. In general, under this FMP overall combined direct, indirect, and induced labor income and FTEs decrease, but this change is not linked to Environmental Justice concerns. Similarly, processing value decreases, as do catcher vessel associated values, but these changes are not tied to Environmental Justice concerns.

Southeast Alaska. The situation in this region is similar to that seen in southcentral Alaska, with the possible exception of the community of Yakutat, which is more predominantly Alaska Native than the other regionally important groundfish communities. Data confidentiality constraints preclude a discussion of Yakutat alone, but otherwise overall Environmental Justice concerns appear not to apply in this region. In general, under this FMP overall combined direct, indirect, and induced labor income and FTEs decrease, but this change is not linked to Environmental Justice concerns. Similarly, processing value decreases as do analogous catcher vessel associated values, but this change is not associated with Environmental Justice concerns. See

Washington Inland Waters. The greater Seattle area is the regional community most engaged in the groundfish fishery, and it is a demographically and economically diverse major metropolitan area. in-region processing does not occur, and while a number of other communities in the region outside of Seattle are home to groundfish catcher vessels, there is no indication that these communities or the associated vessel owners and crew are comprised of minority populations. As described in existing conditions, Environmental Justice concerns for this region are concentrated in the at-sea processing sector, due to the predominance of minority representation within this workforce. Under this FMP , at-sea processing labor income and FTEs decrease by 67 and 64 percent, respectively, which would result in Environmental Justice impacts. See

Oregon Coast. This region is engaged in the commercial groundfish fishery through its regionally owned catcher vessel fleet. This fleet is concentrated in a limited number of communities in the region, and there is no indication that these are minority communities, nor is there any indication that the population directly associated with fleet ownership and/or crew is either a minority population or a low-income population. In general, under this FMP overall combined direct, indirect, and induced labor income and FTEs decrease, as do catcher vessel related values, but these changes are not linked to Environmental Justice concerns. See

CDQ Region. The CDQ region is predominantly comprised of Alaska Native communities that have relatively limited commercial economic opportunities, so any adverse impacts to this program and region are likely to involve Environmental Justice concerns. Under this FMP, the structure of the CDQ program would not change from baseline conditions. However, the precipitous decline of the fishery due to reductions in TAC and area closures associated with specific gear types would result in adverse impacts to the CDQ program (income and employment opportunities for Alaska Natives, economic development revenue available to CDQ communities), and these would be considered Environmental Justice impacts.

Subsistence. Subsistence activities typically disproportionately involve Alaska Native communities and populations, and in a few cases (such as Steller sea lion subsistence) exclusively involve Alaska Native individuals and groups. As a result, adverse impacts to subsistence pursuits are likely to involve Environmental Justice concerns. Subsistence activities where there are potential Environmental Justice issues include the following:

- Harvest of groundfish (which occurs to some extent in all four Alaska regions), Steller sea lion (primarily and activity in the Alaska Peninsula/Aleutian Islands region), and salmon (primarily an issue in western Alaska, where poor runs have adversely affected subsistence harvests).

- The loss of income from fishing that would otherwise be directed toward subsistence pursuits and the loss of access to commercial fishing vessels and gear that would otherwise be available for joint production (which occurs to some extent in all four Alaska regions).

Management measures associated with reductions in TAC and salmon bycatch, and increases in area closures to protect habitat will benefit subsistence harvest of Salmon and Steller sea lions. As a result there would be insignificant Environmental Justice effects on subsistence harvests. However, this FMP would result in significant loss of income and joint production opportunities, primarily in the Alaska Peninsula/Aleutian Island region, resulting in an adverse Environmental Justice effect.

Cumulative Effects of FMP 4.1

The predicted direct and indirect effects of the groundfish fishery under the Alternative 4 are described above. The past/present effects on Environmental Justice Issues are described in Section 3.9. This section will assess the potential for these effects to interact with other reasonably foreseeable future events and activities in the cumulative case. The representative indicator used in this analysis is the same as that used in the direct/indirect analysis (Table 4.8-6).

<u>Environmental Justice</u>

- **Direct/Indirect Effects**. Under FMP 4.1, significantly adverse Environmental Justice effects would result from reductions in minority processing income employment (Alaska Peninsula/Aleutian

Islands, Kodiak Island, Washington inland waters); Alaskan Native harvesting income and employment (Alaska Peninsula/Aleutian Islands); tax revenues to communities with significant Alaskan Native populations (Alaska Peninsula/Aleutian Islands); CDQ region income, employment and economic development funds; and income and joint production opportunities that support subsistence harvests (Alaska Peninsula/Aleutian Islands).

- **Persistent Past Effects**. Persistent past effects include trends and developments in other fisheries, and trends in state and municipal revenue. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects**. Other fisheries, other economic development activities, other sources of municipal state revenue and long-term climate change and regime shift have the potential to adversely or beneficially affect Environmental Justice issues. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Cumulative Effects**. Under FMP 4.1, the reductions in TAC and large closure areas would create significantly adverse cumulative Environmental Justice effects for the Alaska Peninsula/Aleutian Islands, Kodiak and Washington inland waters. The adverse direct/indirect effects on special population income and employment activities, CDQ region income/employment/ development funds, and income and joint production for subsistence pursuits combined with adverse external effects and trends (salmon and crab downturns, reductions in municipal revenue) to result in significantly adverse cumulative Environmental Justice issues in the Alaska Peninsula/ Aleutian Islands, Kodiak Island, Washington inland waters, and CDQ regions. Cumulative effects on subsistence harvest of salmon and Steller sea lion are beneficial but insignificant, and do not raise Environmental Justice concerns.

Direct/Indirect Effects of FMP 4.2

FMP 4.2 suspends the fishery for an indeterminate amount time, and significantly adverse impacts to Alaska Native fishing communities would result in Environmental Justice impacts. Processing worker job losses in the in-region processing sectors in the Alaska Peninsula/Aleutian Islands and Kodiak regions would result in Environmental Justice impacts, as would losses of jobs to at-sea processing workers operating out of the Washington inland waters region. Catcher vessel income and job losses in Alaska Native communities (primarily in the Alaska Peninsula/Aleutian Islands region) would also involve Environmental Justice concerns, as would the loss of tax revenue to communities with predominant Alaska Native populations. Further, impacts to the CDQ program, due to the loss of revenue, employment opportunities, and economic development funds, would be significantly adverse; given the demography of the CDQ region, these constitute Environmental Justice impacts. While subsistence harvest of salmon and Steller sea lions would benefit, the loss of income and joint production opportunities, primarily in the Alaska Peninsula/Aleutian Islands region, would also qualify as an Environmental Justice issue.

Cumulative Effects of FMP 4.2

The predicted direct and indirect effects of the groundfish fishery under the Alternative 4 are described above. The past/present effects on Environmental Justice Issues are described in Section 3.9. This section will assess the potential for these effects to interact with other reasonably foreseeable future events and activities in the cumulative case. The representative indicator used in this analysis is the same as that used in the direct/indirect analysis (Table 4.8-6).

Environmental Justice

- **Direct/Indirect Effects**. Under FMP 4.2, significantly adverse Environmental Justice effects would result from reductions in minority processing income employment (Alaska Peninsula/Aleutian Islands, Kodiak Island, Washington inland waters); Alaskan Native harvesting income and employment (Alaska Peninsula/Aleutian Islands); tax revenues to communities with significant Alaskan Native populations (Alaska Peninsula/Aleutian Islands); CDQ region income, employment and economic development funds; and income and joint production opportunities that support subsistence harvests (Alaska Peninsula/Aleutian Islands).

- **Persistent Past Effects**. Persistent past effects include trends and developments in other fisheries, and trends in state and municipal revenue. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects**. Other fisheries, other economic development activities, other sources of municipal state revenue and long-term climate change and regime shift have the potential to adversely or beneficially affect Environmental Justice issues. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Cumulative Effects.** Under FMP 4.2, the suspension of fisheries would create significantly adverse cumulative Environmental Justice effects similar to FMP 4.1, only more severe. The adverse direct/indirect effects on special population income and employment activities, CDQ region income/employment/ development funds, and income and joint production for subsistence pursuits combine with adverse external effects and trends (salmon and crab downturns, reductions in municipal revenue) to result in conditionally significant cumulative Environmental Justice issues in the Alaska Peninsula/ Aleutian Islands, Kodiak Island, Washington inland waters, and CDQ regions. Cumulative effects on subsistence harvest of salmon and Steller sea lion are beneficial but insignificant, and do not raise Environmental Justice concerns.

4.8.9.6 Market Channels and Benefits to United States Consumers

The predicted direct and indirect effects of the groundfish fishery under FMP 4.1 and FMP 4.2 are described below. The past/present effects on Market Channels and Benefits to U.S. Consumers are described in Section 3.9 and below (Table 3.9-127). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. Representative indicators used in this analysis include product quantity, product year-round availability, product quality, and product diversity on Market Channels and Benefits to U.S. Consumers activities (Table 4.8-6).

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

FMP 4.1 is not expected to have a significant effect on benefits to U.S. consumers of groundfish products relative to the comparative baseline. FMP 4.1 will result in large reductions in the domestic production of several different groundfish products. The projected 5-year mean of the wholesale product value of BSAI and GOA groundfish after primary processing is $0.5 billion. This product value mean is approximately one-third of the comparative baseline. The most likely result of the decrease in the production would be an adverse effect on the U.S. seafood trade balance, as more groundfish products are imported to offset the reduced domestic supply. The imported groundfish products, such as the twice-frozen fillets and blocks imported from China, may be generally lower in quality than domestic products. The price elasticity of demand for groundfish products is fairly high in the U.S. market, but assuming that demand is not perfectly elastic, the decreased production could result in higher prices and a loss of consumer surplus (i.e., net benefits) to the American public. The magnitude of that loss will depend on price elasticities that are not quantifiable at this time and on the degree to which production is shifted toward or away from the export markets. However, it is unlikely that the decrease in consumer surplus will be significant relative to the comparative baseline using the 20 percent standard as the significance criterion.

FMP 4.2 is expected to have a conditionally significant adverse effect on benefits to U.S. consumers of groundfish products relative to the comparative baseline. Both the intensity of this effect and the probability of its occurrence are uncertain. Under FMP 4.2, the production of groundfish products in fisheries occurring in the EEZ off Alaska will be suspended until more information is known on the impacts of fishing on the environment. An estimate of the final market value of BSAI and GOA seafood products that will be foregone under this FMP is not available; however, it would be substantially greater than $1.5 billion, the estimated product value of BSAI and GOA groundfish after primary processing that will be foregone under FMP 4.2. The most likely result of the decrease in the production would be a adverse effect on the U.S. seafood trade balance, as more groundfish products are imported to offset the reduced domestic supply. The imported products, such as the "twice-frozen" fillets and blocks imported from China, may be generally lower in quality than domestic products. Even if more foreign groundfish products are imported, the increase may be unable to compensate for the effects of a suspension of U.S. harvests of groundfish in the EEZ off Alaska. The result could be a significant decrease in the supply of pollock and Pacific cod fillets to the U.S. market. The supply of surimi for the domestic seafood analog market and other products may also be reduced. In turn, these decreases in supply could have adverse effects on American seafood consumers. The price elasticity of demand for groundfish products is fairly high in the U.S. market, but assuming that demand is not perfectly elastic, the suspension of the Alaska groundfish fisheries could result in higher prices for groundfish products and a loss of consumer surplus (i.e., net benefits) to the American public.

Cumulative Effects of FMP 4.1 and FMP 4.2

For a summary of the direct/indirect and cumulative ratings see Table 4.8-6.

Market Channels and Benefits to U.S. Consumers

- **Direct/Indirect Effects of FMP 4.1 and FMP 4.2**. Under FMP 4.1, increases in benefits to U.S. consumers of groundfish products are expected to occur but are insignificant. Under FMP 4.2 the production of groundfish products in fisheries occurring in the EEZ off Alaska will be suspended and the supply of seafood products to the U.S. market will decrease. This is expected to have a conditionally significant adverse effect on benefits to U.S. consumers of groundfish products.

- **Persistent Past Effects**. These effects on benefits to U.S. consumers of groundfish products include: Alaska Seafood Marketing Institute product promotion activities, research and public awareness regarding the health benefits of seafood consumption, aquaculture development increasing overall availability and demand for seafood products, and changes in processing technology increasing seafood quality.

- **Reasonably Foreseeable Future External Effects**. Reasonably foreseeable effects include other fisheries (supply of product) and long-term climate change and regime shift. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Cumulative Effects**. Under FMP 4.1, a cumulative effect is identified for benefits to U.S. consumers of groundfish products, and the effect is judged to be insignificant. The external impacts of other fisheries have the potential to contribute adversely or beneficially to the U.S. consumers of groundfish products and the groundfish market channels. However, the wholesale groundfish product value in conjunction with products from other fisheries is not expected to change benefits to U.S. consumers. The long-term climate change and regime shift could adversely effect availability for market channels due to the natural fluctuations in groundfish stocks. Under FMP 4.2 a cumulative effect is identified for benefits to U.S. consumers of groundfish products, and the effect is judged to be significantly adverse. The suspension of production of groundfish products in fisheries occurring in the EEZ off Alaska could decrease product quality, supply, and production of pollock and Pacific cod fillets, offset the seafood trade balance as more groundfish products are imported, increase prices for groundfish products, and have an adverse effect on seafood consumers.

4.8.9.7 The Value of the Bering Sea and Gulf of Alaska Marine Ecosystems (including Non-Consumptive and Non-Use Benefits)

The predicted direct and indirect effects of the groundfish fishery under FMP 4.1 and FMP 4.2 are described below. Benefits derived from marine ecosystems and associated species are used as a surrogate to evaluate non-consumptive and non-use benefits. The past/present effects on non-consumptive and non-use benefits to U.S. general public are described in Section 3.9 (Table 3.9-127) and below. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. The representative indicator used in this analysis is benefits the public derives from marine ecosystems and associated species (including non-consumptive and non-use benefits) (Table 4.8-6).

Direct/Indirect Effects of FMP 4.1 and FMP 4.2

FMP 4.1 is predicted to significantly increase the level of benefits the Bering Sea and GOA marine ecosystems and associated species provide relative to the comparative baseline. These findings are based on the assessment of the direct and indirect effects of FMP 4.1 on the environment with respect to the ecosystem issues of predator-prey relationships, energy flow and balance, and diversity. This assessment of ecosystem effects is presented in Section 4.8.10 of the draft Programmatic SEIS.

As described in Section 3.9.7, the Bering Sea and GOA marine ecosystems and species associated with them provide a broad range of benefits to the American public. Some of the goods and services these ecosystems produce are not exchanged in normal market transactions but have value nonetheless. While there are difficulties in estimating the value the public places on protecting ecological conditions, Section 3.9.7 provides a qualitative discussion of possible benefits provided by the Bering Sea and GOA marine ecosystems. In addition to supporting commercial fisheries, these ecosystems support an array of recreational fishing and subsistence activities as well as non-consumptive activities such as wildlife viewing. Furthermore, some people may not directly interact with the Bering Sea and GOA marine ecosystems and the various species associated with them but derive satisfaction from knowing that the structure and function of these ecosystems are protected.

The focus in this analysis is on the direct and indirect effects of the alternatives on ecosystem benefits other than those that accrue to members of society who make a living harvesting, processing and distributing BSAI and GOA groundfish products or who purchase and consume these products. The direct and indirect effects of the alternatives on firms and communities that derive value from the commercial harvest and processing of groundfish are described elsewhere in the draft Programmatic SEIS. Similarly, the effects of the alternatives on consumers of groundfish products are discussed in a separate section of the draft Programmatic SEIS.

The value people assign to those marine ecosystem benefits that are unrelated to commercial groundfish fisheries are thought to be considerable. For example, the value of protecting the Steller sea lion alone may be substantial. As discussed in Section 3.9.7, a contingent valuation study suggests that there is a significant willingness to pay on the part of the American public for an expanded federal Steller sea lion recovery program. At this time, however, there is insufficient information to provide a comprehensive measure of the benefits derived from these ecosystems and the various species associated with them.

FMP 4.1 assumes that the current groundfish fisheries are producing large-scale adverse effects on the Bering Sea and GOA marine ecosystems. A primary purpose of this FMP bookend is to provide increased protection for habitat and the overall ecosystem. To mitigate the possibility of detrimental biological and environmental impacts from fishing, for example, this bookend would designate 20-50 percent of the management area as no-take marine reserves covering the full range of marine habitats within the 1,000-m bathymetric line (Figure 4.2-6). As part of this area in the Aleutian Islands, a Special Management Area would be established to protect coral and other live bottom habitats. This area would also include spawning reserve areas for intensively fished species. Comprehensive trawl exclusion zones would be set aside to protect all Steller sea lion critical habitat, and trawling itself would be restricted to only those fisheries that cannot be prosecuted with other gear types.

As discussed in Section 4.8.10, the measures implemented under FMP 4.1 are expected to have significantly or conditionally significant beneficial consequences for predator-prey relationships, energy flow and balance, and diversity. In turn, these beneficial effects on the Bering Sea and GOA marine ecosystems and associated species are expected to lead to a significant increase in the levels of some of the benefits these ecosystems and species provide.

FMP 4.2 is predicted to significantly increase the level of benefits the Bering Sea and GOA marine ecosystems and associated species provide relative to the comparative baseline. These findings are based on the assessment of the direct and indirect effects of FMP 4.2 on the environment with respect to the ecosystem issues of predator-prey relationships, energy flow and balance, and diversity. This assessment of ecosystem effects is presented in Section 4.8.10 of the draft Programmatic SEIS.

By suspending all fishing, FMP 4.2 would remove all risk that groundfish fisheries have an adverse effects on the Bering Sea and GOA marine ecosystems and species associated with them. A groundfish fishery may be reopened under this FMP bookend, but only if it can be shown to pose no significant threat of adverse environmental impacts or if adverse effects can be successfully mitigated through use of fishery-specific regulations. As discussed in Section 4.8.10, these measures are expected to have significantly or conditionally significant beneficial consequences for predator-prey relationships, energy flow and balance, and diversity. In turn, these beneficial effects on the Bering Sea and GOA marine ecosystems and associated species are expected to lead to a significant increase in the levels of some of the benefits these ecosystems and species provide.

Cumulative Effects of FMP 4.1 and FMP 4.2

For a summary of the direct/indirect and cumulative ratings, refer to Table 4.8-6.

<u>Benefits Derived from Marine Ecosystems and Associated Species</u>

- **Direct/Indirect Effects**. FMP 4.1 is predicted to have a significantly beneficial impact on the levels of benefits these ecosystems and associated species generate. Under FMP 4.2 fishing is suspended this is assumed to contribute to healthier ecosystems and significantly increase the benefits these ecosystems and species provide relative to the comparative baseline.

- **Persistent Past Effects**. Persistent past effects on non-consumptive and non-use benefits) include: an increase in public awareness of marine ecosystems; increased participation in recreational fishing and eco-tourism activities; and public perceptions with regard to fisheries management. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects**. Reasonably foreseeable future effects include other fisheries, and long-term climate change and regime shifts. These factors do not vary among alternatives; for more detail refer to the analysis in FMP 1.

- **Cumulative Effects**. Under FMP 4.1, a cumulative effect is identified for benefits the public derives from marine ecosystems and associated species (including non-consumptive and non-use benefits), and the effect is judged to be conditionally significant beneficial. The external impacts of other fisheries have the potential to contribute adversely to benefits the public derives from marine ecosystems and associated species. FMP 4.1 management measures could have adverse effects on the introduction of non-native species. However, the bookend could have beneficial effects on the change in pelagic forage availability, spacial and temporal concentration of fishery impact on forage, removal of top predators (potential for seabird bycatch and subsistence harvests of marine mammals), energy removal and energy redirection, changes in species, functional, and structural habitat diversity for the ecosystem. The long-term climate change and regime shift could adversely effect ecosystems and associated species due to the natural fluctuations in groundfish stocks.

Under FMP 4.2, a cumulative effect is identified for benefits the public derives from marine ecosystems and associated species (including non-consumptive and non-use benefits), and the effect is judged to be conditionally significant beneficial. The external impacts of other fisheries have the potential to contribute adversely to benefits the public derives from marine ecosystems and associated species. The elimination of fishing under FMP 4.2 will provide increased protection for the habitat and overall ecosystem. FMP 4.2 could have beneficial effects on the change in pelagic forage availability, spacial and temporal concentration of fishery impact on forage, removal of top predators (potential for seabird bycatch and subsistence harvests of marine mammals), energy removal and energy redirection, changes in species, functional, and structural habitat diversity for the ecosystem. Future climatic conditions, in combination with fisheries-related pressures, could also affect species diversity.

4.8.10 Ecosystem Alternative 4 Analysis

Ecosystems are populations (consisting of single species) and communities (consisting of two or more species) of interacting organisms and their physical environment that form a functional unit with a characteristic trophic structure (food web) and material cycles (movement of mass and energy among the groups). The following analyses of potential direct/indirect and cumulative effects of Alternative 4 apply to the BSAI and GOA ecosystems. Where available information allows, each ecosystem is addressed separately. In most cases, however, information is insufficient to allow individual consideration, and the two ecosystems are treated as a single entity.

As explained in Section 4.5.10, the analyses include numerous indicators representing potential direct, indirect, and cumulative effects of the alternative and specific bookends where applicable. Significance thresholds for the effect categories are presented in Table 4.1-7.

Direct/Indirect Effects – FMP 4.1

The following discussions assess the potential direct/indirect effects of FMP 4.1 on the BSAI and GOA ecosystems.

<u>Change in Pelagic Forage Availability</u>

Pelagic forage availability is assessed by evaluating population trends in pelagic forage biomass for species with age-structured population models. These include walleye pollock in the GOA (Figure H.4-17 of Appendix H) and Bering Sea walleye pollock and Aleutian Islands Atka mackerel (Figure H.4-18 of Appendix H). Trends in bycatch of other forage species (herring, squid, and forage species group) in the groundfish fisheries are a measure of the potential impact on those groups in the BSAI and GOA (Figure H.4-19 and Figure H.4-20 of Appendix H). Table 4.5-81 summarizes the average values from 2003-2008 for these measures and the percent change in these values from the baseline. In FMP 4.1, pelagic forage biomass in the BSAI (Bering Sea walleye pollock + Aleutian Islands Atka mackerel) would increase slightly by about 2 percent. In the GOA, pelagic forage biomass (specifically, walleye pollock) would increase by 63 percent relative to the baseline. These increases would result from setting F75 percent for prey species in this FMP. Average biomass remains within the bounds of historically estimated biomass that occurred before a target fishery emerged. Bycatch of other forage species would decline by about 45 percent in the BSAI and 79 percent in the GOA. The extensive fishing closure areas in this alternative may change bycatch estimates. The absolute amount of pelagic forage bycatch in each region would be relatively small (900 mt and 60 mt, respectively). Estimates of forage biomass from food web models of the EBS indicate that this bycatch would be a small proportion of the total forage biomass (Aydin *et al*. 2002). However, the lack of population-level assessments for some of the species in the forage species group means that species-level effects are unknown.

On the basis of the above considerations, FMP 4.1 is determined to have an insignificant effect on the BSAI and GOA ecosystems with respect to pelagic forage availability to target species. The increases in target species forage in this alternative have the potential to provide beneficial benefits to marine mammals such as Steller sea lions, harbor seals, and northern fur seals. Therefore, FMP 4.1 is determined to have significantly beneficial (Steller sea lions) and conditionally significant beneficial (northern fur seals) effects on prey availability to marine mammals. Sections 4.8.1 through 4.8.8 discuss the effects of pelagic forage abundance on these groups.

<u>Spatial and Temporal Concentration of Fishery Impact on Forage</u>

The impact of the spatial/temporal concentration of fisheries on forage species is assessed qualitatively by looking at the potential for the alternatives to concentrate fishing on forage species (walleye pollock, Atka mackerel, herring, squid, and other groups) in regions used by predators that are tied to land, such as pinnipeds and breeding seabirds. Additionally, concentration levels high enough to lead to ESA listing or prevention of recovery in an ESA-listed species are also considered. FMP 4.1 has comprehensive trawl exclusion zones to protect all designated SSL critical habitat, continues the ban on forage fish, sets precautionary harvest levels for target species that are prey (pollock and Atka mackerel, in particular), and has finer spatial allocations of TAC. These controls on spatial/temporal allocations of catch are more stringent than those included in the baseline and are judged to have significantly beneficial effects on spatial/temporal forage availability to Steller sea lions and harbor seals. FMP 4.1 is also considered conditionally significant beneficial on the prey availability of northern fur seals. For seabirds, these measures would have an insignificant effect on the spatial/temporal concentration of the fishery on forage species.

<u>Removal of Top Predators</u>

Removal of top predators, either through directed fishing or bycatch, is assessed by evaluating the trophic level of the catch relative to trophic level of the groundfish biomass (Figures H.4-21 through H.4-24 of Appendix H), bycatch levels of sensitive top predator species such as birds and sharks (Figures H.4-25 and H.4-26), and a qualitative evaluation of the potential for catch levels to cause one or more top-level predator species to fall below biologically acceptable limits (minimum stock size threshold for groundfish, ESA listing or prevention of recovery for an ESA-listed species). Trophic level of the catch in both the BSAI and GOA is a very stable property, changing less than 3 percent on average from the baseline, and the trophic level of the groundfish species for which we have age-structured models and which dominate the catch changes less than 1 percent on average. Under FMP 4.1, top-predator bycatch amounts would decrease relative to the baseline by an average of about 13 percent in the BSAI and about 86 percent in the GOA. The absolute values of average catch for these species are estimated to be 585 mt and 180 mt in the respective regions under this FMP (Table 4.5-81). These are large decreases relative to the baseline and would be considered an improvement over existing conditions.

The baseline determination is that historical whaling has resulted in low present-day abundance of whale species in the North Pacific. FMP 4.1 would not further impair the recovery of whale species through direct takes. Although this FMP could increase the amount of longline fishing, which tends to have higher levels of seabird bycatch relative to other fisheries, it proposes to set protection measures for all seabird species and to develop fishing methods that reduce incidental take. Consequently, levels of seabird and pinniped bycatch under FMP 4.1 would not lead to an ESA listing for any of those populations or prevent any of these species from recovery under the ESA. Sections 4.8.7 and 4.8.8 discuss the effects of groundfish fishery direct takes on specific seabird and marine mammal populations. The effect of shark bycatch on shark populations is unknown at present, and research directed at better assessing population levels of these sensitive (late maturing, low fecundity, low natural mortality) species is needed to better assess the potential for groundfish fisheries to affect these populations. By breaking sharks out of the other species group for TAC setting and setting the TAC level on the basis of the least abundant member of the group, FMP 4.1 may provide increased protection for sharks. Thus, it could have a significantly beneficial effect on this top predator group. Stability in trophic level of the catch is indicative of little effect of the fishery on target and PSC species top predators (Greenland turbot, arrowtooth flounder, sablefish, Pacific cod, and Pacific halibut). Overall, FMP 4.1 would have a significantly beneficial effect on top predators.

Introduction of Non-Native Species

The introduction of non-native species through ballast water exchange and hull-fouling organism release from fishing vessels could potentially disrupt the Alaskan marine food web structure (Fay 2002). There have been 24 species of non-indigenous species of plants and animals documented primarily in shallow-water marine and estuarine ecosystems of Alaska, with 15 species recorded in PWS. It is possible that most of these introductions were from tankers or other large commercial vessels that have large amounts of ballast exchange. However, exchange via fishery vessels that take on ballast from areas where invasive species have already been established and then transit through Alaskan inshore waters has been identified as a threat in a recently developed State of Alaska Aquatic Nuisance Species Management Plan (Fay 2002). Consequently, this effect is evaluated as conditionally significant adverse in the baseline.

Total groundfish catch levels are used as indicators for potential changes in the amount of these releases via groundfish fishery vessels (Figures H.4-27 and H.4-28 of Appendix H). Total catch would decrease by about 64 percent in the BSAI and 63 percent in the GOA under FMP 4.1, relative to the baseline. Therefore, FMP 4.1 would substantially reduce the potential for fishing vessel introduction of non-native species through ballast water exchange or release of hull-fouling organisms. However, there is insufficient information regarding fishing effort levels that would result in a successful introduction and this potential effect is evaluated as conditionally significant beneficial with respect to predator-prey relationships.

Energy Flow and Balance

As discussed in Section 3.10, fishing may alter the amount and flow of energy in an ecosystem by removing energy and altering energetic pathways through the return of discards and fish processing offal back into the sea. The recipients, locations, and forms of this returned biomass may differ from those in an unfished system. Baseline energy removals, in the form of total catch, were less than one percent of the total system energy determined by mass-balance modeling of the system and were determined to have an insignificant effect on the ecosystem. FMP 4.1 catch removals (Table 4.5-81), which decrease by about 64 percent and

63 percent from the baseline in the BSAI and GOA, respectively, show the potential for large improvements relative to the baseline with respect to producing changes in system biomass, respiration, production, or energy cycling outside the range of natural variability (Table 4.1-7). Because of existing uncertainty regarding these potential effects, FMP 4.1 is rated conditionally significant beneficial with respect to energy removal.

Energy re-direction, in the form of discards, fishery offal production, or unobserved gear-related mortality, can potentially change the natural pathways of energy flow in the system. Animals damaged when passing through the meshes of trawls may later die and be consumed by scavengers. Bottom trawls can expose benthic organisms and make them more vulnerable to predation. Discards and offal production can cause local enrichment and changes in species composition or water quality if discards or offal returns are concentrated there. These effects were determined to be insignificant at the ecosystem level in the baseline. Estimates of total discards (Figures H.4-29 and H.4-30 of Appendix H) under FMP 4.1 show a 46 percent decrease in the BSAI and a 64 percent decrease in the GOA relative to the baseline. Because these amounts of change would be large improvements over baseline conditions, they would create the potential for a conditionally significant beneficial effect on ecosystem-level energy cycling characteristics. The conditional rating, however, reflects uncertainty regarding the degree to which fishery-related discards, offal release, and gear-related mortality actually affect energy re-direction at the ecosystem level.

Change in Species Diversity

Fishing can alter different measures of diversity. Species-level diversity, or the number of species, can be altered if fishing essentially removes a species from the system. Fishing can alter functional diversity from a trophic standpoint if it selectively removes or depletes a trophic guild member and thus changes the way biomass is distributed within a trophic guild. Functional diversity can be altered if fishing methods, such as bottom trawling, remove or deplete organisms such as corals, sea anemones, or sponges that provide structural habitat for other species. Fishing can alter genetic diversity by selectively removing faster-growing fish or removing spawning aggregations that might have genetic characteristics that are different from other spawning aggregations. Larger, older fishes may be more heterozygous (i.e., have more genetic differences or diversity) and some stock structures may have a genetic component (see review in Jennings and Kaiser 1998). Consequently, one would expect a decline in genetic diversity to result from heavy exploitation of a fishery.

Significance thresholds for effects of fishing on species diversity have catch removals high enough to cause the biomass of one or more species (target or non-target) to fall below, or to be kept from recovering from levels already below minimum biologically acceptable limits (MSST for target species, ESA listing for non-target species) (Table 4.1-7). Bycatch amounts of sensitive (low population turnover rates) groups that lack population estimates (skates, sharks, grenadiers, and sessile invertebrates, such as corals, inhabiting Habitat Areas of Particular Concern, or HAPC) may also indicate potential for fishing impact on these species (Figures H.4-31 and H.4-32 of Appendix H). Closed areas also provide protection, particularly to less-mobile species like HAPC biota, so the amount of area closures across habitat types can indicate the degree of species-level diversity protection. Baseline determinations were made of insignificance for some species and unknown for skates and sharks.

Under FMP 4.1, bycatch of HAPC biota would decrease by about 44 percent in the BSAI and 60 percent in the GOA (Table 4.5-81). This FMP would also provide substantial increases in closed areas in the form of no-take reserves. These closures would produce even greater decreases in HAPC biota bycatches that are not modeled here and would likely be sufficient to prevent species extinction for these sessile animals. Catch amounts of target species, prohibited species, seabirds, and marine mammals would be insufficient to bring these species below minimum population thresholds. The practice of setting TAC for a group based on the least abundance species in the complex, and breaking species out of complexes when possible, would prevent skates, sharks, and grenadiers from reaching minimum population thresholds. Although forage species population levels are not known, their relatively high turnover rates, the ban on forage fish fisheries in this FMP, and the practice of breaking species out of a complex when possible, are considered sufficient to protect them from falling below minimum biologically acceptable limits. Therefore, this alternative is determined to be significantly beneficial since it provides substantial improvements to species diversity relative to the baseline. Sections 4.8.1 through 4.8.8 discuss more detailed analyses of the potential for fishery removals to affect minimum population thresholds for each of these groups and thus ultimately to affect species diversity.

Change in Functional Diversity

Functional (either trophic or structural habitat) diversity can be altered through fishing if fishing selectively removes one member of a functional guild, which may result in increases in other guild members. Indicators of the possible magnitude of effects include qualitative evaluation of guild or size diversity changes relative to fishery removals, bottom gear effort changes that would provide a measure of benthic guild disturbance, and bycatch amounts of HAPC biota, a structural habitat guild. Members of the HAPC biota guild serve important functional roles in providing fish and invertebrates with structural habitat and refuge from predation. The long-lived nature of corals, in particular, makes them susceptible to permanent eradication in fished areas. Some of the area closures in FMP 4.1 have been designed with corals in mind and would ensure that there is a broad spatial distribution of corals in the Aleutian Islands, in particular. Therefore, FMP 4.1 is determined to have potential for significant improvements relative to the baseline condition for structural habitat diversity. Thus, FMP 4.1 may provide significantly beneficial improvements relative to the baseline with respect to both trophic and structural habitat diversity.

Change in Genetic Diversity

Genetic diversity can be affected by fishing through heavy exploitation of certain spawning aggregations or systematic targeting of older age classes that tend to have greater genetic diversity. Under FMP 4.1, no target species would fall below MSST, there would be finer areas for spatial management of TAC, and spawning area reserves would be established to protect exploited species that are fished intensively at spawning time. Consequently, the groundfish fisheries would have an insignificant effect on genetic diversity as managed under FMP 4.1. However, baseline genetic diversity remains unknown for most species and the actual direct/indirect effects of fishing on genetic diversity are also largely unknown.

Cumulative Effects Analysis – FMP 4.1

The following sections discuss the potential cumulative effects on the ecosystem of FMP 4.1, acting additively or interactively with the effects of external human actions and natural processes persisting from the past, ongoing in the present, and predicted for the reasonably foreseeable future. These potential cumulative effects are summarized in Table 4.8-7. Data and calculations supporting the cumulative energy removal analyses for all of the alternatives are presented in Table 4.5-81.

<u>Change in Pelagic Forage Availability</u>

- **Direct/Indirect Effects.** The effects of FMP 4.1 are expected to be significantly beneficial for prey species utilized by the Steller sea lion, and conditionally significant beneficial for northern fur seal forage availability. FMP 4.1 would have an insignificant effect on BSAI and GOA groundfish target species with respect to pelagic forage availability.

- **Persistent Past Effects.** Past effects of forage fish bycatch by the BSAI pollock and GOA rockfish domestic fisheries, and targeted domestic catches of pollock and Atka mackerel, are likely to have affected forage fish populations in ways that may persist into the present and future (Section 3.10.1.4). From about 1925 to 1941, Alaska herring harvests for oil and meal ranged from about 50,000 to 150,000 mt per year, and a large foreign herring fishery removed from about 30,000 to 150,000 mt per year during the 1960s and 1970s (ADF&G 2003a). Past climatic changes, including inter-decadal oscillations and ENSO events, have been shown to affect forage fish populations (Section 3.10.1.5), and these effects may persist.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska manages herring fisheries on a sustainable basis and has established a maximum exploitation rate (fraction of the spawning population removed by the fishery) of 20 percent. Fisheries are closed if stock size falls below MSST. Lower exploitation rates are applied when herring stocks decline to near-threshold levels (ADF&G 2003a). This management approach is expected to continue for the indefinite future. Subsistence harvests will continue to remove an increment of pelagic forage biomass each year. Relative to the BSAI and GOA groundfish fisheries, however, the additional contribution of subsistence fisheries to the annual removal of pelagic forage biomass is likely to be very small. The EVOS suggests that a large oil or fuel spill that coincides in space and time with herring or capelin spawning would most likely produce population declines, and other pelagic forage species (such as eulachon, which spawn on beaches) might also be adversely affected. Finally, future climate changes, especially a regime shift, would likely affect the productivity, and thereby the population sizes, of pelagic forage species (Section 3.10.1.5).

- **Cumulative Effects.** Based on the direct/indirect effects conclusions for FMP 4.1, the groundfish fisheries would contribute a beneficial increment to any broader cumulative effect. A potentially adverse contribution by one or more external factors, including State of Alaska directed fishery removals and subsistence harvests of forage fishes such as herring, capelin, or eulachon, could offset the beneficial contribution of the groundfish fisheries by some increment of forage fish removal. In addition, a large marine oil or fuel spill would have the potential to deplete forage fish populations to a significant extent. Therefore, the potential cumulative effect associated with FMP 4.1 is considered to be conditionally significant beneficial because the beneficial contribution of this FMP could be offset by external factors under the conditions described.

Spatial/Temporal Concentration of Fishery Impact on Forage

- **Direct/Indirect Effects.** The effects of implementing FMP 4.1 are expected to be significantly beneficial for prey species utilized by the Steller sea lion, and conditionally significant beneficial for northern fur seal forage availability. FMP 4.1 would have an insignificant effect on seabirds with respect to pelagic forage availability.

- **Persistent Past Effects.** Geographic and seasonal concentrations of past forage fish bycatch from the BSAI pollock and GOA rockfish fisheries, herring bycatch, and targeted catches of pollock and Atka mackerel have affected forage fish populations in ways that may have persisted into the present and future (Section 3.10.1.4). Past herring fisheries have followed a stable pattern of timing and location dictated by the spawning behavior of the fish (ADF&G 2003a). Past climatic changes, including inter-decadal oscillations and ENSO events, have shown effects on recruitment rates and distribution patterns of forage fish populations (Section 3.10.1.5). Such effects may be exerting a persistent effect on forage fish populations, although evidence is not sufficient to allow quantification.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska directed herring fishery will exert fishing pressures on herring and other forage fish populations at particular times and places that could overlap with fishing pressures from the groundfish fisheries. Because the herring fishery is mainly inshore, overlapping with the groundfish fishery is more likely temporal than spatial. Subsistence harvest patterns are not coordinated with commercial fishing effort and will sometimes overlap with spatial/temporal patterns of the groundfish fishery, but the incremental contribution of subsistence to this cumulative effect will continue to be negligible. The EVOS of 1989 suggests that a large oil or fuel spill that coincides in space and time with herring or capelin spawning would most likely produce population declines and adversely impact other pelagic forage species (such as eulachon, which spawn on beaches). Finally, future climate change, especially a regime shift, could alter the spatial/temporal distributions of pelagic forage species in ways that are synergistic with spatial/temporal concentrations of fishing effort in the BSAI and GOA groundfish fisheries.

- **Cumulative Effects.** The potential effects of the spatial/temporal concentration of fisheries on forage species availability as modeled under FMP 4.1 are rated as significantly beneficial for Steller sea lion prey species, conditionally significant beneficial for northern fur seal prey species, and insignificant for seabird forage availability. A potentially adverse contribution by one or more external factors could offset this beneficial contribution by some increment of forage fish removal in the future. For example, if the fishing efforts of State of Alaska directed fisheries, principally for herring, and subsistence fish harvests converge in space and time with a fuel or oil spill, forage fish populations could be depressed sufficiently to impair the long-term viability of ecologically important top predators such as seabirds and marine mammals (Table 4.1-7). Future climate change, consistent with effects observed in the recent past (Section 3.10.1.5), could alter the spatial/temporal distributions of pelagic forage species and offset the beneficial contribution of groundfish fishery management. The potential cumulative effect associated with FMP 4.1 is considered conditionally significant beneficial because the beneficial contribution of these FMPs could be offset by external factors under the conditions described.

Removal of Top Predators

- **Direct/Indirect Effects.** FMP 4.1 would have a significantly beneficial effect on top predators. Under FMP 4.1, the predicted decreases in catch are large relative to the baseline and would be an improvement over existing conditions. Protection measures would be put in place for all seabird species, and fishing methods developed to reduce incidental take. Therefore, levels of seabird and pinniped bycatch in the groundfish fisheries under FMP 4.1 would not lead to an ESA listing for any of those populations or prevent any of these species from recovery under the ESA.

  FMP 4.1 would have a conditionally significant adverse effect on seabirds; an insignificant effect on whales, pinnipeds, top-predator target, and PSC species; and an unknown effect on sharks. The greatest concern regarding the effects of FMP 4.1 on top predators is the increased potential for bycatch of seabirds. Increased fishing effort and the maintenance of former, rather than improved seabird protection measures, under FMP 4.1 are considered conditionally significant adverse measures for ESA-listed seabirds such as short-tailed albatross. Also, removal of area closures around the Pribilof Islands may lead to disproportionate take of fulmars from that colony. The conditionally significant rating reflects uncertainty of future bycatch levels and existing population-level effects of bycatch removals on seabird species (Section 3.7).

- **Persistent Past Effects**. Before passage of the MSA in 1976, groundfish fisheries in the BSAI and GOA produced much higher than present bycatch levels of sharks, seabirds, and marine mammals. Historical whaling, resulting in high mortality levels in the 1960s (Section 3.10.1.3), produced a sustained effect on these slowly reproducing populations that is reflected in the low present-day abundance of whale species in the North Pacific. State of Alaska directed groundfish fisheries, which are small and sustainably regulated, have annually removed top predators such as sablefish and Pacific cod at levels safely above MSST (ADF&G 2003b). These fisheries also produced shark, seabird, and marine mammal bycatch in the past, although quantitative data are lacking on past and current bycatch levels in these fisheries. Past and present groundfish fisheries operating outside of U.S. jurisdiction in the western Bering Sea have also contributed to the bycatch of top predators, in some cases at high levels (Sections 3.7.1 and 3.10.1). Marine mammals continue to be removed for subsistence, although at much lower levels than in the past, and past harvests may have had a sustained effect on some populations that persist today. Finally, there is evidence that past climatic variability may have affected the recruitment and distribution of some top predator fish species (Section 3.10.1.5; Hollowed *et al.* 1998).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery will continue to remove a sustainable portion of the Pacific halibut population, a top predator. The current management plan is likely to continue in the reasonably foreseeable future, although a modified approach has been proposed to produce a yield similar to the present policy while reducing variations in annual yield due to changes in stock abundance, assessment methods, and estimated removals by other fisheries (Clark and Hare 2003). High levels of seabird bycatch and resulting direct mortality are expected to continue annually from North Pacific Ocean longline fisheries operating outside of the EEZ. Available data and estimates for the annual incidental take of individual bird species by these external fisheries are provided and discussed in Sections 3.7.1-19. The State of Alaska directed groundfish fisheries, operating in state waters of the eastern GOA and southeast Alaska, Cook Inlet, PWS, Kodiak, and the Alaska Peninsula, and in all state waters for lingcod, sablefish, and Pacific cod, will continue to remove targeted top predatory fish species in small numbers relative to the domestic groundfish fisheries in federal waters (ADF&G 2003b). Subsistence harvests of marine mammals will continue in the future with an increasing trend toward co-management by NOAA Fisheries and Alaska Native organizations. The Protected Resources Division of NOAA Fisheries will continue to develop management and conservation programs to ensure that annual subsistence harvests are sustainable (NOAA Fisheries 2003). A large fuel or oil spill at sea would result in direct mortality of marine mammals, with mortality levels depending on the location, size, and timing of the spill. Finally, a future climatic regime shift could alter total numbers of top predators in the BSAI and GOA ecosystems by increasing or limiting recruitment.

- **Cumulative Effects.** Based on the potential effects of FMP 4.1 on top predator populations, the groundfish fisheries could contribute a beneficial increment to any broader cumulative effect on top predators. A potentially adverse contribution by one or more external factors, particularly a continuation of high levels of seabird bycatch by North Pacific Ocean longline fisheries operating outside the EEZ, would incrementally offset the beneficial contribution of FMP 4.1. Because these external fisheries are generally not managed in conjunction with the BSAI and GOA domestic groundfish fisheries, there is a likelihood that the present high levels of seabird bycatch outside the EEZ will continue in the future. The conditions under which the beneficial contribution could be offset are the continuation of high external seabird bycatch rates in conjunction with a large fuel or oil spill, along with incremental removals of top predators by the IPHC longline fishery, State of Alaska directed groundfish fisheries, and subsistence harvests of marine mammals. As determined from recent climatic studies (Section 3.3), a climatic regime shift is probable in the future and could influence the potential cumulative effect by affecting biological recruitment. For these reasons, the effects of FMP 4.1 are determined to be conditionally significant beneficial.

<u>Introduction of Non-Native Species</u>

- **Direct/Indirect Effects.** FMP 4.1 may reduce the potential for adverse effects on predator-prey relationships through the introduction of non-native species through limiting fishing vessels in Alaskan waters annually. This potential effect is considered conditionally significant beneficial due to lack of information regarding fishing effort levels and the probability that an introduced exotic species will establish a viable population.

- **Persistent Past Effects.** For decades, the annual arrival of groundfish fishing vessels from ports outside of Alaska has made it possible for non-native species to enter Alaskan waters through the release of ballast water and hull-fouling organisms. Commercial shipping has provided a similar means for the introduction of non-native species (Fay 2002). There have been 24 non-indigenous species of plants and animals documented in Alaskan waters, with 15 of these recorded in PWS, where most of the research has been conducted. Although oil tankers, through the release of ballast water, have been speculated to be the primary source for these introductions, cruise ships and fishing vessels coming from areas where invasive species have already been established have also been identified as a threat in the State of Alaska Aquatic Nuisance Species Management Plan (Fay 2002). From 1991 to 2001, 396,522 accidental escapes of Atlantic salmon were reported from British Columbia fish farms (ADF&G 2002a). Concerns have been expressed regarding the potential effects of introduced Atlantic salmon on native Pacific salmon populations, including diseases and parasites, colonization, interbreeding and hybridization, predation, habitat destruction, and competition, particularly in locations where depressed stocks of Pacific salmon species provide a potential niche for the Atlantic species (Brodeur and Busby 1998, ADF&G 2002a). In the past, Alaska's northern climate, geographic isolation, and small human population, among other factors, may have prevented the establishment of viable populations by non-native species introduced from more temperate regions (Fay 2002).

- **Reasonably Foreseeable Future External Effects.** IPHC longline fishery vessels, international longline and groundfish fleets operating outside the EEZ, and vessels participating in State of Alaska directed fisheries will continue to be potential sources of exotic introductions in the reasonably foreseeable future. In addition, commercial shipping, including cruise ships, barges and tankers with high-volume ballast water releases, will continue to bring non-native species into Alaskan waters on a recurring basis, maintaining a continuing pressure on indigenous populations (Fay 2002). Escapes and releases of farmed Atlantic salmon from Washington State and British Columbia net-pens might eventually establish runs in GOA coastal streams and rivers. Introduced pathogens and parasites associated with farmed Atlantic or Pacific salmon could infect wild stocks. A future regime shift or long-term warming trend could remove the protection that colder conditions may currently provide against exotic species, allowing viable non-native populations to become established.

- **Cumulative Effects.** The potential effect of FMP 4.1 on the introduction of non-native species is rated conditionally significant beneficial. However, when sources of exotic species external to the domestic groundfish industry are considered in combination with FMP 4.1, it is conceivable that viable populations could eventually become established in the BSAI and/or GOA (Table 4.1-7). If these external factors remain similar to baseline conditions in the future, the cumulative outcome would be beneficially influenced under FMP 4.1. One possible, but unproven, condition for this outcome would be a future climatic regime shift or long-term warming trend that might allow exotic species currently limited by low seawater temperatures to establish viable populations in the BSAI and/or GOA. In considering these conditions, the potential cumulative effects of FMP 4.1 are rated conditionally significant beneficial for the introduction of non-native species.

Energy Removal

- **Direct/Indirect Effects.** The effects of FMP 4.1 on energy removal would be conditionally significant beneficial. Total catch under FMP 4.1 and FMP 4.2 decreases by about 64 and 63 percent from the baseline in the BSAI and GOA, respectively (Table 4.5-81). These are large improvements relative to the baseline in producing changes in system biomass, respiration, production, or energy cycling outside the range of natural variability (Table 4.1-7).

- **Persistent Past Effects.** The domestic groundfish fisheries, State of Alaska commercial fisheries, IPHC longline fisheries, commercial harvests of marine mammals, and subsistence harvests have all removed biomass from the BSAI and GOA ecosystems, either as targeted species or as bycatch, and these removals, in a regulated and mitigated form, continue today (Section 3.10). Aggregate biomass levels removed by unregulated past human activities would have been influenced by climatic effects on overall system productivity, with biomass removals increasing as productivity increased and decreasing with climate-related productivity declines**.**

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fisheries, State of Alaska commercial fisheries, subsistence fish harvests, and subsistence marine mammal harvests will continue to remove biomass from the BSAI and GOA ecosystems in the future. The incremental contribution of the combined State of Alaska herring and crab and IPHC halibut fisheries is estimated at about 4 percent of the cumulative biomass that would be removed annually under this FMP (Table 4.5-81). The State of Alaska directed groundfish and subsistence fisheries will remove an additional small increment annually (ADF&G 2003b, 2001). It should be noted that Russian and other fisheries operating in the western Bering Sea and in international waters of the central Bering Sea (doughnut hole) will also remove biomass in the future, but these regions show sufficient differences from the EBS with respect to production regimes and topographic and hydrographic features that are viewed as only partly comparable systems, and their interactive components with the EBS, where present, have not yet been characterized (Aydin *et al*. 2002).

- **Cumulative Effects.** The implementation of FMP 4.1 is predicted to have a conditionally significant beneficial cumulative effect on energy removal. If the annual total catches of the State of Alaska herring and crab and IPHC halibut fisheries in the future are similar to the 1997-2001 averages, the combined total catch of these external fisheries will represent a 17.3 percent addition to the estimated total catch for the groundfish fisheries alone under this FMP (Table 4.5-81). Thus, under FMP 4.1, the groundfish fisheries would remove a much smaller portion of the cumulative total energy (as biomass) than under Alternatives 1, 2, or 3, where the relative contributions of the external fisheries would be smaller. Whether this improvement in biomass removal would actually produce a measurable increase in energy within the BSAI and GOA ecosystems, and how that increase would be biologically manifested, cannot be predicted.

Energy Redirection

- **Direct/Indirect Effects.** The effects of FMP 4.1 on energy redirection are evaluated as conditionally significant beneficial. Projections of total discard biomass modeled for FMP 4.1 show about a 46 percent decrease in the BSAI and a 64 percent decrease in the GOA from baseline conditions (Table 4.5-81). These are large changes from baseline conditions, and create the potential for a conditionally significant beneficial effect on ecosystem-level energy cycling characteristics (Table 4.1-7).

- **Persistent Past Effects.** Ecosystem energetics is a dynamic process and it is difficult to know whether past changes in energy cycling and pathways of energy flow in the BSAI and GOA produced effects that still persist. The most far-reaching changes in quantities and geographic patterns of bycatch discards and offal production from both fish and marine mammal harvests came with international agreements, legislation, and regulatory actions in the 1950s through the 1970s, culminating in passage of the MSA in 1976 (Section 3.10.1.3). These corrective actions greatly curtailed the destabilizing levels of energy redirection that reached their peak in the mid-twentieth century from commercial whaling, fur seal harvests, high-seas driftnet fisheries, and the international commercial groundfish and salmon fisheries that existed. It seems likely, therefore, that under current management practices, quantities and patterns of energy redirection in the BSAI and GOA are much more limited than 50 years ago.

- **Reasonably Foreseeable Future External Effects.** Quantities and geographic patterns of bycatch discards and fish processing wastes released into the sea from the IPHC and State of Alaska commercial fisheries and subsistence harvests are not expected to change substantially in the future. External energy will also enter the system as graywater and refuse released into the sea from commercial freighters, tankers, and cruise ships. Finally, future climatic trends have the potential to affect energy cycling in the ecosystem; in particular, a warming trend would be expected to accelerate rates of energy conversion, whereas cooler conditions would tend to have a retarding effect.

- **Cumulative Effects.** The implementation of FMP 4.1 is predicted to have a conditionally significant beneficial cumulative effect on the ecosystem through energy redirection. The BSAI and GOA groundfish fisheries would remove and return much smaller quantities of energy (as biomass) relative to external sources such as the IPHC halibut fishery, State of Alaska commercial fisheries, annual subsistence harvests of fish and marine mammals. At the local level, water quality degradation will still result from the release of fish processing offal into low-energy environments, such as coves and bays, where nutrients from these wastes can concentrate in sheltered waters and alter local patterns of energy cycling. However, it is expected that the lower quantities of fish processing waste released under FMP 4.1would moderate this effect.

Change in Species Diversity

- **Direct/Indirect Effects.** Potential effects of FMP 4.1 on species diversity are rated as significantly beneficial for all groups. Targeted catch reductions and greater discrimination in TAC setting, substantial bycatch reductions, increases in closed areas in the form of no-take reserves, the ban on forage fish fisheries, and other protective measures under this FMP would all be significant influences in keeping most species above minimum biologically acceptable limits (Table 4.1-7).

- **Persistent Past Effects**. Although the pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries have cumulatively removed large quantities of fish from the BSAI and GOA ecosystems in the past, the timing of various increases and decreases in species abundance of fish, seabirds, and marine mammals has not shown a consistent correlation with groundfish fishing intensity (Sections 3.10.1). With the notable exception of the Steller's sea cow extinction in the 1760s (Section 3.10.1.1), changes in species diversity have not characterized the BSAI and GOA ecosystems. Although no fishing-related species removals have been documented under fisheries management policies in effect during the past 30 years, elasmobranchs (sharks, skates, and rays) are particularly susceptible to removal, and benthic invertebrate (including HAPC) species are susceptible to bottom trawling (Section 3.10.3). Seabirds have been particularly vulnerable to bycatch mortality, leading to reduced populations of some bird species below minimum biologically acceptable limits. Lack of data on seabird population trends prevents analysis of past effects of fisheries management or environmental change on most seabird species (Section 3.7), but commercial fisheries have been implicated in some declines through bycatch potential. Livingston *et al*. (1999) found that long-term increases and decreases in the abundance of selected BSAI invertebrate, fish, bird, and marine mammal species did not show beneficial correlations with prey abundance, and that cyclic fluctuations in species abundance occurred in both fished and unfished species. As emphasized in Section 3.10.1.5, evidence is accumulating that physical oceanographic factors, particularly climate, have a controlling influence on biological community composition in the BSAI and GOA.

- **Reasonably Foreseeable Future External Effects.** Although past levels of seabird bycatch by the IPHC, western Bering Sea, and State of Alaska fisheries have not been thoroughly or consistently quantified, they are considered substantial and can be expected to continue in the future (Section 3.7). In addition, subsistence harvests of some marine mammal species (Section 3.8), particularly those with relatively small and geographically distinct subpopulations (e.g, belugas, harbor seals), may deplete numbers to levels near or below biologically acceptable limits in the future. The potential for introduced exotic species to establish viable populations in the BSAI and GOA will also continue. Such exotics may include Atlantic salmon escapes from net-pen farms, invertebrates and plants introduced through ballast water and from ship hulls, and pathogens introduced by Pacific salmon species that have escaped from fish farms (Fay 2002, ADF&G 2002a, Brodeur and Busby 1998). Future climate changes could alter the productivity and distribution of individual species and make it easier for introduced exotics to establish viable populations.

- **Cumulative Effects.** FMP 4.1 would produce a conditionally significant beneficial cumulative effect on species diversity, relative to the baseline, by reducing adverse contributions from the BSAI and GOA groundfish fisheries, particularly with respect to seabird bycatch. The beneficial incremental contribution of FMP 4.1, however, could be offset by any of several possible conditions in the future. Seabird bycatch from the IPHC longline fishery, western Bering Sea fisheries, and State of Alaska commercial fisheries could increase. Also, one or more introduced exotic species might establish a viable population that would change species diversity in a adverse way by competing with native species for food and habitat (Fay 2002). The consistent, sustained concentration of harvest effort on particularly accessible subpopulations of marine mammals from year to year could intensify the external adverse contribution. Finally, climate change has the potential to alter species productivity and distribution, and a long-term warming trend might facilitate the establishment of viable populations by one or more exotic species.

<u>Change in Functional (Trophic) Diversity</u>

- **Direct/Indirect Effects.** The effects of the groundfish fisheries on trophic diversity under FMP 4.1 are predicted to be significantly beneficial. This rating reflects the potential of the reduced fishing effort and increased protective measures under this FMP to sustain natural levels of species, size, age, and other measures of diversity within trophic guilds and to maintain functional diversity within the range of natural variability observed for the system (Table 4.1-7).

- **Persistent Past Effects**. It is considered unlikely that past removals of fish by the pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries significantly affected the variety of species within trophic guilds. Livingston *et al*. (1999) found no evidence that groundfish fisheries had caused declines in trophic guild diversity for the groups studied. They also found that past changes in species diversity within guilds related to increases in a dominant guild member (e.g., pollock, rock sole) rather than to decreases in abundance caused by fishing pressure (Section 3.10.3). Past variations in climate, such as ENSO events, interdecadal oscillations, and regime shifts, may have affected trophic diversity by influencing the productivity and distribution of different species in different ways, thereby altering the relative proportions of species within guilds. However, little research on this type of effect was conducted in the BSAI and GOA in past decades.

- **Reasonably Foreseeable Future External Effects.** NOAA Fisheries and ADF&G biologists have recently brought attention to the potential for escaped farmed Atlantic salmon to establish viable Alaskan populations in competition with one or more of the five Pacific salmon species and steelhead (Brodeur and Busby 1998, ADF&G 2002a, Fay 2002). In addition, the concentrated take of marine mammals from the same local subpopulations over a period of years could affect species diversity within piscivore guilds, that is, guilds consisting of fish-eating species. Releases of ballast water and hull-fouling organisms introduced to BSAI and GOA waters from fishing vessels and commercial shipping could also lead to the establishment of viable populations in competition with native species at similar trophic levels (Fay 2002). A climatic regime shift in the future could affect trophic diversity by forcing trends that expand some trophic levels and contract others, and a long-term warming trend could facilitate the establishment of relatively cold-intolerant exotic populations.

- **Cumulative Effects.** The implementation of FMP 4.1 would produce a conditionally significant beneficial cumulative effect by reducing fishing pressures and increasing protective measures that would help to sustain diversity within trophic guilds. Incremental contributions from several external sources could offset the beneficial contribution of FMP 4.1. However, none of these potential external conditions is likely to be interactive or synergistic with the direct/indirect effects of FMP 4.1 because different trophic guilds may be affected and an offsetting effect on trophic diversity overall is possible in the future.

<u>Change in Functional (Structural Habitat) Diversity</u>

- **Direct/Indirect Effects.** The issue of concern with respect to functional diversity in terms of structural habitat is the removal, by bottom gear, of HAPC biota such as corals, sea anemones and other sessile invertebrates that provide physical structures used as habitat by other species, including economically important groundfish species and their prey. Present trawl closures to protect the Steller's sea lion are spread throughout the Aleutian chain, but these closures are further inshore than areas where corals can be found. Some of the area closures in FMP 4.1 have been designed with corals in mind and would ensure that there is a broad spatial distribution of corals, particularly in the Aleutians. Also, bottom trawl effort would likely decline in this FMP and area closures would provide additional protection to benthic communities. FMP 4.1 is rated as significantly beneficial to structural habitat diversity.

- **Persistent Past Effects.** Bottom-trawling by the pre-MSA international groundfish fisheries, groundfish fisheries after passage of the MSA in 1976, and State of Alaska scallop fisheries have all contributed to the damage or depletion of the structural habitat functional guild in past years. Because little is known about the taxonomic structure of benthic communities of the BSAI and GOA, any past effects of trawling and other fishing-related activities on the species diversity of these communities cannot be quantified. Long-term climatic trends may also have influenced HAPC species through effects on their productivity and distribution, but in the absence of data no conclusions can be made.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska scallop fishery will employ bottom dredges that will continue to damage or remove structural habitat provided by sessile invertebrates such as corals, sea anemones, and sponges. This effect is not likely to be reduced in the future. In addition, a large oil or fuel spill from commercial shipping could contact areas covered by these sensitive bottom-dwelling organisms and damage or kill them. A climatic regime shift could change the mean annual seawater temperature sufficiently to increase or retard the growth of benthic organisms, thereby altering structural habitat diversity.

- **Cumulative Effects.** The implementation of FMP 4.1 would produce a conditionally significant beneficial cumulative effect on structural habitat diversity. The direct/indirect contribution of FMP 4.1 could be offset under at least three conditions. First, the contribution of the scallop fishery, which employs bottom dredges, could partially offset the reduction in bottom trawling by the groundfish fisheries, continuing to damage and remove HAPC biota. Second, a large petroleum spill could also damage these sensitive organisms. Third, a change in seawater temperature resulting from a climatic regime shift in the reasonably foreseeable future could reduce the productivity (and thus population size, growth, and ability to recover from damage) as well as distribution of sensitive bottom-dwelling invertebrates that provide ecologically important structural habitat.

Change in Genetic Diversity

- **Direct/Indirect Effects.** Under FMP 4.1 it is not expected that target species would fall below MSST, and spatial/temporal management of TAC, other catch, and selectivity patterns in the fisheries would be similar to present conditions. Fishing pressure would not focus on specific spawning aggregations or systematically target older age classes that tend to have greater genetic diversity. Therefore, effects of the groundfish fisheries on genetic diversity would be insignificant under FMP 4.1. However, baseline genetic diversity remains unknown for most species, and the actual effects of fishing on genetic diversity under this FMP are also largely unknown.

- **Persistent Past Effects.** The pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries have cumulatively removed large quantities of fish from the BSAI and GOA ecosystems in the past, but data has not been available to indicate whether genetic diversity was measurably affected. As discussed in Section 3.10.3, if a fishery concentrates on certain spawning aggregations or on older (larger) age classes of a target species that tend to have greater genetic diversity (dating from an earlier period when fishing was less intensive), then genetic diversity will tend to decline in fished versus unfished systems. It is possible that genetic diversity has already declined in the BSAI and GOA ecosystems, but this cannot be known in the absence of data. Genetic assessments of North Pacific pollock populations and subpopulations conducted by Bailey *et al*. (1999) have found genetic variations among different stocks, but these studies have not found genetic variability across time within the same stocks that might indicate effects from commercial fishing. Heavy exploitation of certain spawning aggregations existed historically (e.g., Bogoslof pollock), but recent and current spatial/temporal management of groundfish has been designed to reduce fishing pressure on spawning aggregations.

- **Reasonably Foreseeable Future External Effects.** Several external factors have the potential to affect the genetic diversity of the BSAI and GOA ecosystems. Atlantic salmon escapes from coastal net-pen farms in Washington State and British Columbia could establish Alaskan runs and viable populations (ADF&G 2002a, Fay 2002). Subsistence harvests of fish could concentrate effort on the same specific subpopulations from year to year, inadvertently but selectively depleting genetically distinct stocks. Similarly, subsistence harvests of some marine mammal species (Section 3.8), particularly those with relatively small and geographically distinct subpopulations (e.g, belugas, harbor seals), may also deplete genetic diversity. The potential for introduced exotic invertebrates to establish viable populations in the BSAI and GOA will unavoidably continue with fishing vessel and commercial shipping traffic in the future. Such exotics may also include pathogens introduced by Pacific salmon that have escaped from fish farms (Fay 2002, ADF&G 2002a, Brodeur and Busby 1998). Future climate changes could alter the productivity and distribution of individual species and enable introduced exotics to establish viable populations.

- **Cumulative Effects.** The implementation of FMP 4.1 is predicted to have an insignificant cumulative effect on genetic diversity. Several external factors, such as Atlantic salmon escapes, subsistence harvests of marine mammals that concentrate on the same subpopulations year after year, exotic species introduced through commercial shipping traffic, and climatic facilitation of viable exotic populations, have the potential to produce changes in the genetic diversity of the BSAI and GOA ecosystems. None of these, however, would directly involve the genetic diversity of species targeted or taken incidentally by the groundfish fisheries. Thus, external sources for potential change in genetic diversity would not be additive or interactive with the groundfish fisheries in the future.

Direct/Indirect Effects FMP 4.2

The following discussions assess the potential direct/indirect effects of FMP 4.2 on the BSAI and GOA ecosystems.

FMP 4.2 would close the BSAI and GOA to all commercial fishing for groundfish and initiate a process whereby fisheries could be reopened after being certified as having no adverse effect on the environment. It is assumed that a substantial research program would be initiated to determine foraging needs of dependent species and life-history parameters, genetic characteristics, and abundance and distribution of species proposed for target fisheries. Fishery bycatch of non-target species and gear effects on habitat would also be evaluated before a fishery could be opened. Natural levels of ecosystem variability and the influence of climate on ecosystem production would also have to be determined. Therefore, we determine that FMP 4.2 would produce significantly or conditionally significant beneficial effects on many biological aspects of the marine ecosystem, relative to the baseline. Potential effects of this FMP would be beneficial with respect to pelagic forage availability to marine mammals such as Steller sea lions and northern fur seals. There would be no significant change with respect to forage availability to target species and birds. Significantly beneficial effects to spatial/temporal concentration of fisheries on forage would accrue to Steller sea lions and northern fur seals, but there would be no significant change in this regard for seabirds. FMP 4.2 would bring significantly or conditionally significant improvements to removal of top predator species, introduction of non-native species, energy removal and redirection, species diversity, and functional (trophic and structural habitat) diversity. FMP 4.2 would not significantly affect genetic diversity. However, baseline genetic diversity remains unknown for most species and the actual effects that fisheries would eventually have on genetic diversity under this FMP are largely unknown.

Cumulative Effects Analysis FMP 4.2

The potential cumulative effects resulting from implementation of FMP 4.2 are similar to those predicted for FMP 4.1. Ratings of potential direct/indirect effects predicted for FMP 4.1 would remain the same under FMP 4.2, along with the same contributions from persistent past effects and reasonably foreseeable future external effects. These contributing factors and potential cumulative effects are summarized for both FMP 4.1 and FMP 4.2 in Table 4.8-7.

4.8.11 Summary of Alternative 4 Analysis

The direct, indirect and cumulative ratings for all resource categories analyzed under this alternative are summarized in Tables 4.8-7.

Table number	Resource category	Components	Section 4.8 reference
4.8-1	Target groundfish species	Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA) walleye pollock, BSAI and GOA Pacific cod, BSAI and GOA sablefish, BSAI and GOA Atka mackerel, BSAI yellowfin sole, GOA shallow water flatfish, BSAI rock sole, BSAI and GOA flathead sole, BSAI and GOA arrowtooth flounder, BSAI Greenland turbot, GOA deepwater flatfish, BSAI Alaska plaice, BSAI other flatfish, GOA rex sole, BSAI and GOA Pacific ocean perch, GOA thornyhead rockfish, BSAI and GOA northern rockfish, BSAI and GOA shortraker/ rougheye rockfish, BSAI other rockfish, GOA slope rockfish, GOA pelagic shelf rockfish, GOA demersal shelf rockfish.	4.8.1
4.8-2	Prohibited, other, forage and non-specified species	Pacific halibut, Pacific salmon and steelhead trout, Pacific herring, crab. Other species category. Forage fish category. Grenadier.	4.8.2 4.8.3 4.8.4 4.8.5
4.8-3	Habitat	BSAI, GOA	4.8.6
4.8-4	Seabirds	Black-footed albatross, laysan albatross, short-tailed albatross, northern fulmar, shearwaters, storm-petrels, cormorants, spectacled eider, Steller's eider, jaegers, gulls, kittiwakes, terns, murres, guillemots, murrelets, auklets, puffins.	4.8.7

Table number	Resource category	Components	Section 4.8 reference
4.8-5	Marine mammals	Steller sea lion, northern fur seals, Pacific walrus, harbor seals, spotted seal, bearded seal, ringed seal, ribbon seal, northern elephant, sea otter, blue whale, fin whale, sei whale, minke whale, humpback whale, gray whale, northern right whale, bowhead whale, sperm whale, beaked whales (Baird's, Cuvier's and Stejneger's), Pacific white-sided dolphin, killer whale, beluga whale, harbor porpoise, Dall's porpoise.	4.8.8
4.8-6	Socioeconomics	Harvesting and processing sector (catcher vessels, catcher processors , inshore processors and motherships). Regional socioeconomic profiles (population, processing ownership and activity, catcher vessel ownership and activity, tax revenue, employment and income). Community development quota (CDQ) allocations. Subsistence (subsistence use of groundfish, subsistence use of Steller sea lions, salmon subsistence fisheries, indirect subsistence factors: income and joint production). Environmental justice. Market channels and benefits to United States consumers (product quantity, product year-round availability, product quality, product diversity). Non-market goods (benefits derived from marine ecosystems and associated species).	4.8.9.1 4.8.9.2 4.8.9.3 4.8.9.4 4.8.9.5 4.8.9.6 4.8.9.7
4.8-7	Ecosystem	Forage fish availability, spatial/temporal concentration of fisheries, introduction of non-native species, removal of top predators, energy redirection, energy removal, species diversity, guild diversity, genetic diversity.	4.8.10

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