STOCK ASSESSMENT AND FISHERY EVALUATION REPORT FOR THE GROUNDFISH FISHERIES OF THE GULF OF ALASKA AND BERING SEA/ALEUTIAN ISLANDS AREA:

ECONOMIC STATUS OF THE GROUNDFISH FISHERIES OFF ALASKA, 2005

Edited by
Terry Hiatt

With contributions from
Ron Felthoven, Hans Geier, Alan Haynie, David Layton, Dan Lew, Amanda Poole,
Robert Rowe, Jennifer Sepez, Chang Seung, Emilie Springer and Edward Waters

Economic and Social Sciences Research Program
Resource Ecology and Fisheries Management Division
Alaska Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way N.E.
Seattle, Washington 98115-6349

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For additional information concerning this report contact:

Terry Hiatt
Resource Ecology and Fisheries Management Division
Alaska Fisheries Science Center
7600 Sand Point Way N.E.
Seattle, Washington 98115-6349
(206) 526-6414
terry.hiatt@noaa.gov

ABSTRACT

The domestic groundfish fishery off Alaska is an important segment of the U.S. fishing industry. This report contains figures and tables which summarize various aspects of the economic performance of the fishery. Generally, data are presented for the domestic groundfish fishery for 2001 through 2005. Limited catch and ex-vessel value data are reported for earlier years in order to depict the rapid development of the domestic groundfish fishery in the 1980s and to provide a more complete historical perspective on catch. Pacific halibut (*Hippoglossus stenolepis*) is not included in data for the groundfish fishery in this report because for management purposes halibut is not part of the groundfish complex.

The report provides estimates of total groundfish catch, groundfish discards and discard rates, prohibited species bycatch and bycatch rates, the ex-vessel value of the groundfish catch, the ex-vessel value of the catch in other Alaska fisheries, the gross product value (F.O.B. Alaska) of the resulting groundfish seafood products, the number and sizes of vessels that participated in the Alaska groundfish fisheries, vessel activity, and employment on at-sea processors.

In addition, this report contains data on some of the external factors which, in part, determine the economic status of the fisheries. Such factors include foreign exchange rates, the prices and price indexes of products that compete with products from these fisheries, domestic per capita consumption of seafood products, and fishery imports.

This report also includes project descriptions and updates for ongoing research activities of the Economics and Social Science Research Program (ESSRP) at the Alaska Fisheries Science Center, and describes some of the research and data collection to be undertaken in 2007. In addition, we have included a list of publications that have arisen out of our work, as well as three draft manuscripts for recently completed (or nearly complete) projects. Contact information is included for each of the ongoing projects so that readers may contact us for more detail or an update on the project status.

Finally, it should be noted that the estimates in this report are intended both to provide information that can be used to describe the Alaska groundfish fisheries, and to provide industry and others an opportunity to comment on the validity of these estimates.

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INTRODUCTION

The domestic groundfish fishery off Alaska is an important segment of the U.S. fishing industry. With a total catch of 2.2 million metric tons (t), a retained catch of 2.1 million t, and an ex-vessel value of $740 million in 2005, it accounted for 50% of the weight and 19% of the ex-vessel value of total U.S. domestic landings as reported in Fisheries of the United States, 2005. The value of the 2005 catch after primary processing was approximately $2.0 billion (F.O.B. Alaska).

All but a small part of the commercial groundfish catch off Alaska occurs in the groundfish fisheries managed under the Fishery Management Plans (FMP) for the Gulf of Alaska (GOA) and the Bering Sea/Aleutian Islands area (BSAI) groundfish fisheries. In 2005, other fisheries accounted for only about 18,000 t of the catch reported above. The footnotes for each table indicate if the estimates provided in that table are only for the fisheries with catch that is counted against federal TACs or if they also include other Alaska groundfish fisheries.

The fishery management and development policies for the BSAI and GOA groundfish fisheries have resulted in high levels of catch, ex-vessel value (i.e., revenue), processed product value (i.e., revenue), exports, employment, and other measures of economic activity. The cost data required to estimate the success of these policies with respect to net benefits to either the participants in these fisheries or the Nation are not available. However, the use of the race for fish as a principal mechanism for allocating the groundfish quotas and prohibited species catch (PSC) limits among competing fishing operations has adversely affected at least some aspects of the economic performance of the fisheries. The individual fishing quota (IFQ) program for the fixed gear sablefish fishery, the Western Alaska Community Development Quota (CDQ) program for BSAI groundfish, and the American Fisheries Act (AFA) cooperatives for the BSAI pollock fishery have demonstrated that eliminating the race for fish as the allocation mechanism and replacing it with a market-based allocation mechanism can decrease harvesting and processing costs, increase the value of the groundfish catch, and, in some cases, decrease the cost of providing more protection for target species, non-target species, marine mammals, and seabirds. It is anticipated that the recent rationalization program instituted in the BSAI crab fisheries will generate many of the same benefits. However, it is unclear at this time how such benefits will be distributed; as with most management measures, there may be winners and losers.

This report presents the economic status of groundfish fisheries off Alaska in terms of economic activity and outputs using estimates of catch, bycatch, ex-vessel prices and value (i.e., revenue), the size and level of activity of the groundfish fleet, and the weight and gross value of (i.e., F.O.B. Alaska revenue from) processed products. The catch, ex-vessel value, and fleet size and activity data are for the fishing industry activities that are reflected in Weekly Production Reports, Observer Reports, fish tickets, and the Commercial Operators' Annual Reports. All catch data reported for 1991-2002 are based on the blend estimates of total catch, which were used by the National Marine Fisheries

Service (NMFS) to monitor groundfish and PSC quotas in those years. Catch data for 2003-05 come from NMFS's new catch-accounting system, which replaces the blend as the primary tool for monitoring groundfish and PSC quotas.

A variety of external factors influence the economic status of the fisheries. Therefore, information concerning the following external factors are included in this report: foreign exchange rates, the prices and price indexes of products that compete with products from these fisheries, gross domestic product implicit price deflators, and fishery imports. This report updates last year's report (Hiatt et al. 2005) and is intended to serve as a reference document for those involved in making decisions with respect to conservation, management, and use of GOA and BSAI fishery resources.

The qualifications made in both the overview of the fisheries and the footnotes to the tables are critical to understanding the information contained in this report.

The estimates in this report are intended both to provide information that can be used to describe the Alaska groundfish fisheries and to provide the industry and others an opportunity to comment on the validity of these estimates. It is hoped that the industry and others will identify estimates in this report that can be improved and provide the information and methods necessary to improve them for both past and future years. There are two reasons why it is important that such improvements be made. First, with better estimates, the report will be more successful in monitoring the economic performance of the fisheries and in identifying changes in economic performance that should be addressed through regulatory actions. Second, the estimates in this report often will be used as the basis for estimating the effects of proposed fishery management actions. Therefore, improved estimates in this report will allow more informed decisions by those involved in managing and conducting the Alaska groundfish fisheries. The industry and other stakeholders in these fisheries can further improve the usefulness of this report by suggesting other measures of economic performance that should be included in the report, or other ways of summarizing the data that are the basis for this report, and participating in voluntary survey efforts NMFS may undertake in the future to improve existing data shortages.

OVERVIEW

The commercial groundfish catch off Alaska totaled 2.2 million t in 2005, approximately the same as in 2004 (Fig. 1 and Table 1). The real ex-vessel value of the catch, excluding the value added by at-sea processing, increased from $645 million in 2004 to $686 million in 2005 (Fig. 3 and Table 16). The gross value of the 2005 catch after primary processing was approximately $2.0 billion (F.O.B. Alaska). The groundfish fisheries accounted for the largest share (52%) of the ex-vessel value of all commercial fisheries off Alaska in 2005 (Fig. 4, Tables 16 and 17), while the Pacific salmon (*Oncorhynchus spp*.) fishery was second with $292 million or 22% of the total Alaska ex-vessel value. The value of the Pacific halibut (*Hippoglossus stenolepis*) catch amounted to $170 million or 13% of the total for Alaska, and exceeded the ex-vessel value of the shellfish fishery by about $11 million.

During the last 14 years, estimated total catch in the commercial groundfish fisheries off Alaska (including foreign and joint venture fisheries as well as the domestic fishery) varied between 1.7 and 2.3 million t (Fig. 1 and Table 1). The rapid displacement of the foreign and joint-venture fisheries by the domestic fishery between 1984 and 1991 can be seen by comparing Figures 1 and 2. By 1991, the domestic fishery accounted for all of the commercial groundfish catch off Alaska.

The peak catch occurred in 1991, in part, because blend estimates of catch and bycatch were not yet used to monitor most quotas. If they had been, several fisheries would have been closed earlier in the year. There are three reasons why the catch estimates for 1988 through 1990 have a significant downward bias compared to the estimates for the other years. First, the domestic fishery accounted for a large part of total catch in 1988 through 1990. Second, discards were not included in the reported estimates of domestic catch prior to 1991, but they were included in the catch estimates for the foreign and joint venture fisheries. Based on estimates of the discard rates for 1992 through 1995, discards would have been about 16% of total catch. Finally, the blend estimates of catch, excluding at-sea discards, tend to exceed the estimates based solely on industry reports and, prior to 1991, only industry reports were used to estimate retained catch in the domestic fishery. Variations in the catch estimates also reflect changes in the total allowable catch (TAC), area closures or restrictions, and bycatch restrictions.

The information provided by what was formerly the North Pacific Groundfish Observer Program and is now the Fisheries Monitoring and Analysis Division (FMA) of the Alaska Fisheries Science Center has had a key role in the success of the groundfish management regime. For example, it would not be possible to monitor total allowable catches (TACs) in terms of total catch without observer data from the FMA. Similarly, the PSC limits, which have been a key factor in controlling the bycatch of prohibited species, could not be used without such data. In recent years, the reliance on observer data for individual vessel accounting is of particular importance in the management of the CDQ program and AFA fisheries. In addition, much of the information that is used to assess the status of groundfish stocks, to monitor the interactions between the groundfish fishery and marine mammals and sea birds, and to analyze fishery management actions is provided by the FMA. Estimates of the numbers of vessels and plants with observers, observer-deployment days, and estimated observer costs by year and type of operation for 2004-05 are presented in Table 51.

Walleye (Alaska) pollock (*Theragra chalcogramma*) has been the dominant species in the commercial groundfish catch off Alaska. The 2005 pollock catch of 1.57 million t accounted for 72% of the total groundfish catch of 2.2 million t (Table 1). The pollock catch increased by about 1.3% from 2004. The next major species, Pacific cod (*Gadus macrocephalus*), accounted for 252,600 t or 11.6% of the total 2005 groundfish catch. The Pacific cod catch was down about 6.6% from a year earlier. The 2005 catch of flatfish, which includes yellowfin sole (*Pleuronectes asper*), rock sole (*Pleuronectes bilineatus*), and arrowtooth flounder (*Atheresthes stomias*) was 210,100 t, up about 6.2%

from 2004. Pollock, Pacific cod, and flatfish comprised just over 93% of the total 2005 catch. Other important species are sablefish (*Anoplopoma fimbria*), rockfish (*Sebastes* and *Sebastolobus spp.*), and Atka mackerel (*Pleurogrammus monopterygius*). The contributions of the major groundfish species or species groups to the total catch in the domestic groundfish fisheries off Alaska are depicted in Figure 2.

Trawl, hook and line (including longline and jigs), and pot gear account for virtually all the catch in the BSAI and GOA groundfish fisheries. There are catcher vessels and catcher/processor vessels for each of these three gear groups. Table 2 presents catch data by area, gear, vessel type, and species. The catch data in Table 2 and the catch, ex-vessel value, and vessel information in the tables of the rest of this report are for the BSAI and GOA FMP fisheries, unless otherwise indicated.

In the last five years, the trawl catch averaged about 91% of the total catch, while the catch with hook and line gear accounted for 7.9%. Most species are harvested predominately by one type of gear, which typically accounts for 90% or more of the catch. The one exception is Pacific cod, where in 2005, 36.7% (87,000 t) was taken by trawls, 51.5% (122,000 t) by hook-and-line gear, and 11.8% (28,000 t) by pots. In each of the years since 2001, catcher vessels took 46-47% of the total catch and catcher/processors took the remainder. That increase from years prior to 1999 (not shown in Table 2) is explained in part by the AFA, which among other things increased the share of the BSAI pollock TAC allocated to catcher vessels delivering to shoreside processors. The distribution of catch between catcher vessels and catcher/processor vessels differed substantially by species and area.

The discards of groundfish in the groundfish fishery have received increased attention in recent years by NMFS, the Council, Congress, and the public at large. Table 6 presents the blend (2001-02) and catch-accounting system (2003-05) estimates of the discarded groundfish catch and discard rates by gear, area, and species. The discard rate is the percent of total catch that is discarded.

Although these are the best available estimates of discards and are used for several management purposes, these estimates are not necessarily accurate. The groundfish TACs are established and monitored in terms of total catch, not retained catch; this means that both retained catch and discarded catch are counted against the TACs. Therefore, the catch-composition sampling methods used by at-sea observers provide the basis for NMFS to make good estimates of total catch by species, not the disposition of that catch. Observers on vessels sample randomly chosen catches for species composition. For each sampled haul, they also make a rough visual approximation of the weight of the non-prohibited species in their samples that are being retained by the vessel. This is expressed as the percent of that species that is retained. Approximating this percentage is difficult because discards occur in a variety of places on fishing vessels. Discards include fish falling off of processing conveyor belts, dumping of large portions of nets before bringing them on-board the vessel, dumping fish from the decks, size sorting by crewmen, quality-control discard, etc. Because observers can only be in one place at a time, they can provide only this rough approximation based on their visual observations rather than data from direct sampling. The discard estimate derived by expanding these approximations from sampled hauls to the remainder of the catch may be inaccurate because the approximation may be inaccurate. The numbers derived from the observer discard approximation can provide users with some information as to the disposition of the catch, but the discard numbers should not be treated as sound estimates. At best, they should be considered a rough gauge of the quantity of discard occurring.

For the BSAI and GOA fisheries as a whole, the annual discard rate for groundfish in creased from 6.2% in 2001 to 6.8% in 2002, increased slightly to 7.0% in 2003, was essentially unchanged at 7.0% in 2004, and then decreased to 5.2% in 2005. The overall discard rate in 2001 represents a 57% reduction from the 1997 rate of 14.5% (not shown in Table 6), a result of prohibiting pollock and Pacific cod discards in all BSAI and GOA groundfish fisheries beginning in 1998. Total discards decreased by about 59% from 1997 to 2001 due to the reduction in the discard rate and a 3.1% reduction in total catch. The prohibition on pollock and Pacific cod discards was so effective in decreasing the overall discard rate because the discards of these two species had accounted for 43% of the overall discards in 1997. The benefits and costs of the reduction in discards since 1997 have not been determined. In 2005, the overall discard rates were 8.4% and 5.0%, respectively, for the GOA and the BSAI compared to 16.2% and 14.3% in 1997.

Although the fixed gear fisheries accounted for a small part of either total catch or total discards, in 1998 and later years the overall discard rates were substantially higher for fixed gear (11.5% in 2005) than for trawl gear (4.6% in 2005). Prior to 1998, the overall discard rates had been similar for these two gear groups. This change occurred because the prohibition on pollock and Pacific cod discards had a much larger effect on trawl discards than on fixed gear discards. In the BSAI, the 2005 discard rates were 12.6% and 4.3% for fixed and trawl gear, respectively. In the GOA, however, the corresponding discard rates were 6.4% and 8.9%. One explanation for the relatively low discard rates for the BSAI trawl fishery is the dominance of the pollock fishery with very low discard rates. The mortality rates of groundfish that are discarded are thought to differ by gear or species; however, estimates of groundfish discard mortality are not available.

Target fisheries are defined by area, gear and target species. The target designations are used to estimate prohibited species catch (PSC), to apportion PSC limits by fishery (i.e., establish PSC allowances by fishery) and to monitor those PSC allowances. The target fishery designations can also be used to provide estimates of catch and bycatch data by fishery. The blend catch data are assigned to a target fishery by processor, week, area, and gear. The new catch-accounting system, which replaced the blend as the primary source of catch data in 2003, assigns the target at the trip level rather than weekly, except for the approximately 4% of total catch that comes from NMFS Weekly Production Reports (WPR). CDQ fishing activity is targeted separately from non-CDQ fishing. Generally, the species or species group that accounts for the largest proportion of the retained catch of the TAC species is considered the target species. One exception to the dominant retained-catch rule is that the target for the pelagic pollock fishery is assigned if 95 percent or more of the total catch is pollock.

Tables 3 and 4, 7 and 8, and 9 and 10, respectively, provide estimates of total catch, discarded catch, and discard rates by species, area, gear, and target fishery. Within each area or gear type, there are substantial differences in discard rates among target fisheries. Similarly, within a target fishery, there are often substantial differences in discard rates by species. Typically, in each target fishery the discard rates are very high except for the target species. The regulatory exceptions to the prohibition on pollock and Pacific cod discards explain, in part, why there are still high discard rates for these two species in some fisheries.

The bycatch of Pacific halibut, crab, Pacific salmon, and Pacific herring (*Clupea pallasi*) has been an important management issue for more than twenty years. The retention of these species was prohibited first in the foreign groundfish fisheries. This was done to ensure that groundfish fishermen had no incentive to target these species. Estimates of the bycatch of these prohibited species for 2002-05 are summarized by area and gear in Table 11. More detailed estimates of prohibited species bycatch and of bycatch rates for 2004 and 2005 are in Tables 12 - 15. The estimates for halibut are in terms of bycatch mortality because the bycatch limits for halibut are set and monitored using estimated discard mortality rates. The estimates for the other prohibited species are of total bycatch, this is in part due to the lack of well established discard mortality rates for these species. The discard mortality rates probably approach 100% for salmon and herring in the groundfish fishery as a whole; the discard mortality rates for crab, however, may be substantially lower.

An extensive at-sea observer program was developed for the foreign fleets and then extended to the domestic fishery once it had all but replaced participation by foreign fishing and processing vessels. The observer program, now the Fisheries Monitoring and Analysis Division (FMA) of the Alaska Fisheries Science Center, resulted in fundamental changes in the nature of the bycatch problem. First, by providing good estimates of total groundfish catch and non-groundfish bycatch by species, it eliminated much of the concern that total fishing mortality was being underestimated due to fish that were discarded at sea. Second, it made it possible to establish, monitor, and enforce the groundfish quotas in terms of total catch as opposed to only retained catch. Third, it made it possible to implement and enforce bycatch quotas for the non-groundfish species that by regulation had to be discarded at sea. Finally, it provided extensive information that managers and the industry could use to assess methods to reduce bycatch and bycatch mortality. In summary, the observer program provided fishery managers with the information and tools necessary to prevent bycatch from adversely affecting the stocks of the bycatch species. Therefore, the bycatch in the groundfish fishery is principally not a conservation problem but it can be an allocation problem. Although this does not make it less controversial, it does help identify the types of information and management measures that are required to reduce bycatch to the extent practicable, as is required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA).

Residents of Alaska and of other states, particularly Washington and Oregon, are active participants in the BSAI and GOA groundfish fisheries. Catch data by residency of vessel owners are presented in Table 5. These data were extracted from the NMFS blend and catch accounting system catch databases and from the State of Alaska groundfish fish ticket database and vessel-registration file which includes the stated residency of each vessel owner. For the domestic groundfish fishery as a whole, 95% of the 2005 catch volume was made by vessels with owners who indicated that they were not residents of Alaska. The catches of the two vessel-residence groups were much closer to being equal in the Gulf where Alaskan vessels accounted for the majority of the Pacific cod catch.

Table 18 contains the estimated ex-vessel prices that were used with estimates of retained catch to calculate ex-vessel values. The estimates of ex-vessel value by area, gear, type of vessel, and species are in Table 19. The ex-vessel value of the domestic landings in the FMP fisheries, excluding the value added by at-sea processing, increased from $585 million in 2001 to $619 million in 2002, decreased in 2003 to $608 million, increased to $625 million in 2004, and increased again to $686 million in 2005. The distribution of ex-vessel value by type of vessel differed by area, gear and species. In 2005, catcher vessels accounted for 51% of the ex-vessel value of the groundfish landings compared to 47% of the total catch because catcher vessels take larger percentages of higher-priced species such as sablefish, which was $2.18 per pound in 2005. Similarly, trawl gear accounted for only 71% of the total ex-vessel value compared to 91% of the catch because much of the trawl catch is of low-priced species such as pollock, which was about $0.13 per pound in 2005.

Tables 20 and 21 summarize the ex-vessel value of catch delivered to shoreside processors by vessel-size class, gear, and area. Table 20 gives the total ex-vessel value in each category and Table 21 gives the ex-vessel value per vessel. The relative dominance of each of the three vessel size classes differs by area and by gear.

Table 22 provides estimates of ex-vessel value by residency of vessel owners, area, and species. For the BSAI and GOA combined, 89% of the 2005 ex-vessel value was accounted for by vessels with owners who indicated that they were not residents of Alaska. Vessels with owners who indicated that they were residents of Alaska accounted for 11% of the total. The vessels owned by residents of Alaska accounted for a much larger share of the ex-vessel value than of catch (11% compared to 4.5%) because these vessels accounted for relatively large shares of the higher-priced species such as sablefish.

Table 23 presents estimates of ex-vessel value of catch delivered to shoreside processors, and Table 24 gives the ex-vessel value of groundfish as a percentage of the ex-vessel value of all species delivered to shoreside processors. The data in both tables, which include both state and federally managed groundfish, are reported by processor group, which is a classification of shoreside processors based primarily on their geographical locations. The processor groups are described in the footnote to the tables.

Estimates of weight and value of the processed products made with BSAI and GOA groundfish catch are presented by species, product form, area, and type of processor in Tables 25, 28 and 29. Product price-per-pound estimates are presented in Table 26, and estimates of total product value per round metric ton of retained catch (first wholesale prices) are reported in Table 27.

Gross product value (F.O.B. Alaska) data, through primary processing, are summarized by category of processor and by area in Table 31, and by catcher/processor category, size class and area in Table 32. Table 33 reports gross product value per vessel, categorized in the same way as Table 32. Tables 34 and 35 present gross product value of groundfish processed by shoreside processors and the groundfish gross product value as a percentage of all-species gross product value, with both tables broken down by processor group. The processor groups are the same as in Tables 23 and 24 and no distinction is made between groundfish catch from the state and federally managed groundfish fisheries.

Beginning in 2002, all processors (including previously-exempted catcher/processors that operate exclusively in the EEZ and process only their own catch) have been required to submit the Alaska Department of Fish and Game (ADF&G) Commercial Operators' Annual Report (COAR). Even though complete at-sea production data are now available from the COAR, however, the estimates of groundfish gross product value (i.e., revenue) for at-sea processors in 2002 through 2005 are calculated the same as in previous years in order to provide a comparison of the estimates from year to year. These estimates are based on COAR product price data (submitted voluntarily by at-sea processors for activity through 2001) and on product quantity data in the WPR. Beginning with the 2001 report (Hiatt et al. 2001), the estimates of gross product value for shoreside processors are based on COAR product price and quantity data. Prior to that, the estimates for all processors were based on COAR price data and WPR product quantity data.

The requirement that all processors now report their production in the COAR enables us to present Table 30, which gives estimates of the weight and value of processed products from catch in the non-groundfish commercial fisheries of Alaska.

For the purposes of Regulatory Flexibility Act analyses, a business involved in fish harvesting is a small business if it is independently owned and operated and not dominant in its field of operation (including its affiliates) and if it has combined annual receipts not in excess of $4.0 million for all its affiliated operations worldwide (the Small Business Administration raised the threshold from $3.5 million to $4.0 million in early 2006). The information necessary to determine if a vessel is independently owned and operated and had gross earnings of less than $4.0 million is not available. However, by using estimates of Alaska groundfish revenue by vessel, it is possible to identify vessels that clearly are not small entities. Estimates of both the numbers of fishing vessels that clearly are not small entities and the numbers of fishing vessels that could be small entities are presented in Tables 36 and 37, respectively. With more complete revenue, ownership and affiliation information, some of the vessels included in Table 37 would be determined to be large entities. Estimates of the average revenue per vessel for the vessels in Tables 36 and 37, respectively, are presented in Tables 38 and 39.

Estimates of the numbers and net registered tonnage of vessels in the groundfish fisheries are presented by area and gear in Table 40 and estimates of the numbers of vessels that landed groundfish are depicted in Fig. 6 by gear type. More detailed information on the BSAI and GOA groundfish vessels by type of vessel, vessel size class, catch amount classes, and residency of vessel owners is in Tables 41 - 46. In particular, Table 43 gives detailed estimates of the numbers of smaller (less than 60 feet) hook-and-line catcher vessels. Estimates of the number of vessels by month, gear, and area are in Table 47. Table 48 provides estimates of the number of catcher vessel weeks by size class, area, gear, and target fishery. Table 49 contains similar information for catcher/processor vessels.

The Weekly Production Reports include employment data for at-sea processors but not inshore processors. Those data are summarized in Table 50 by month and area. The data indicate that in 2005, the crew weeks (defined as the number of crew aboard each vessel in a week summed over the entire year) totaled 102,414 with the majority of them (98,835) occurring in the BSAI groundfish fishery. In 2005, the maximum monthly employment (16,364) occurred in February. Much of this was accounted for by the BSAI pollock fishery.

There are a variety of at least partially external factors that affect the economic performance of the BSAI and GOA groundfish fisheries. They include landing market prices in Japan, wholesale prices in Japan, U.S. imports of groundfish products, U.S. per capita consumption of seafood, U.S. consumer and producer price indexes, and foreign exchange rates. Such data are included in Tables 52 - 60. U.S. cold-storage holdings data, which were published in this report in previous years, have not been collected by NMFS since the end of 2002. The availability of cold-storage holdings data depends on the cooperation of industry in the form of voluntary reporting, which has declined to the extent that reports compiled from the data were deemed by NMFS management to lack sufficient accuracy. Consequently, the affected tables have been omitted from this report, but the pre-2003 levels may be found in Tables 48 and 49 of earlier reports.

Exchange rates and world supplies of fishery products play a major role in international trade. Exchange rates change rapidly and can significantly affect the economic status of the groundfish fisheries. There is also considerable uncertainty concerning the future conditions of stocks, the resulting quotas, and future changes to the fishery management regimes for the BSAI and GOA groundfish fisheries. The management actions taken to allocate the catch between various user groups can significantly affect the economic health of either the domestic fishery as a whole or segments of the fishery. Changes in fishery management measures are expected as the result of continued concerns with: 1) the bycatch of prohibited species; 2) the discard and utilization of groundfish catch; 3) the effects of the groundfish fisheries on marine mammals and sea birds; 4) other effects of the groundfish fisheries on the ecosystem and habitat; 5) excess harvesting and processing capacity; and 6) the allocations of groundfish quotas among user groups.

CITATIONS

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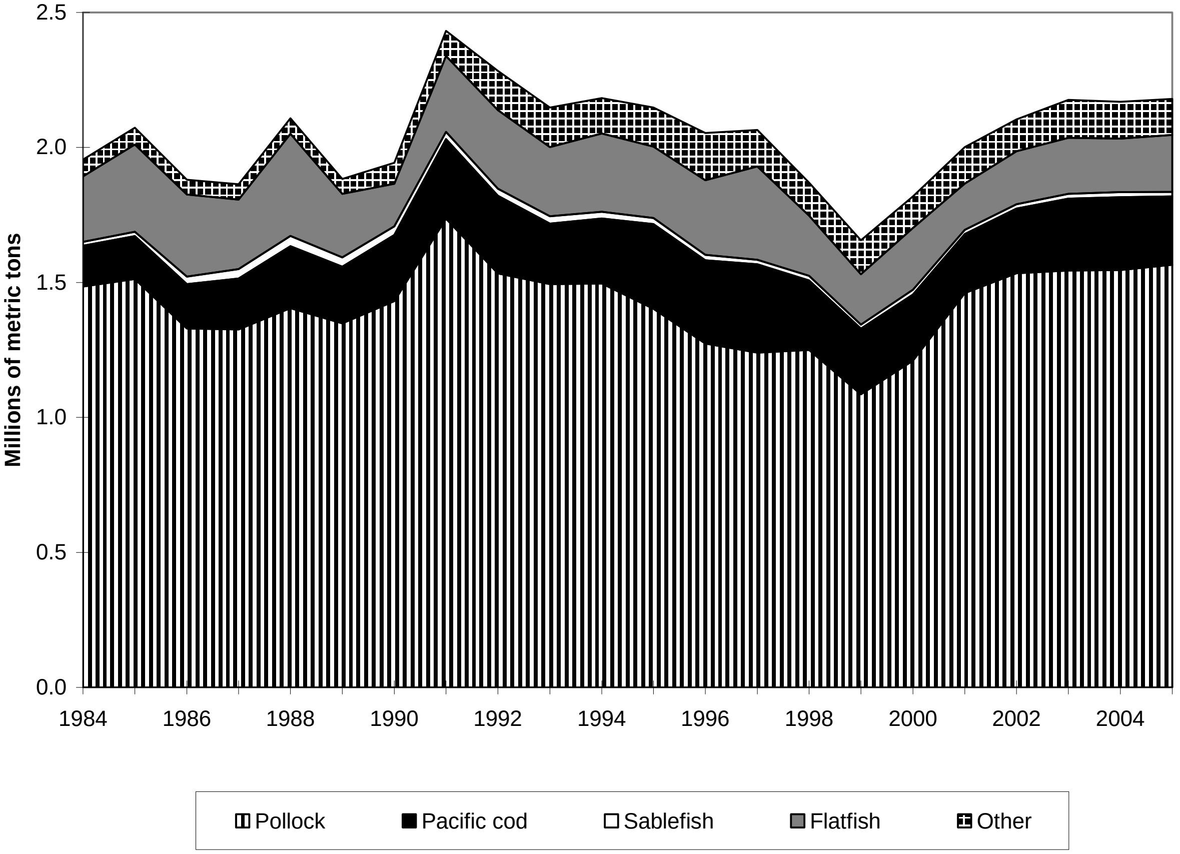


Figure 1. Groundfish catch in the commercial fisheries off Alaska by species, 1984-2005.

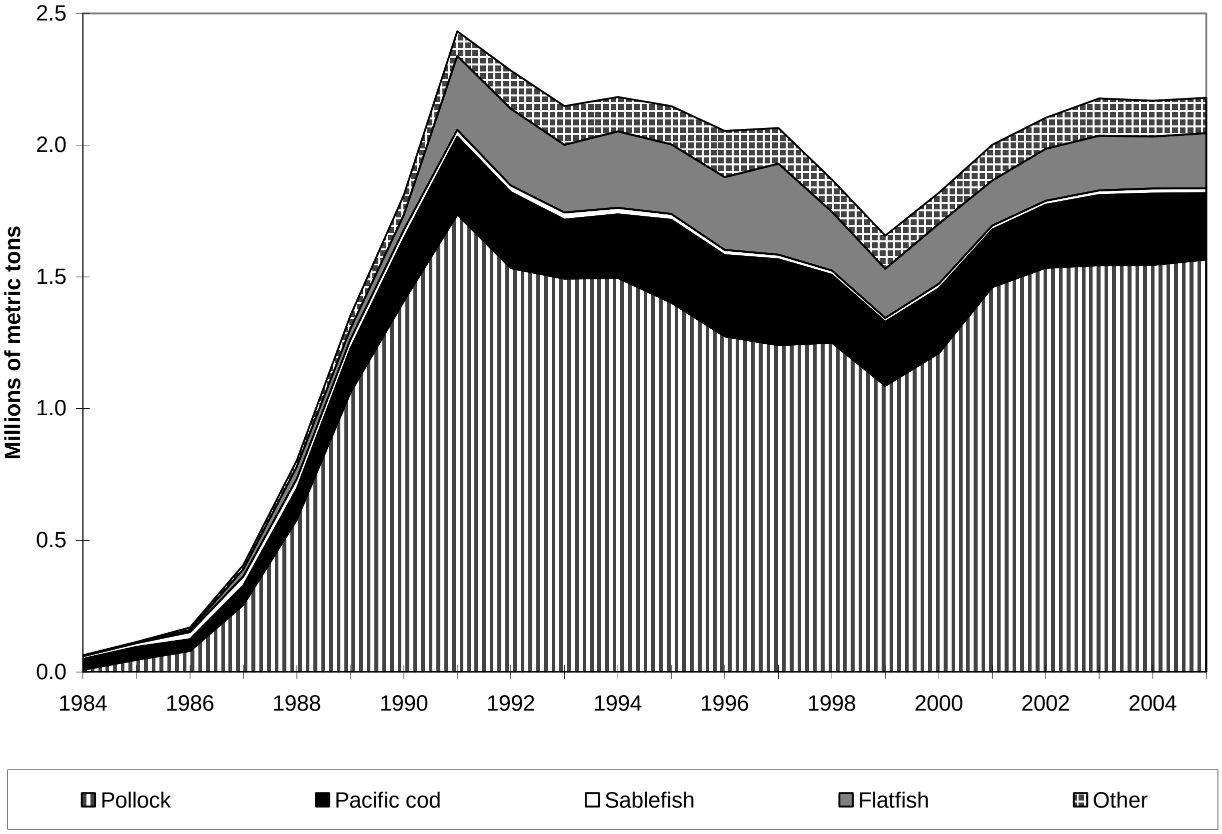


Figure 2. Groundfish catch in the domestic commercial fisheries off Alaska by species, 1984-2005.

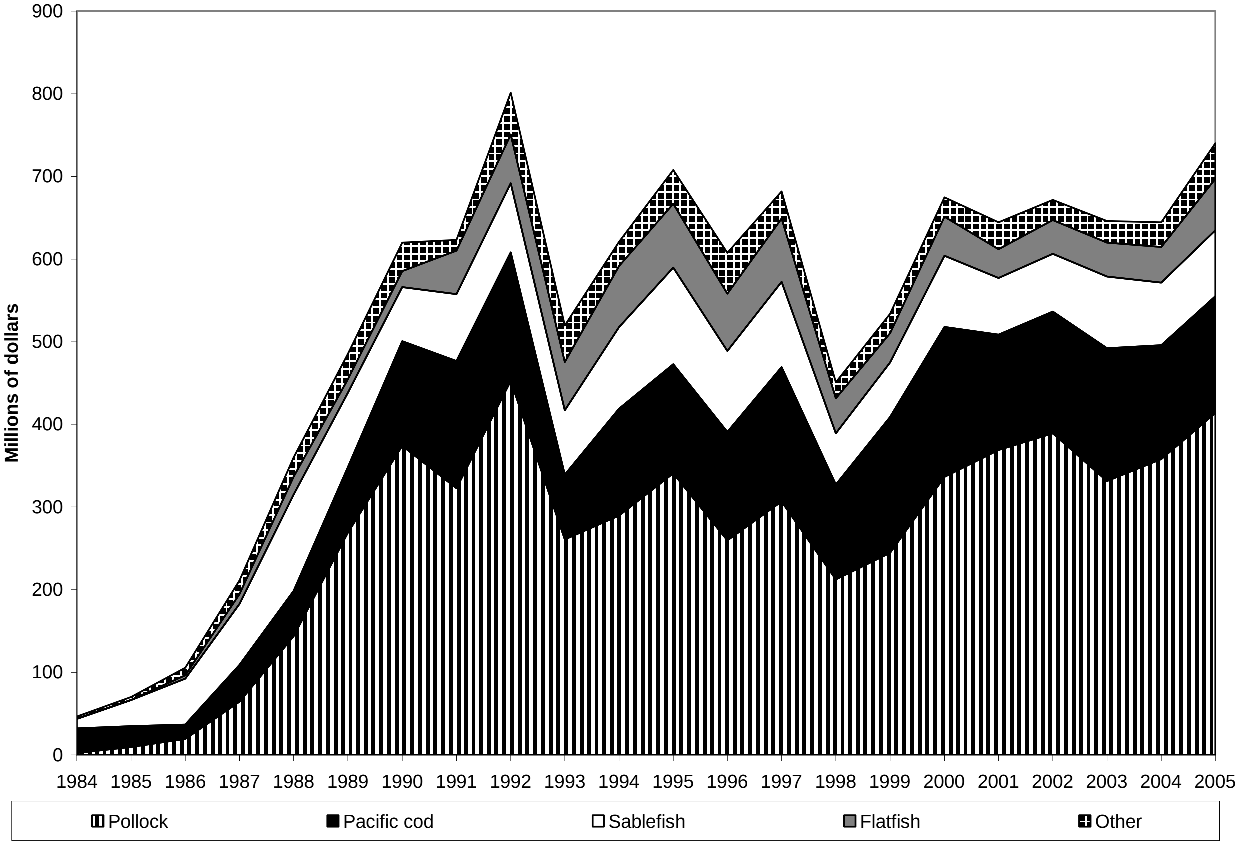


Figure 3. Real ex-vessel value of the groundfish catch in the domestic commercial fisheries off Alaska by species, 1984-2005 (base year = 2005).

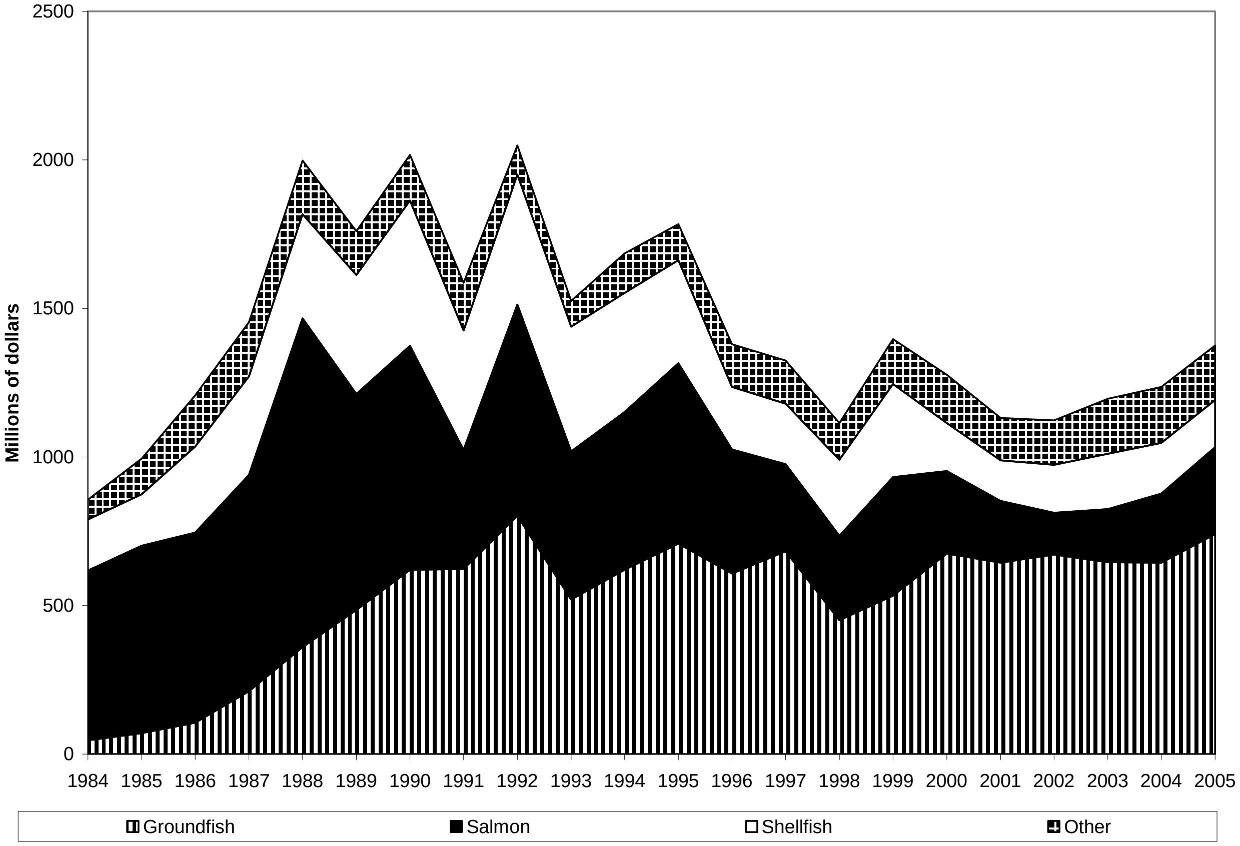


Figure 4. Real ex-vessel value of the domestic fish and shellfish catch off Alaska, 1984-2005 (base year = 2005).

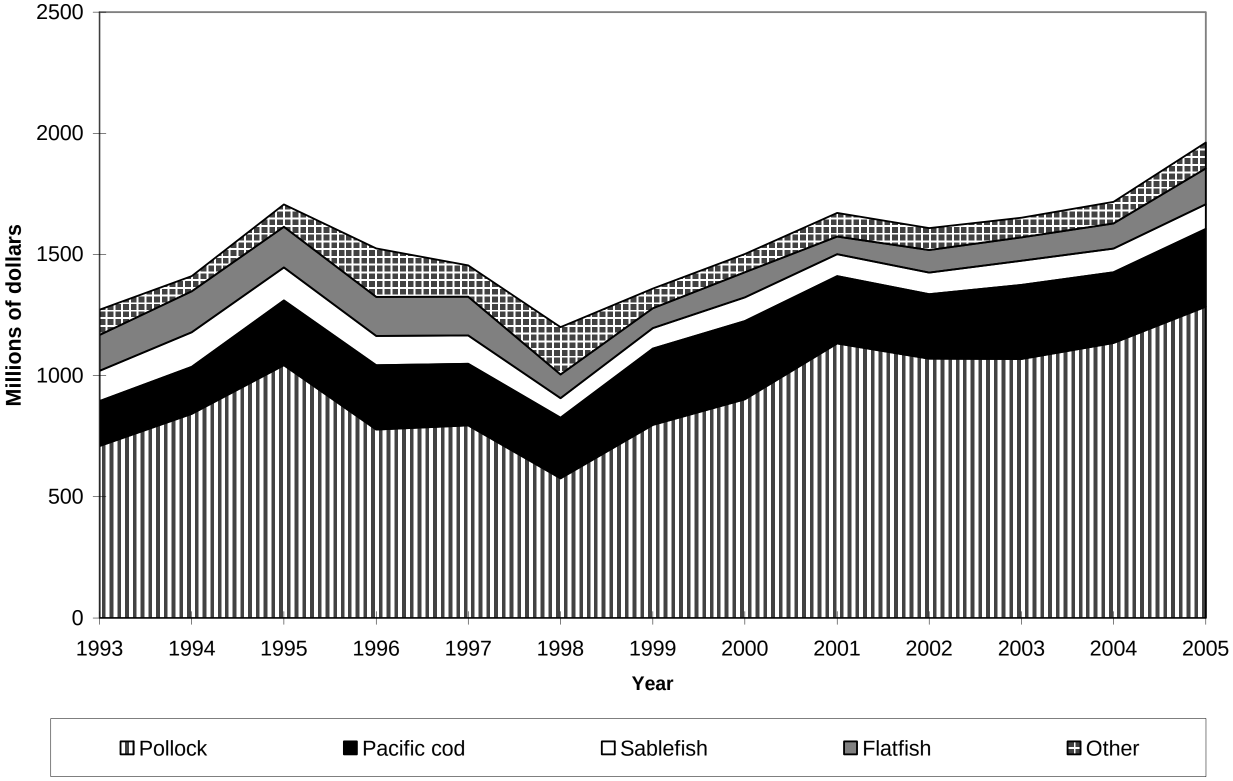
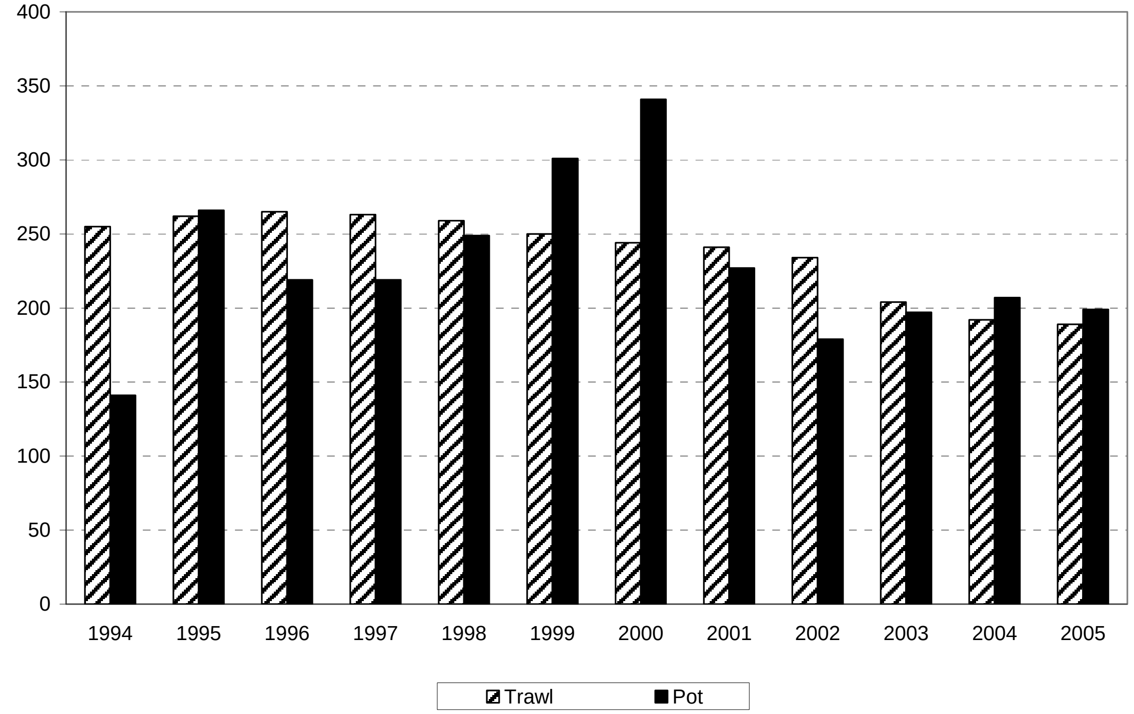


Figure 5. Real gross product value of the groundfish catch off Alaska, 1993-2005 (base year = 2005).



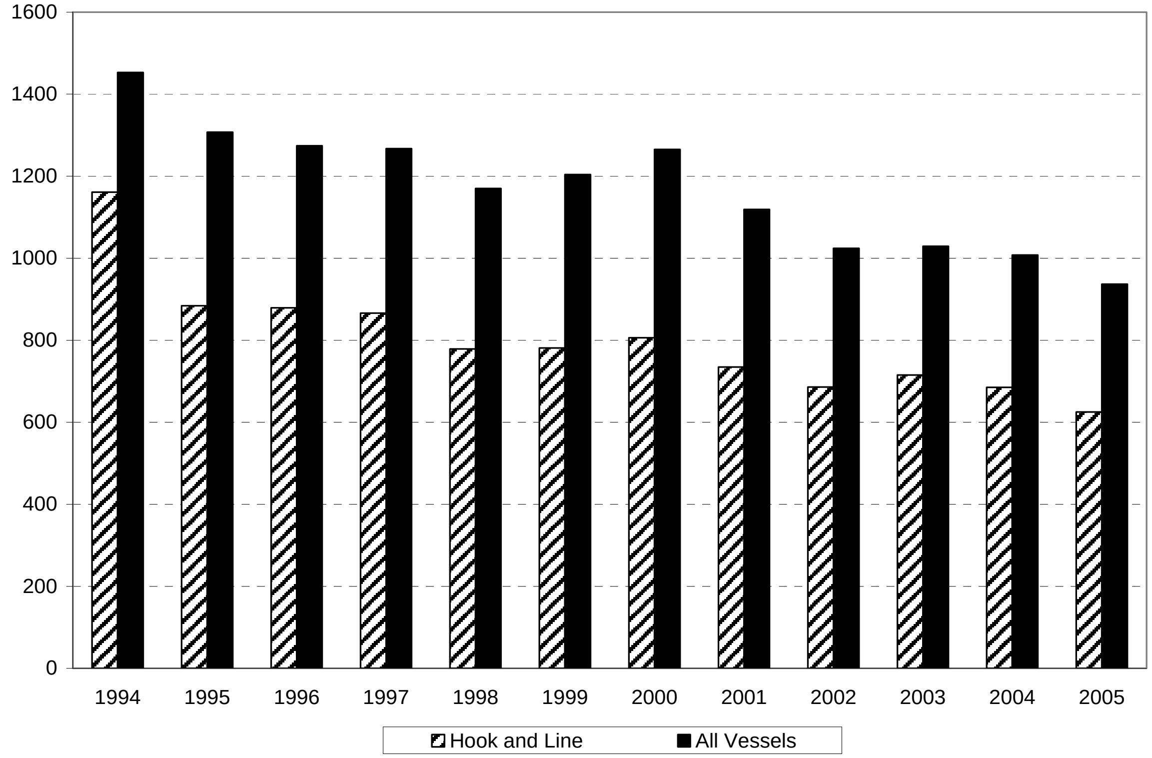


Figure 6. Number of vessels in the domestic groundfish fishery off Alaska by gear type, 1994-2005.

Table 1. Groundfish catch in the commercial fisheries off Alaska by area and species, 1992-2005 (1,000 metric tons, round weight).

		Pollock	Sablefish	Pacific cod	Flatfish	Rockfish	Atka mackerel	Total
Gulf of Alaska	1992	90.9	23.6	80.7	41.9	24.9	6.4	280.7
	1993	108.9	24.8	56.5	39.5	19.7	5.1	261.4
	1994	107.3	22.5	47.5	36.0	16.1	3.5	235.8
	1995	72.6	20.8	69.0	32.3	19.3	.7	218.1
	1996	51.3	18.2	68.3	43.1	18.2	1.6	205.2
	1997	90.1	15.7	68.5	33.6	19.8	.3	233.5
	1998	125.1	15.2	62.1	23.3	19.5	.3	249.3
	1999	95.6	13.9	68.6	24.9	24.5	.3	231.6
	2000	76.4	15.7	54.5	37.3	21.5	.2	211.1
	2001	72.6	13.2	41.6	31.8	21.5	.1	185.6
	2002	51.9	13.5	42.4	34.1	22.2	.1	168.4
	2003	50.7	15.5	52.9	43.3	23.9	.6	193.4
	2004	63.9	16.9	56.7	23.0	22.2	.8	188.0
	2005	80.9	15.0	47.5	29.7	20.6	.8	199.5
Bering Sea and Aleutian Islands	1992	1,442.9	2.2	207.3	248.9	17.9	48.5	2,003.0
	1993	1,384.6	2.7	167.4	216.9	24.7	66.0	1,887.2
	1994	1,388.6	2.4	193.8	253.4	18.7	65.4	1,947.2
	1995	1,329.5	2.0	245.0	232.2	16.8	81.6	1,929.8
	1996	1,222.3	1.4	240.7	233.7	24.0	103.9	1,848.6
	1997	1,150.5	1.3	257.8	311.9	17.0	65.8	1,831.1
	1998	1,125.1	1.2	195.8	199.8	15.5	57.1	1,620.9
	1999	990.9	1.4	173.9	161.6	19.9	56.2	1,425.0
	2000	1,134.0	1.8	191.1	190.9	16.4	47.2	1,608.0
	2001	1,388.3	1.9	176.7	140.2	17.6	61.6	1,815.4
	2002	1,482.4	2.3	196.7	162.4	16.8	45.3	1,935.8
	2003	1,493.9	2.2	213.1	164.4	20.9	59.4	1,983.5
	2004	1,481.7	2.0	213.8	174.8	17.7	60.6	1,981.1
	2005	1,484.9	2.6	205.1	180.4	15.1	62.0	1,980.7
All Alaska	1992	1,533.8	25.7	288.0	290.8	42.8	54.9	2,283.7
	1993	1,493.5	27.5	223.9	256.4	44.4	71.2	2,148.6
	1994	1,495.9	24.9	241.3	289.4	34.8	68.9	2,183.0
	1995	1,402.1	22.9	314.0	264.4	36.1	82.3	2,147.9
	1996	1,273.6	19.6	309.0	276.8	42.2	105.5	2,053.8
	1997	1,240.7	17.1	326.2	345.6	36.9	66.2	2,064.6
	1998	1,250.2	16.4	257.9	223.1	34.9	57.4	1,870.2
	1999	1,086.4	15.3	242.5	186.4	44.4	56.5	1,656.6
	2000	1,210.3	17.5	245.6	228.2	37.9	47.4	1,819.1
	2001	1,460.9	15.1	218.4	172.0	39.1	61.6	2,001.0
	2002	1,534.3	15.8	239.1	196.5	39.0	45.4	2,104.2
	2003	1,544.6	17.7	265.9	207.7	44.8	59.9	2,176.8
	2004	1,545.6	18.9	270.5	197.8	39.9	61.4	2,169.2
	2005	1,565.8	17.5	252.6	210.1	35.7	62.8	2,180.2

Notes: These estimates include catch from federal and state of Alaska fisheries. Totals may include additional categories.

Source: Blend estimates for 1992-2002. Catch-accounting system estimates for 2003-05. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 2. Groundfish catch off Alaska by area, vessel type, gear and species, 2001-05 (1,000 metric tons, round weight).

			Gulf of Alaska			Bering Sea and Aleutian			All Alaska		
			Catcher vessels	Catcher processors	Total	Catcher vessels	Catcher processors	Total	Catcher vessels	Catcher processors	Total
All gear	All Groundfish	2001	144	38	182	791	1,024	1,815	935	1,062	1,997
		2002	119	47	165	864	1,072	1,936	983	1,119	2,101
		2003	124	55	179	883	1,100	1,983	1,007	1,155	2,162
		2004	140	32	172	857	1,124	1,981	997	1,156	2,153
		2005	154	31	185	858	1,120	1,977	1,011	1,151	2,162
Hook & Line	Sablefish	2001	9	1	11	1	0	1	10	2	12
		2002	9	2	11	1	1	1	10	2	12
		2003	11	2	13	1	1	1	12	2	14
		2004	13	2	14	0	0	1	13	2	15
		2005	11	2	13	0	1	1	11	2	14
	Pacific cod	2001	6	4	10	1	108	108	7	112	118
		2002	7	8	15	1	103	103	7	111	118
		2003	4	6	10	1	109	110	4	115	119
		2004	6	5	11	1	112	113	7	117	124
		2005	5	1	6	1	114	116	6	116	122
	Flatfish	2001	1	0	1	1	5	6	1	5	7
		2002	0	0	1	0	5	5	1	5	6
		2003	0	0	0	1	5	5	1	5	6
		2004	0	0	0	0	5	5	0	5	5
		2005	0	0	0	0	5	5	0	6	6
	Rockfish	2001	2	0	2	0	1	1	2	1	2
		2002	1	0	1	0	0	1	1	1	2
		2003	1	0	1	0	0	0	1	1	2
		2004	1	0	1	0	0	0	1	1	2
		2005	1	0	1	0	0	0	1	0	1
	All Groundfish	2001	19	6	25	2	135	138	21	141	163
		2002	18	11	29	2	130	132	20	140	161
		2003	18	9	27	2	139	142	20	148	168
		2004	21	7	29	2	142	143	23	149	172
		2005	18	4	22	2	145	147	20	149	169
Pot	Pacific cod	2001	6	2	7	14	3	17	19	5	24
		2002	7	1	8	13	2	15	20	3	23
		2003	13	-	13	20	2	22	33	2	35
		2004	15	-	15	14	3	17	29	3	32
		2005	15	-	15	14	-	14	28	-	28

Table 2. Continued.

			Gulf of Alaska			Bering Sea and Aleutian			All Alaska		
			Catcher vessels	Catcher processors	Total	Catcher vessels	Catcher processors	Total	Catcher vessels	Catcher processors	Total
Trawl	Pollock	2001	71	0	71	746	636	1,382	817	636	1,453
		2002	50	0	51	799	677	1,476	849	677	1,526
		2003	49	1	49	807	679	1,487	856	680	1,536
		2004	62	0	63	792	685	1,476	854	685	1,539
		2005	80	0	80	797	683	1,481	877	684	1,561
	Sablefish	2001	1	1	1	0	0	0	1	1	2
		2002	1	1	2	0	0	0	1	2	2
		2003	1	1	2	0	0	0	1	1	2
		2004	1	1	1	0	0	0	1	1	2
		2005	1	1	1	0	0	0	1	1	2
	Pacific cod	2001	21	3	24	21	30	51	43	33	76
		2002	18	1	20	41	37	79	60	39	98
		2003	17	2	19	42	40	81	58	42	100
		2004	16	1	18	38	45	84	55	47	101
		2005	13	1	15	35	38	72	48	39	87
	Flatfish	2001	17	14	31	3	131	134	20	145	165
		2002	14	20	33	4	153	157	18	172	191
		2003	14	29	43	6	153	159	20	182	202
		2004	14	9	23	6	164	170	19	173	193
		2005	17	13	29	4	170	175	21	183	204
	Rockfish	2001	7	11	19	0	17	17	7	28	35
		2002	9	12	20	0	16	16	9	28	37
		2003	10	12	22	0	20	20	11	32	43
		2004	9	12	21	0	17	17	10	28	38
		2005	8	11	19	1	14	15	9	26	34
	Atka mackerel	2001	0	0	0	0	61	61	0	61	61
		2002	0	0	0	0	45	45	0	45	45
		2003	0	1	1	2	57	59	2	58	60
		2004	0	1	1	1	59	60	1	60	61
		2005	0	1	1	1	61	62	1	62	63
	All Groundfish	2001	119	30	149	774	886	1,660	893	916	1,809
		2002	94	35	129	847	940	1,788	941	975	1,916
		2003	93	46	139	859	959	1,818	952	1,006	1,958
		2004	103	24	128	840	979	1,819	943	1,003	1,947
		2005	121	28	148	840	974	1,814	961	1,002	1,962

Note: The estimates are of total catch (i.e., retained and discarded catch). All groundfish include additional species categories. These estimates include only catch counted against federal TACs. A dash (-) indicates that data are not available, either because there was no activity or to preserve confidentiality.

Source: Blend (2001-02) and Catch Accounting System (2003-05) estimates, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 3. Gulf of Alaska groundfish catch by species, gear, and target fishery, 2004-05 (1,000 metric tons, round weight).

			Species											
			Pollock	Sable-fish	Pacific cod	Arrow-tooth	Flathd. sole	Rex sole	Flat deep	Flat shallow	Rock-fish	Atka mack.	Other	Total
2004 Gear/ Target	Hook & line	Sablefish	.0	13.5	.1	.2	.0	-	.0	.0	.8	.0	.3	15.0
		Pacific cod	.0	.0	10.3	.1	.0	-	.0	.0	.1	.0	.9	11.4
		Rockfish	-	.0	.0	-	-	-	-	-	.3	-	-	.3
		Halibut	.0	.7	.2	.0	.0	-	.0	.0	.2	.0	.1	1.3
		Total	.2	14.3	10.7	.3	.0	-	.0	.0	1.3	.0	1.8	28.6
	Pot	Pacific cod	.0	-	14.9	.0	.0	.0	-	.0	.0	.0	.5	15.4
		Total	.0	-	14.9	.0	.0	.0	-	.0	.0	.0	.5	15.5
	Trawl	Pollock, bottom	9.6	.0	.3	.7	.2	.0	.0	.0	.1	.0	.1	11.1
		Pollock, pelagic	52.0	.0	.2	.3	.1	.0	.0	.0	.0	.0	.2	52.8
		Sablefish	-	.1	-	.0	.0	.0	.0	-	.0	-	.0	.2
		Pacific cod	.2	.0	13.5	1.6	.1	.1	.0	.8	.3	.0	.2	16.7
		Arrowtooth	.2	.1	.5	6.0	.8	.2	.1	.3	.1	.0	.4	8.5
		Flathead sole	.0	.0	.2	1.5	.9	.2	.0	.0	.0	.0	.1	3.1
		Rex sole	.0	.0	.2	2.0	.1	.7	.0	.0	.3	.0	.1	3.5
		Flatfish, deep	.0	.1	.1	.3	.0	.0	.5	.0	.0	-	.0	1.2
		Flatfish, shallow	.1	.0	.8	.7	.2	.0	.0	1.8	.0	.0	.5	4.1
		Rockfish	.4	1.0	1.7	1.8	.1	.1	.1	.1	19.8	.7	.1	26.0
		Total	62.6	1.3	17.6	15.0	2.4	1.5	.7	3.1	20.7	.8	2.2	127.7
	All gear	Total	62.8	15.6	43.1	15.3	2.4	1.5	.7	3.1	22.0	.8	4.5	171.8

Table 3. Continued.

			Species											
			Pollock	Sable-fish	Pacific cod	Arrow-tooth	Flathd. sole	Rex sole	Flat deep	Flat shallow	Rock-fish	Atka mack.	Other	Total
2005 Gear/ Target	Hook & line	Pollock, bottom	.1	.0	.0	.0	.0	-	-	.0	-	-	.0	.1
		Sablefish	.0	11.9	.1	.2	-	-	.0	.0	.7	.0	.6	13.5
		Pacific cod	.0	.0	5.6	.1	.0	.0	-	.0	.0	.0	.6	6.3
		Arrowtooth	.0	.0	.0	.0	.0	-	-	.0	.0	-	.1	.1
		Rockfish	-	.0	.0	.0	.0	-	-	.0	.1	-	-	.2
		Halibut	.0	.9	.2	.0	.0	.0	.0	.0	.2	.0	.1	1.5
		Total	.1	12.8	5.9	.4	.0	.0	.0	.0	1.1	.0	1.6	21.9
	Pot	Pacific cod	.0	-	14.7	.0	.0	.0	.0	.0	.0	.0	.3	15.0
		Total	.0	-	14.7	.0	.0	.0	.0	.0	.0	.0	.3	15.0
	Trawl	Pollock, bottom	16.7	.0	.2	1.6	.1	.0	.0	.0	.0	.0	.5	19.1
		Pollock, pelagic	62.6	.0	.2	.7	.1	.0	.0	.0	.1	.0	.4	64.0
		Pacific cod	.0	.0	11.1	.6	.0	.0	.0	.3	.0	.0	.1	12.3
		Arrowtooth	.3	.1	.6	10.7	1.2	.7	.1	.1	.2	.0	.9	15.0
		Flathead sole	.0	.0	.2	1.8	.6	.3	.0	.0	.0	.0	.1	3.1
		Rex sole	.0	.0	.1	1.7	.1	.9	.0	.0	.2	.0	.1	3.2
		Flatfish, deep	.0	.0	.0	.0	.0	.0	.1	.0	.0	-	.0	.2
		Flatfish, shallow	.1	.0	1.2	1.3	.3	.1	.0	4.2	.0	.0	.8	8.2
		Rockfish	.3	1.0	.9	1.0	.1	.1	.1	.1	18.7	.7	.1	22.9
		Total	80.0	1.2	14.5	19.4	2.5	2.2	.4	4.8	19.3	.8	3.1	148.2
	All gear	Total	80.1	14.0	35.1	19.8	2.5	2.2	.4	4.8	20.4	.8	5.0	185.1

Notes: Totals may include additional categories. The target, determined by AFSC staff, is based on processor, week, processing mode, NMFS area, and gear. These estimates include only catch counted against federal TACs.

Source: Catch-accounting system estimates, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 4. Bering Sea and Aleutian Islands groundfish catch by species, gear, and target fishery, 2004-05 (1,000 metric tons, round weight).

			Species												
			Pollock	Sable-fish	Pacific cod	Arrow-tooth	Flathd. sole	Rock sole	Turbot	Yellow fin	Flat other	Rock-fish	Atka mack.	Other	Total
2004 Gear/ Target	Hook & line	Sablefish	-	.6	.0	.0	-	-	.1	-	-	.1	.0	.0	.8
		Pacific cod	5.3	.0	112.8	1.4	.6	.0	.2	.6	.2	.2	.0	18.6	140.1
		Turbot	.0	.1	.0	.2	.0	.0	1.2	-	.0	.1	.0	.1	1.7
		Halibut	.0	.1	.1	.1	.0	.0	.1	.0	.0	.0	.0	.3	.7
		Total	5.4	.9	113.0	1.6	.6	.0	1.5	.6	.2	.4	.0	19.1	143.4
	Pot	Sablefish	.0	.8	.0	.1	.0	.0	.0	-	.0	.0	.0	.0	.9
		Pacific cod	.0	.0	17.2	.0	.0	.0	-	.1	.0	.0	.1	.3	17.8
		Total	.0	.8	17.2	.1	.0	.0	.0	.1	.0	.0	.1	.5	18.9
	Trawl	Pollock, bottom	18.6	.0	.3	.1	.1	.3	.0	.2	.2	.1	.6	.3	20.7
		Pollock, pelagic	1,417.3	.0	6.2	.5	2.0	2.3	.0	.7	.3	.4	.4	1.9	1,432.1
		Sablefish	.0	.0	.0	.0	.0	.0	.0	-	.0	.0	.0	.0	.1
		Pacific cod	13.8	.1	62.1	8.0	2.8	9.2	.1	1.8	2.4	.5	4.8	3.4	109.1
		Arrowtooth	.5	.1	.2	1.6	.1	.1	.1	.0	.3	.1	.4	.1	3.5
		Flathead sole	5.1	.0	2.8	3.7	9.6	2.1	.2	2.4	.6	.1	.0	1.8	28.6
		Rock sole	9.0	.0	5.7	.3	.9	24.3	.0	4.0	1.9	.0	.0	.8	47.0
		Turbot	.1	.0	.0	.1	.0	.0	.1	.0	.0	.0	-	.0	.3
		Yellowfin	10.5	.0	3.6	.3	1.1	10.0	.0	65.5	6.3	.0	.0	1.6	98.9
		Other flatfish	.6	.0	.2	1.0	.1	.1	.1	.0	.3	.0	.1	.1	2.7
		Rockfish	.3	.0	.1	.4	.0	.0	.1	-	.0	8.9	.3	.1	10.3
		Atka mackerel	.5	.0	2.4	.4	.0	.2	.1	.0	.1	7.1	53.6	.7	65.2
		Total	1,476.3	.3	83.6	16.5	16.8	48.6	.7	74.7	12.7	17.3	60.4	10.9	1,818.8
	All gear	Total	1,481.7	2.0	213.8	18.3	17.4	48.7	2.2	75.4	12.9	17.7	60.6	30.6	1,981.1

Table 4. Continued.

			Species												
			Pollock	Sable-fish	Pacific cod	Arrow-tooth	Flathd. sole	Rock sole	Turbot	Yellow fin	Flat other	Rock-fish	Atka mack.	Other	Total
2005 Gear/ Target	Hook & line	Sablefish	.0	.7	.0	.0	.0	.0	.1	-	.0	.1	-	.0	.9
		Pacific cod	4.2	.0	115.6	1.7	.6	.1	.2	.7	.3	.1	.0	20.4	143.8
		Turbot	.0	.1	.0	.2	.0	-	1.5	-	.0	.1	-	.2	2.0
		Halibut	.0	.1	.2	.0	.0	.0	.1	.0	.0	.0	.0	.1	.6
		Total	4.2	.9	115.8	2.0	.6	.1	1.8	.7	.3	.3	.0	20.7	147.3
	Pot	Sablefish	.0	1.3	.0	.0	.0	-	.0	-	.0	.0	.0	.0	1.3
		Pacific cod	.0	.0	17.0	.0	.0	.0	.0	.1	.0	.0	.3	.4	17.7
		Total	.0	1.3	17.0	.1	.0	.0	.0	.1	.0	.0	.3	.4	19.1
	Trawl	Pollock, bottom	29.1	.0	1.0	.1	.3	.1	.0	.0	.1	.3	.5	.5	32.0
		Pollock, pelagic	1,417.4	.0	6.4	.6	2.1	1.0	.0	.0	.3	.6	.2	1.7	1,430.4
		Pacific cod	10.6	.0	50.8	4.0	1.4	7.9	.0	1.3	1.7	.5	1.1	1.9	81.2
		Arrowtooth	1.1	.1	.5	2.2	.3	.1	.2	.0	.4	.1	.4	.3	5.6
		Flathead sole	3.7	.0	2.1	2.6	9.2	1.2	.1	2.2	.8	.0	.1	1.4	23.4
		Rock sole	7.2	.0	5.2	.6	.9	16.7	.0	7.6	2.3	.0	.0	.9	41.4
		Turbot	.0	.0	-	.0	.0	.0	.0	-	.0	.0	-	.0	.1
		Yellowfin	10.3	.0	3.8	.6	1.2	10.1	.0	82.4	9.4	.0	.1	2.1	120.1
		Other flatfish	.3	.0	.1	.7	.1	.1	.0	.0	.4	.1	.1	.1	2.0
		Rockfish	.4	.1	.1	.3	.0	.0	.1	-	.0	7.0	.2	.1	8.3
		Atka mackerel	.5	.0	2.3	.4	.0	.2	.2	.0	.1	6.2	59.1	.6	69.7
		Total	1,480.7	.4	72.2	12.2	15.5	37.3	.7	93.6	15.5	14.8	61.8	9.5	1,814.3
	All gear	Total	1,484.9	2.6	205.1	14.2	16.1	37.4	2.6	94.4	15.8	15.1	62.0	30.6	1,980.7

Notes: Totals may include additional categories. The target, determined by AFSC staff, is based on processor, week, processing mode, NMFS area, and gear. These estimates include only catch counted against federal TACs.

Source: Catch-accounting system estimates, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 5. Groundfish catch off Alaska by area, residency, and species, 2001-05 (1,000 metric tons, round weight).

		Gulf of Alaska			Bering Sea and Aleutian			All Alaska		
		Alaska	Other	Unknown	Alaska	Other	Unknown	Alaska	Other	Unknown
All groundfish	2001	70	111	1	46	1,767	2	116	1,878	3
	2002	66	98	1	45	1,889	2	112	1,987	2
	2003	67	112	0	53	1,931	0	120	2,043	0
	2004	71	100	0	47	1,934	0	119	2,034	0
	2005	70	114	1	28	1,953	0	98	2,067	1
Pollock	2001	29	42	0	16	1,370	2	45	1,412	2
	2002	19	31	0	17	1,464	1	36	1,496	1
	2003	18	31	0	16	1,478	0	34	1,509	0
	2004	24	39	0	16	1,466	0	39	1,505	0
	2005	30	50	0	12	1,472	0	43	1,522	0
Sablefish	2001	6	7	0	1	1	0	6	8	0
	2002	6	7	0	1	1	0	7	8	0
	2003	7	8	0	1	1	0	7	9	0
	2004	7	8	0	1	1	0	8	10	0
	2005	6	8	0	1	2	0	7	10	0
Pacific cod	2001	22	20	0	17	160	0	39	180	0
	2002	25	17	0	19	178	0	44	195	0
	2003	23	18	0	20	193	0	44	211	0
	2004	25	18	0	19	194	0	45	212	0
	2005	23	12	0	14	191	0	36	204	0
Flatfish	2001	8	23	0	3	137	0	12	160	0
	2002	10	24	0	7	156	0	17	180	0
	2003	10	34	0	11	154	0	20	187	0
	2004	8	15	0	7	168	0	15	183	0
	2005	6	24	0	0	180	0	6	204	0
Rockfish	2001	4	17	0	3	15	0	6	31	0
	2002	5	16	0	0	17	0	6	33	0
	2003	6	18	0	0	21	0	6	38	0
	2004	5	17	0	0	17	0	5	34	0
	2005	4	17	0	0	15	0	4	32	0
Atka mackerel	2001	0	0	0	5	57	0	5	57	0
	2002	0	0	0	0	45	0	0	45	0
	2003	0	0	0	3	57	0	3	57	0
	2004	0	1	0	3	57	0	3	58	0
	2005	0	1	0	0	62	0	0	63	0

Notes: These estimates include only catch counted against federal TACs. Catch delivered to motherships is classified by the residence of the owner of the mothership. All other catch is classified by the residence of the owner of the fishing vessel. All groundfish include additional species categories.

Source: Blend estimates (2001-02), Catch Accounting System estimates (2003-05), fish tickets, CFEC vessel data, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 6. Discards and discard rates for groundfish catch off Alaska by area, gear, and species, 2001-05 (1,000 metric tons, round weight).

			Fixed		Trawl		All gear	
			Total Discards	Discard Rate	Total Discards	Discard Rate	Total Discards	Discard Rate
Gulf of Alaska	All Groundfish	2001	3.6	11.1%	20.7	13.9%	24.2	13.4%
		2002	2.7	7.3%	20.4	15.8%	23.0	13.9%
		2003	3.0	7.5%	27.7	19.9%	30.7	17.1%
		2004	3.0	6.9%	14.7	11.5%	17.8	10.3%
		2005	2.4	6.4%	13.1	8.9%	15.5	8.4%
	Pollock	2001	.0	9.3%	.7	1.0%	.7	1.0%
		2002	.0	16.7%	1.1	2.2%	1.1	2.2%
		2003	.0	15.8%	1.0	2.1%	1.0	2.1%
		2004	.0	14.8%	1.1	1.7%	1.1	1.8%
		2005	.0	3.6%	1.1	1.4%	1.1	1.4%
	Sablefish	2001	.3	2.6%	.5	35.3%	.8	6.4%
		2002	.3	2.9%	.7	36.1%	1.0	8.0%
		2003	.4	3.5%	.7	38.7%	1.2	8.0%
		2004	.4	3.0%	.2	14.8%	.6	4.0%
		2005	.2	1.7%	.2	15.4%	.4	2.9%
	Pacific cod	2001	.3	1.9%	1.6	6.5%	1.9	4.6%
		2002	.2	.9%	3.5	17.7%	3.7	8.8%
		2003	.4	1.7%	2.1	11.1%	2.5	6.1%
		2004	.4	1.6%	.9	5.1%	1.3	3.0%
		2005	.2	1.1%	.7	5.0%	1.0	2.7%
	Flatfish	2001	.8	94.1%	13.7	44.3%	14.5	45.6%
		2002	.7	95.9%	11.2	33.7%	11.9	35.0%
		2003	.3	86.2%	19.2	44.7%	19.5	45.0%
		2004	.3	85.9%	9.5	41.9%	9.8	42.6%
		2005	.3	68.4%	8.6	29.3%	8.9	29.8%
	Rockfish	2001	.6	32.6%	2.0	10.6%	2.5	12.5%
		2002	.3	21.9%	1.9	9.4%	2.2	10.1%
		2003	.4	26.8%	3.2	14.3%	3.5	15.1%
		2004	.3	24.4%	2.0	9.6%	2.3	10.5%
		2005	.2	18.4%	1.2	6.4%	1.4	7.0%
	Atka mackerel	2001	.0	93.2%	.0	22.6%	.0	23.5%
		2002	.0	87.1%	.0	60.3%	.1	61.1%
		2003	.0	98.8%	.2	42.7%	.3	43.6%
		2004	.0	96.9%	.3	38.6%	.3	40.1%
		2005	.0	99.4%	.1	17.5%	.2	19.4%

Table 6. Continued.

			Fixed		Trawl		All gear	
			Total Discards	Discard Rate	Total Discards	Discard Rate	Total Discards	Discard Rate
Bering Sea & Aleutians	All Groundfish	2001	20.5	13.2%	79.0	4.8%	99.5	5.5%
		2002	18.8	12.7%	100.1	5.6%	119.0	6.1%
		2003	18.6	11.3%	101.0	5.6%	119.6	6.0%
		2004	20.9	12.9%	112.5	6.2%	133.4	6.7%
		2005	21.0	12.6%	77.1	4.3%	98.1	5.0%
	Pollock	2001	1.0	16.7%	16.7	1.2%	17.7	1.3%
		2002	.9	13.3%	20.6	1.4%	21.4	1.4%
		2003	.8	11.1%	17.4	1.2%	18.2	1.2%
		2004	.7	12.9%	22.8	1.5%	23.4	1.6%
		2005	.6	13.9%	17.2	1.2%	17.7	1.2%
	Sablefish	2001	.1	6.9%	.0	7.1%	.1	6.9%
		2002	.2	8.0%	.0	14.7%	.2	9.0%
		2003	.1	7.2%	.1	39.5%	.3	11.9%
		2004	.0	2.7%	.1	26.5%	.1	6.6%
		2005	.1	2.6%	.0	8.2%	.1	3.4%
	Pacific cod	2001	1.8	1.5%	1.1	2.1%	2.9	1.7%
		2002	2.4	2.0%	1.9	2.4%	4.3	2.2%
		2003	2.3	1.7%	1.1	1.3%	3.4	1.6%
		2004	2.0	1.5%	.8	.9%	2.8	1.3%
		2005	2.9	2.1%	.7	1.0%	3.5	1.7%
	Flatfish	2001	3.1	51.2%	37.8	28.2%	40.8	29.1%
		2002	2.8	53.2%	52.6	33.5%	55.4	34.1%
		2003	3.3	58.4%	52.0	32.8%	55.3	33.7%
		2004	2.9	60.9%	62.4	36.7%	65.4	37.4%
		2005	2.7	48.0%	43.6	24.9%	46.3	25.6%
	Rockfish	2001	.4	58.7%	8.1	47.9%	8.5	48.4%
		2002	.4	58.9%	5.5	34.1%	5.9	35.0%
		2003	.2	47.0%	7.5	36.8%	7.7	37.1%
		2004	.2	51.5%	6.3	36.5%	6.5	36.8%
		2005	.1	34.5%	4.8	32.3%	4.9	32.4%
	Atka mackerel	2001	.2	53.6%	4.4	7.1%	4.5	7.3%
		2002	.1	98.6%	7.5	16.5%	7.6	16.7%
		2003	.2	96.1%	14.1	23.8%	14.3	24.1%
		2004	.2	98.8%	11.7	19.4%	11.9	19.6%
		2005	.3	96.9%	3.8	6.1%	4.0	6.5%

Table 6. Continued.

			Fixed		Trawl		All gear	
			Total Discards	Discard Rate	Total Discards	Discard Rate	Total Discards	Discard Rate
All Alaska	All Groundfish	2001	24.1	12.8%	99.7	5.5%	123.7	6.2%
		2002	21.5	11.6%	120.5	6.3%	142.0	6.8%
		2003	21.6	10.6%	128.7	6.6%	150.4	7.0%
		2004	23.9	11.6%	127.2	6.5%	151.1	7.0%
		2005	23.4	11.5%	90.3	4.6%	113.6	5.2%
	Pollock	2001	1.0	16.6%	17.4	1.2%	18.5	1.3%
		2002	.9	13.4%	21.7	1.4%	22.6	1.5%
		2003	.8	11.1%	18.5	1.2%	19.3	1.2%
		2004	.7	13.0%	23.8	1.5%	24.5	1.6%
		2005	.6	13.7%	18.3	1.2%	18.8	1.2%
	Sablefish	2001	.4	3.2%	.5	29.1%	.9	6.4%
		2002	.5	3.7%	.7	32.9%	1.2	8.2%
		2003	.6	4.0%	.8	38.8%	1.4	8.6%
		2004	.5	2.9%	.3	17.1%	.8	4.3%
		2005	.3	1.9%	.2	13.7%	.5	3.0%
	Pacific cod	2001	2.2	1.5%	2.7	3.5%	4.8	2.2%
		2002	2.6	1.8%	5.4	5.5%	8.0	3.3%
		2003	2.7	1.7%	3.2	3.2%	5.9	2.3%
		2004	2.4	1.6%	1.7	1.6%	4.1	1.6%
		2005	3.1	2.0%	1.4	1.6%	4.5	1.9%
	Flatfish	2001	3.9	56.7%	51.5	31.2%	55.3	32.2%
		2002	3.5	58.2%	63.9	33.5%	67.4	34.3%
		2003	3.6	60.1%	71.2	35.3%	74.8	36.0%
		2004	3.2	62.7%	71.9	37.3%	75.1	38.0%
		2005	2.9	49.3%	52.2	25.6%	55.1	26.2%
	Rockfish	2001	1.0	40.3%	10.1	28.4%	11.1	29.2%
		2002	.6	33.4%	7.4	20.3%	8.1	21.0%
		2003	.6	31.5%	10.7	25.2%	11.3	25.4%
		2004	.5	30.4%	8.3	21.8%	8.8	22.2%
		2005	.3	21.7%	6.0	17.6%	6.3	17.8%
	Atka mackerel	2001	.2	53.8%	4.4	7.1%	4.5	7.4%
		2002	.1	98.3%	7.5	16.6%	7.6	16.8%
		2003	.2	96.2%	14.3	24.0%	14.5	24.3%
		2004	.2	98.6%	12.0	19.6%	12.2	19.9%
		2005	.3	97.1%	3.9	6.2%	4.2	6.7%

Notes: All groundfish and all gear may include additional categories. These estimates include only catch counted against federal TACs. Although these are the best available estimates of discards and are used for several management purposes, these estimates are not necessarily accurate. The reasons for this are as follows: 1) they are wholly or partially derived from observer estimates; 2) discards occur at many different places on vessels; 3) observers record only a rough approximation of what they see; 4) the sampling methods used by at-sea observers provide the basis for NMFS to make good estimates of total catch by species, not the disposition of that catch.

Source: Blend estimates (2001-02) and catch accounting system estimates (2003-05) National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 7. Gulf of Alaska groundfish discards by species, gear, and target fishery, 2004-05 (1,000 metric tons, round weight).

			Species											
			Pollock	Sable-fish	Pacific cod	Arrow-tooth	Flathd. sole	Rex sole	Flat deep	Flat shallow	Rock-fish	Atka mack.	Other	Total
2004 Gear/ Target	Hook & line	Sablefish	.0	.4	.0	.2	.0	-	.0	.0	.2	.0	.3	1.2
		Pacific cod	.0	.0	.2	.0	.0	-	.0	.0	.0	.0	.7	1.0
		Rockfish	-	.0	.0	-	-	-	-	-	.0	-	-	.0
		Halibut	.0	.0	.2	.0	.0	-	.0	.0	.0	.0	.1	.3
		Total	.0	.4	.3	.3	.0	-	.0	.0	.3	.0	1.1	2.5
	Pot	Pacific cod	.0	-	.1	.0	.0	.0	-	.0	.0	.0	.4	.5
		Total	.0	-	.1	.0	.0	.0	-	.0	.0	.0	.4	.5
	Trawl	Pollock, bottom	.1	.0	.1	.1	.0	.0	.0	.0	.1	.0	.0	.5
		Pollock, pelagic	.6	.0	.0	.1	.0	.0	.0	.0	.0	.0	.1	.9
		Sablefish	-	.0	-	.0	.0	.0	.0	-	.0	-	.0	.0
		Pacific cod	.1	.0	.0	1.3	.0	.0	.0	.2	.2	.0	.1	2.1
		Arrowtooth	.0	.0	.1	1.4	.1	.0	.0	.0	.0	.0	.1	1.7
		Flathead sole	.0	.0	.1	1.4	.2	.0	.0	.0	.0	.0	.1	1.9
		Rex sole	.0	.0	.0	1.9	.0	.0	.0	.0	.2	.0	.0	2.3
		Flatfish, deep	.0	.1	.0	.3	.0	.0	.0	.0	.0	-	.0	.4
		Flatfish, shallow	.0	.0	.4	.5	.0	.0	.0	.1	.0	.0	.2	1.3
		Rockfish	.1	.1	.1	1.3	.0	.0	.1	.0	1.4	.3	.1	3.5
		Total	1.1	.2	.9	8.4	.5	.1	.1	.4	2.0	.3	.8	14.7
	All gear	Total	1.1	.6	1.3	8.6	.5	.1	.1	.4	2.3	.3	2.3	17.8

Table 7. Continued.

			Species											
			Pollock	Sable-fish	Pacific cod	Arrow-tooth	Flathd. sole	Rex sole	Flat deep	Flat shallow	Rock-fish	Atka mack.	Other	Total
2005 Gear/ Target	Hook & line	Pollock, bottom	.0	.0	.0	.0	.0	-	-	.0	-	-	.0	.0
		Sablefish	.0	.2	.0	.1	-	-	.0	.0	.2	.0	.5	1.1
		Pacific cod	.0	.0	.0	.1	.0	.0	-	.0	.0	.0	.5	.7
		Arrowtooth	.0	.0	.0	.0	.0	-	-	.0	.0	-	.1	.1
		Rockfish	-	.0	.0	.0	.0	-	-	.0	.0	-	-	.0
		Halibut	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.1	.2
		Total	.0	.2	.2	.2	.0	.0	.0	.0	.2	.0	1.2	2.1
	Pot	Pacific cod	.0	-	.1	.0	.0	.0	.0	.0	.0	.0	.2	.3
		Total	.0	-	.1	.0	.0	.0	.0	.0	.0	.0	.2	.3
	Trawl	Pollock, bottom	.3	.0	.0	.1	.0	.0	.0	.0	.0	.0	.1	.5
		Pollock, pelagic	.7	.0	.0	.1	.0	.0	.0	.0	.0	.0	.2	1.1
		Pacific cod	.0	.0	.0	.5	.0	.0	.0	.1	.0	.0	.1	.7
		Arrowtooth	.0	.0	.2	2.1	.2	.1	.1	.0	.1	.0	.3	3.0
		Flathead sole	.0	.0	.0	1.6	.1	.0	.0	.0	.0	.0	.1	1.9
		Rex sole	.0	.0	.0	1.6	.0	.0	.0	.0	.1	.0	.0	1.9
		Flatfish, deep	.0	.0	.0	.0	.0	.0	.0	.0	.0	-	.0	.0
		Flatfish, shallow	.0	.0	.5	.9	.0	.0	.0	.2	.0	.0	.2	1.9
		Rockfish	.0	.1	.0	.7	.0	.0	.1	.0	.9	.1	.1	2.1
		Total	1.1	.2	.7	7.5	.3	.2	.2	.3	1.2	.1	1.2	13.1
	All gear	Total	1.1	.4	1.0	7.7	.3	.2	.2	.3	1.4	.2	2.6	15.5

Notes: Totals may include additional categories. The target, determined by AFSC staff, is based on processor, week, processing mode, NMFS area, and gear. These estimates include only catch counted against federal TACs. Although these are the best available estimates of discards and are used for several management purposes, these estimates are not necessarily accurate. The reasons for this are as follows: 1) they are wholly or partially derived from observer estimates; 2) discards occur at many different places on vessels; 3) observers record only a rough approximation of what they see; and 4) the sampling methods used by at-sea observers provide NMFS the basis to make good estimates of total catch by species, not the disposition of that catch.

Source: Catch-accounting system estimates, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 8. Bering Sea and Aleutian Islands groundfish discards by species, gear, and target fishery, 2004-05 (1,000 metric tons, round weight).

			Species												
			Pollock	Sable-fish	Pacific cod	Arrow-tooth	Flathd. sole	Rock sole	Turbot	Yellow fin	Flat other	Rock-fish	Atka mack.	Other	Total
2004 Gear/ Target	Hook & line	Sablefish	-	.0	.0	.0	-	-	.0	-	-	.0	.0	.0	.0
		Pacific cod	.7	.0	1.9	1.3	.6	.0	.0	.5	.2	.1	.0	14.2	19.6
		Turbot	.0	.0	.0	.0	.0	.0	.0	-	.0	.0	.0	.1	.2
		Halibut	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2	.4
		Total	.7	.0	2.0	1.4	.6	.0	.1	.5	.2	.2	.0	14.6	20.2
	Pot	Sablefish	.0	.0	.0	.0	.0	.0	.0	-	.0	.0	.0	.0	.1
		Pacific cod	.0	.0	.0	.0	.0	.0	-	.1	.0	.0	.1	.3	.6
		Total	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.1	.3	.6
	Trawl	Pollock, bottom	.0	.0	.0	.1	.0	.0	.0	.0	.2	.0	.1	.1	.6
		Pollock, pelagic	.4	.0	.1	.4	1.1	1.0	.0	.4	.2	.2	.2	1.1	5.1
		Sablefish	.0	.0	.0	.0	.0	.0	.0	-	.0	.0	.0	.0	.1
		Pacific cod	9.1	.0	.3	7.3	1.8	6.6	.0	1.4	1.9	.4	3.8	2.8	35.5
		Arrowtooth	.3	.0	.0	.7	.0	.0	.0	.0	.0	.0	.3	.1	1.6
		Flathead sole	3.4	.0	.0	2.3	1.1	1.1	.1	.4	.5	.0	.0	1.2	10.1
		Rock sole	4.4	.0	.2	.3	.6	8.3	.0	2.1	1.8	.0	.0	.7	18.4
		Turbot	.1	.0	.0	.1	.0	.0	.0	.0	.0	.0	-	.0	.2
		Yellowfin	4.2	.0	.1	.2	.3	4.3	.0	7.9	5.9	.0	.0	1.5	24.3
		Other flatfish	.5	.0	.0	.8	.0	.0	.0	.0	.0	.0	.1	.1	1.6
		Rockfish	.1	.0	.0	.3	.0	.0	.0	-	.0	.4	.1	.1	1.0
		Atka mackerel	.1	.0	.0	.4	.0	.1	.0	.0	.0	5.3	7.1	.7	13.8
		Total	22.7	.1	.8	13.0	4.9	21.5	.2	12.2	10.7	6.3	11.7	8.4	112.5
	All gear	Total	23.4	.1	2.8	14.4	5.4	21.5	.4	12.7	10.9	6.5	11.9	23.3	133.4

Table 8. Continued.

			Species												
			Pollock	Sable- fish	Pacific cod	Arrow- tooth	Flathd. sole	Rock sole	Turbot	Yellow fin	Flat other	Rock- fish	Atka mack.	Other	Total
2005 Gear/ Target	Hook & line	Sablefish	.0	.0	.0	.0	.0	.0	.0	-	.0	.0	-	.0	.1
		Pacific cod	.6	.0	2.6	1.0	.5	.1	.0	.6	.2	.1	.0	14.0	19.8
		Turbot	.0	.0	.0	.0	.0	-	.0	-	.0	.0	-	.1	.2
		Halibut	.0	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.1	.3
		Total	.6	.0	2.8	1.0	.6	.1	.1	.6	.2	.1	.0	14.3	20.4
	Pot	Sablefish	.0	.0	.0	.0	.0	-	.0	-	.0	.0	.0	.0	.1
		Pacific cod	.0	.0	.1	.0	.0	.0	.0	.1	.0	.0	.2	.2	.6
		Total	.0	.0	.1	.0	.0	.0	.0	.1	.0	.0	.2	.2	.6
	Trawl	Pollock, bottom	.1	.0	.0	.0	.1	.0	.0	.0	.1	.1	.1	.0	.6
		Pollock, pelagic	.5	.0	.0	.2	.8	.5	.0	.0	.1	.1	.0	.9	3.2
		Pacific cod	6.6	.0	.2	2.8	.9	5.0	.0	1.0	1.3	.4	.7	1.6	20.5
		Arrowtooth	.7	.0	.0	.5	.1	.0	.0	.0	.0	.0	.2	.2	1.8
		Flathead sole	2.1	.0	.0	.9	.9	.6	.0	.5	.6	.0	.0	1.1	6.8
		Rock sole	3.4	.0	.1	.3	.2	2.7	.0	1.3	2.2	.0	.0	.8	11.0
		Turbot	.0	.0	-	.0	.0	.0	.0	-	.0	.0	-	.0	.0
		Yellowfin	3.3	.0	.2	.2	.3	4.0	.0	5.5	8.5	.0	.0	1.8	23.9
		Other flatfish	.2	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.1	1.0
		Rockfish	.0	.0	.0	.1	.0	.0	.0	-	.0	.2	.1	.1	.5
		Atka mackerel	.2	.0	.1	.2	.0	.1	.0	.0	.0	3.9	2.6	.5	7.7
		Total	17.1	.0	.7	5.9	3.3	13.0	.1	8.4	12.9	4.8	3.8	7.1	77.1
	All gear	Total	17.7	.1	3.5	6.9	3.9	13.0	.2	9.1	13.2	4.9	4.0	21.6	98.1

Notes: Totals may include additional categories. The target, determined by AFSC staff, is based on processor, week, processing mode, NMFS area, and gear. These estimates include only catch counted against federal TACs. Although these are the best available estimates of discards and are used for several management purposes, these estimates are not necessarily accurate. The reasons for this are discussed in the Notes for Table 7.

Source: Catch-accounting system estimates, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 9. Gulf of Alaska groundfish discard rates by species, gear, and target fishery, 2004-05 (percent).

			Species											
			Pollock	Sable-fish	Pacific cod	Arrow-tooth	Flathd. sole	Rex sole	Flat deep	Flat shallow	Rock-fish	Atka mack.	Other	Total
2004 Gear/ Target	Hook & line	Sablefish	3.1	3.0	21.8	89.0	100.0	-	99.7	100.0	29.1	100.0	96.1	8.0
		Pacific cod	24.0	80.5	1.5	66.4	59.9	-	100.0	91.5	76.4	98.1	77.8	8.6
		Rockfish	-	.1	1.9	-	-	-	-	-	.0	-	-	.1
		Halibut	100.0	1.2	61.8	98.0	100.0	-	67.6	77.1	15.2	100.0	87.1	23.8
		Total	7.3	3.0	3.0	84.8	60.6	-	98.5	92.1	22.8	98.1	63.7	8.7
	Pot	Pacific cod	95.7	-	.6	100.0	100.0	.0	-	100.0	99.7	96.6	73.8	3.4
		Total	95.7	-	.6	100.0	100.0	.0	-	100.0	99.7	96.6	71.4	3.4
	Trawl	Pollock, bottom	1.4	3.4	34.3	10.6	6.3	2.8	.0	61.6	90.5	99.8	60.4	4.4
		Pollock, pelagic	1.2	45.0	8.8	19.7	32.2	48.5	.0	24.9	8.4	31.9	58.5	1.7
		Sablefish	-	.0	-	100.0	.0	96.4	100.0	-	18.2	-	95.7	22.3
		Pacific cod	68.7	31.8	.2	82.2	53.6	18.9	97.9	27.1	80.0	40.2	75.1	12.5
		Arrowtooth	6.7	56.8	26.5	22.9	10.8	9.1	20.1	6.3	25.4	100.0	13.5	20.5
		Flathead sole	55.0	.1	32.7	97.0	26.2	7.6	60.0	46.8	69.7	31.0	59.2	61.6
		Rex sole	1.6	15.2	15.5	96.4	21.5	2.2	100.0	3.5	75.2	61.0	37.2	65.4
		Flatfish, deep	67.3	62.4	25.1	77.6	.0	.0	.0	.1	16.2	-	68.7	33.1
		Flatfish, shallow	20.6	62.5	53.3	76.8	8.4	7.5	46.6	5.7	47.0	34.7	35.4	31.0
		Rockfish	27.1	9.2	3.9	73.4	58.4	30.6	67.3	22.4	6.9	35.9	81.2	13.5
		Total	1.7	14.8	5.1	55.9	19.9	7.5	17.0	12.6	9.6	38.6	37.2	11.5
	All gear	Total	1.8	4.0	3.0	56.4	20.0	7.5	19.3	13.0	10.5	40.1	51.7	10.3

Table 9. Continued.

			Species											
			Pollock	Sable- fish	Pacific cod	Arrow- tooth	Flathd. sole	Rex sole	Flat deep	Flat shallow	Rock- fish	Atka mack.	Other	Total
2005 Gear/ Target	Hook & line	Pollock, bottom	.0	100.0	.0	.0	.0	-	-	100.0	-	-	.0	.1
		Sablefish	30.9	1.5	51.0	57.6	-	-	94.5	100.0	22.7	100.0	96.0	8.1
		Pacific cod	.4	59.0	.4	98.0	100.0	100.0	-	100.0	83.4	100.0	83.0	10.3
		Arrowtooth	100.0	98.4	100.0	2.0	100.0	-	-	100.0	92.7	-	100.0	89.0
		Rockfish	-	.0	.0	.0	100.0	-	-	.0	.2	-	-	.2
		Halibut	100.0	2.4	30.0	94.4	100.0	100.0	95.9	100.0	6.7	100.0	77.6	15.5
		Total	1.4	1.7	2.6	66.0	95.1	100.0	94.6	98.0	17.5	100.0	79.3	9.5
	Pot	Pacific cod	78.0	-	.5	100.0	71.2	100.0	.0	98.9	99.0	99.4	62.6	1.9
		Total	78.0	-	.5	100.0	71.2	100.0	.0	98.9	99.0	99.4	62.2	1.9
	Trawl	Pollock, bottom	1.9	5.2	.1	6.0	.8	1.2	.0	26.3	.7	.0	20.3	2.7
		Pollock, pelagic	1.1	70.2	3.2	20.3	13.3	35.2	.0	50.3	44.2	.0	46.0	1.7
		Pacific cod	63.7	7.9	.2	76.6	43.4	20.1	94.6	17.8	69.3	81.1	85.2	5.9
		Arrowtooth	5.2	36.6	26.4	19.2	12.4	10.0	68.3	9.9	50.4	11.6	36.2	20.2
		Flathead sole	.7	6.7	12.3	90.5	17.3	13.9	99.0	5.8	90.1	10.9	72.3	61.8
		Rex sole	1.0	9.7	12.1	90.6	14.8	3.5	98.0	1.3	85.9	66.2	34.5	57.8
		Flatfish, deep	.0	.0	.0	9.5	.0	.0	.3	.0	.0	-	.0	1.2
		Flatfish, shallow	10.8	39.2	37.9	66.9	8.7	3.8	65.7	5.3	67.3	70.9	24.6	23.0
		Rockfish	6.7	13.7	4.1	71.9	11.1	31.8	83.4	35.8	4.7	14.1	87.1	9.1
		Total	1.4	15.4	5.0	38.7	13.1	8.6	57.5	6.8	6.4	17.5	37.7	8.9
	All gear	Total	1.4	2.9	2.7	39.2	13.3	8.6	58.4	7.0	7.0	19.4	52.2	8.4

Notes: Totals may include additional categories. The target, determined by AFSC staff, is based on processor, week, processing mode, NMFS area, and gear. These estimates include only catch counted against federal TACs. Although these are the best available estimates of discards and are used for several management purposes, these estimates are not necessarily accurate. The reasons for this are as follows: 1) they are wholly or partially derived from observer estimates; 2) discards occur at many different places on vessels; 3) observers record only a rough approximation of what they see; and 4) the sampling methods used by at-sea observers provide the basis for NMFS to make good estimates of total catch by species, not the disposition of that catch.

Source: Catch-accounting system estimates, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 10. Bering Sea and Aleutian Islands groundfish discard rates by species, gear, and target fishery, 2004-05 (percent).

			Species												
			Pollock	Sable-fish	Pacific cod	Arrow-tooth	Flathd. sole	Rock sole	Turbot	Yellow fin	Flat other	Rock-fish	Atka mack.	Other	Total
2004 Gear/ Target	Hook & line	Sablefish	-	.2	.0	31.7	-	-	7.2	-	-	13.9	100.0	87.6	4.7
		Pacific cod	12.9	80.9	1.7	94.2	95.8	99.5	14.8	77.4	96.1	82.2	99.6	76.1	14.0
		Turbot	21.0	13.0	3.0	21.6	99.8	100.0	1.5	-	100.0	25.6	100.0	79.7	11.6
		Halibut	47.3	.6	36.0	79.9	79.8	21.4	68.9	.0	73.8	39.9	100.0	90.1	57.0
		Total	12.9	3.4	1.7	84.9	95.9	99.3	6.6	77.4	96.1	50.9	99.6	76.1	14.1
	Pot	Sablefish	20.1	1.8	12.6	61.4	90.0	.0	65.8	-	87.5	53.7	2.7	88.5	8.7
		Pacific cod	55.0	100.0	.3	100.0	27.2	95.9	-	99.7	79.6	100.0	98.9	82.8	3.1
		Total	53.8	1.9	.3	63.8	29.3	95.8	62.6	99.7	80.0	74.9	98.6	52.5	3.4
	Trawl	Pollock, bottom	.1	46.8	.1	97.5	19.4	6.7	73.6	15.1	96.4	7.3	15.6	34.1	2.9
		Pollock, pelagic	.0	28.9	1.6	77.9	52.5	42.0	49.6	60.1	54.8	35.6	50.4	61.2	.4
		Sablefish	68.1	.5	.0	59.9	40.1	30.1	.0	-	16.4	18.4	82.4	99.3	40.6
		Pacific cod	66.0	39.7	.6	91.1	64.3	71.5	59.1	76.4	79.1	72.6	79.1	80.9	32.6
		Arrowtooth	64.5	32.8	.4	46.4	32.3	64.0	34.6	16.1	10.5	24.1	65.9	83.7	46.1
		Flathead sole	67.3	3.2	1.8	61.2	11.3	51.3	46.8	15.2	81.3	10.0	9.2	66.0	35.5
		Rock sole	49.2	12.7	2.8	87.1	62.5	34.1	11.0	52.0	94.3	18.8	4.2	92.2	39.2
		Turbot	93.9	.0	.0	99.5	.4	85.2	2.5	50.4	33.9	38.2	-	70.7	57.9
		Yellowfin	39.9	10.3	2.0	77.7	23.5	42.5	100.0	12.0	93.4	9.3	4.0	92.8	24.5
		Other flatfish	79.0	12.3	.4	84.6	21.2	43.3	43.5	33.8	9.2	42.3	67.1	73.3	60.6
		Rockfish	42.0	33.6	1.6	76.5	46.5	51.0	3.1	-	50.8	4.4	41.6	94.1	10.2
		Atka mackerel	23.2	21.4	1.6	83.6	46.7	71.7	33.4	73.1	17.2	75.1	13.2	95.8	21.2
		Total	1.5	26.5	.9	78.4	28.9	44.2	34.4	16.3	84.5	36.5	19.4	77.3	6.2
	All gear	Total	1.6	6.6	1.3	78.9	31.2	44.2	15.8	16.9	84.6	36.8	19.6	76.1	6.7

Table 10. Continued.

			Species												
			Pollock	Sable-fish	Pacific cod	Arrow-tooth	Flathd. sole	Rock sole	Turbot	Yellow fin	Flat other	Rock-fish	Atka mack.	Other	Total
2005 Gear/ Target	Hook & line	Sablefish	13.5	.6	16.9	45.7	100.0	.0	17.0	-	100.0	10.8	-	97.7	7.8
		Pacific cod	13.9	53.2	2.3	57.8	88.7	98.4	10.4	83.2	97.0	68.4	99.9	68.9	13.7
		Turbot	18.7	13.3	1.0	1.8	100.0	-	1.4	-	98.8	8.5	-	86.7	9.5
		Halibut	21.5	.7	78.2	14.8	100.0	91.6	76.5	.0	100.0	46.4	100.0	89.1	58.9
		Total	13.9	3.1	2.4	51.7	88.8	95.6	5.1	83.2	97.0	33.2	99.9	69.1	13.8
	Pot	Sablefish	90.8	2.1	73.2	64.6	100.0	-	61.2	-	69.8	54.2	100.0	76.2	5.3
		Pacific cod	26.4	100.0	.4	100.0	94.8	97.9	100.0	99.6	99.7	100.0	96.6	44.9	3.1
		Total	27.9	2.2	.4	67.9	95.6	97.9	61.2	99.6	96.4	83.5	96.6	44.1	3.3
	Trawl	Pollock, bottom	.4	22.3	.0	43.9	28.2	34.7	.0	91.0	52.2	38.3	20.3	8.5	1.9
		Pollock, pelagic	.0	22.5	.5	31.6	39.8	50.4	41.0	63.7	21.6	20.7	12.2	51.7	.2
		Pacific cod	62.2	18.1	.4	69.6	65.8	63.0	77.1	79.8	78.1	70.9	60.0	86.8	25.3
		Arrowtooth	63.4	7.6	5.0	23.8	22.1	26.1	5.0	8.6	4.5	43.4	59.4	74.2	32.3
		Flathead sole	57.6	.8	1.9	35.6	10.2	48.9	9.4	21.4	81.7	10.1	1.2	78.4	29.1
		Rock sole	47.4	10.1	1.9	52.2	21.4	16.1	88.8	17.2	96.5	100.0	14.9	86.9	26.6
		Turbot	100.0	.0	-	19.6	11.5	.0	.0	-	3.3	8.7	-	91.8	15.1
		Yellowfin	31.6	.0	4.5	37.9	23.0	39.8	96.4	6.7	91.1	22.6	22.1	84.7	19.9
		Other flatfish	82.0	35.9	7.2	71.5	36.4	63.8	13.3	73.0	4.5	36.8	47.8	86.6	51.3
		Rockfish	1.4	.0	.0	46.5	96.4	84.0	3.5	-	16.7	2.6	25.6	100.0	5.5
		Atka mackerel	35.0	3.9	5.9	46.5	39.7	46.1	21.9	16.4	15.4	63.2	4.4	92.4	11.1
		Total	1.2	8.2	1.0	48.2	21.5	34.7	13.7	9.0	83.1	32.3	6.1	74.8	4.3
	All gear	Total	1.2	3.4	1.7	48.8	24.1	34.8	7.8	9.6	83.3	32.4	6.5	70.6	5.0

Notes: Totals may include additional categories. The target, determined by AFSC staff, is based on processor, week, processing mode, NMFS area, and gear. These estimates include only catch counted against federal TACs. Although these are the best available estimates of discards and are used for several management purposes, these estimates are not necessarily accurate. The reasons for this are discussed in the Notes for Table 9.

Source: Catch-accounting system estimates, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 11. Prohibited species bycatch by species, area and gear, 2002-05
(metric tons (t) or number in 1,000s)

			Halibut mort. (t)	Herring (t)	Chinook (1,000s)	Other salmon (1,000s)	Red king crab (1,000s)	Other k. crab (1,000s)	Bairdi (1,000s)	Other tanner (1,000s)
Bering Sea & Aleutians	Hook & Line	2002	698	0	0	0	26	18	17	76
		2003	573	0	0	0	13	2	12	64
		2004	504	0	0	0	15	1	10	45
		2005	607	0	0	0	16	1	13	51
	Pot	2002	8	-	-	0	1	27	80	280
		2003	5	-	-	-	0	143	93	23
		2004	4	-	-	-	0	66	28	95
		2005	3	-	-	-	4	2	108	72
	Trawl	2002	3,399	130	40	81	105	16	1,110	1,131
		2003	3,435	966	55	194	94	6	997	703
		2004	3,303	1,093	62	448	79	6	817	1,803
		2005	3,470	693	76	703	115	6	1,567	3,304
	All gear	2002	4,106	130	40	81	133	61	1,207	1,487
		2003	4,014	966	55	194	107	151	1,103	789
		2004	3,812	1,093	62	448	94	73	855	1,943
		2005	4,081	693	76	703	135	10	1,688	3,428
Gulf of Alaska	Hook & Line	2002	-	-	-	-	0	0	0	0
		2003	-	-	-	0	0	0	0	0
		2004	-	-	0	0	-	0	0	0
		2005	-	-	-	0	0	0	2	-
	Pot	2002	2	-	-	-	0	-	93	3
		2003	14	-	-	-	-	-	10	-
		2004	23	-	-	-	0	-	15	-
		2005	45	-	-	-	-	-	116	-
	Trawl	2002	2,005	2	13	4	0	1	88	3
		2003	2,080	13	16	10	0	1	138	1
		2004	2,287	277	18	6	0	0	64	-
		2005	2,032	12	31	7	0	-	118	0
	All gear	2002	2,007	2	13	4	0	1	182	5
		2003	2,094	13	16	11	0	1	148	1
		2004	2,310	277	18	6	0	0	79	0
		2005	2,077	12	31	7	0	0	236	0
All Alaska	All gear	2002	6,113	133	53	84	133	62	1,389	1,492
		2003	6,108	979	71	205	107	152	1,250	791
		2004	6,122	1,370	80	454	94	74	934	1,943
		2005	6,158	705	108	710	135	10	1,925	3,428

Notes: These estimates include only catches counted against federal TACs. Totals may include additional categories. The estimates of halibut bycatch mortality are based on the International Pacific Halibut Commission discard mortality rates that were used for in-season management. The halibut Individual Fishing Quota program allows retention of halibut in the hook-and-line groundfish fisheries, making true halibut bycatch numbers unavailable. This is particularly a problem in the GOA for all hook-and-line fisheries and in the BSAI for the sablefish hook-and-line fishery. Therefore, estimates of halibut bycatch mortality are not included in this table for those fisheries.

Source: Blend estimates (2002) Catch Accounting System (2003-05), National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 12. Prohibited species bycatch in the Gulf of Alaska by species,gear, and groundfish target fishery, 2004-05 (Metric tons (t) or number in 1,000s).

			Halibut mortality (t)	Herring (t)	Red king crab (1,000s)	Other king crab (1,000s)	Bairdi (1,000s)	Other tanner (1,000s)	Chinook (1,000s)	Other salmon (1,000s)
2004	Hook & Line	Sablefish	n.a.	.0	.0	.0	.0	.1	.0	.2
		Pacific cod	n.a.	.0	.0	.0	.0	.0	.0	.0
		Total	n.a.	.0	.0	.0	.0	.1	.0	.2
	Pot	Pacific cod	22.9	.0	.0	.0	15.1	.0	.0	.0
		Total	22.9	.0	.0	.0	15.1	.0	.0	.0
	Trawl	Pollock, bottom	13.7	88.1	.1	.0	1.1	.0	5.4	.2
		Pollock, pelagic	1.1	189.6	.0	.0	.1	.0	7.9	.4
		Sablefish	1.3	.0	.0	.0	.0	.0	.0	.0
		Pacific cod	969.2	.0	.0	.0	1.2	.0	1.0	.1
		Arrowtooth	301.9	.0	.0	.0	33.2	.0	.3	.0
		Flathd. sole	63.6	.0	.0	.0	7.4	.0	1.4	.1
		Rex sole	189.6	.0	.0	.0	9.0	.0	.5	1.1
		Flat deep	57.8	.0	.0	.0	.0	.0	.0	.0
		Flat shallow	367.7	.0	.0	.0	10.2	.0	.5	3.4
		Rockfish	299.5	.0	.3	.3	1.5	.0	.9	.5
		Total	2,290.5	277.7	.3	.3	63.8	.0	17.9	5.7
	All gear	Total	2,313.4	277.7	.4	.4	79.0	.1	18.0	5.9
2005	Hook & Line	Sablefish	n.a.	.0	.1	.1	.3	.0	.0	.2
		Pacific cod	n.a.	.0	.0	.0	1.4	.0	.0	.0
		Total	n.a.	.0	.1	.1	1.7	.0	.0	.2
	Pot	Pacific cod	45.6	.0	.0	.0	116.0	.0	.0	.0
		Total	45.6	.0	.0	.0	116.0	.0	.0	.0
	Trawl	Pollock, bottom	1.9	.1	.0	.0	.0	.0	15.0	.1
		Pollock, pelagic	.5	12.2	.0	.0	.0	.0	13.0	.7
		Pacific cod	651.8	.0	.0	.0	1.3	.0	.0	.1
		Arrowtooth	503.7	.0	.0	.0	69.7	.0	1.8	.4
		Flathd. sole	32.7	.0	.0	.0	32.5	.0	.0	.0
		Rex sole	53.5	.0	.0	.0	7.9	.0	.5	.1
		Flat shallow	556.0	.1	.1	.0	6.1	.0	.1	1.8
		Rockfish	262.0	.0	.0	.0	1.6	.0	.5	3.5
		Total	2,062.2	12.4	.1	.0	119.2	.0	30.9	6.7
	All gear	Total	2,107.8	12.4	.2	.1	237.0	.0	30.9	6.9

Notes: These estimates include only catches counted against federal TACs. Totals may include additional categories. The target, calculated by AFSC staff, is based on processor, week, processing mode, NMFS area and gear. The estimates of halibut bycatch mortality are based on the International Pacific Halibut Commission discard mortality rates that were used for in-season management. The halibut Individual Fishing Quota program allows retention of halibut in the hook-and-line groundfish fisheries, making true halibut bycatch numbers unavailable. Therefore, estimates of halibut bycatch mortality are not included in this table for those fisheries.

Source: Catch Accounting System, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 13. Prohibited species bycatch in the Bering Sea and Aleutian Islands by species, gear, and groundfish target fishery, 2004-05 (Metric tons (t) or number in 1,000s).

			Halibut mortality (t)	Herring (t)	Red king crab (1,000s)	Other king crab (1,000s)	Bairdi (1,000s)	Other tanner (1,000s)	Chinook (1,000s)	Other salmon (1,000s)
2004	Hook & Line	Sablefish	n.a.	.0	.0	.2	.0	.0	.0	.0
		Pacific cod	492.5	.0	15.4	1.0	10.7	45.7	.0	.1
		Turbot	20.6	.0	.0	.2	.0	.0	.0	.1
		Total	514.5	.0	15.4	1.5	10.7	45.7	.1	.2
	Pot	Sablefish	1.0	.0	.0	66.0	.0	.0	.0	.0
		Pacific cod	2.9	.0	.3	.0	27.9	95.1	.0	.0
		Total	3.9	.0	.3	66.1	28.0	95.1	.0	.0
	Trawl	Pollock, bottom	2.7	33.3	.0	.0	.0	.0	.7	2.0
		Pollock, pelagic	92.1	1,100.8	.0	.0	1.2	.7	53.3	436.2
		Sablefish	1.6	.8	.0	.0	.1	.0	.0	.0
		Pacific cod	1,578.1	8.3	1.8	2.0	221.3	87.5	6.1	6.5
		Arrowtooth	94.6	.1	.1	.7	3.4	1.0	1.1	.0
		Flathd. sole	446.2	6.3	.1	.1	166.5	131.6	.4	2.4
		Rock sole	541.0	5.7	43.2	.4	176.1	189.3	.7	.0
		Turbot	2.1	.0	.0	.1	.0	.1	.0	.0
		Yellowfin	466.7	87.2	39.3	.0	260.9	1,400.1	.0	.3
		Flat, other	57.0	.0	.0	.0	9.5	.8	.0	.1
		Rockfish	57.3	.0	.0	2.5	.2	.0	.0	.0
		Atka mack.	72.2	.0	.0	.0	.4	.1	.7	.1
		Total	3,419.8	1,242.6	84.6	5.8	842.2	1,823.5	63.0	447.6
	All gear	Total	3,938.2	1,242.6	100.3	73.4	881.0	1,964.2	63.1	447.8

Table 13. Continued.

			Halibut mortality (t)	Herring (t)	Red king crab (1,000s)	Other king crab (1,000s)	Bairdi (1,000s)	Other tanner (1,000s)	Chinook (1,000s)	Other salmon (1,000s)
2005	Hook & Line	Sablefish	n.a.	.0	.0	.2	.0	.0	.0	.0
		Pacific cod	595.2	.0	16.2	1.1	12.8	51.2	.0	.1
		Arrowtooth	.1	.0	.0	.0	.0	.0	.0	.0
		Turbot	12.1	.0	.0	.0	.0	.0	.0	.0
		Total	607.9	.0	16.2	1.4	12.9	51.2	.1	.1
	Pot	Sablefish	.7	.0	.0	1.8	.2	.1	.0	.0
		Pacific cod	2.9	.0	3.6	.5	109.7	73.7	.0	.0
		Total	3.6	.0	3.6	2.3	109.9	73.8	.0	.0
	Trawl	Pollock, bottom	14.7	175.0	.0	.0	.0	.1	2.2	7.8
		Pollock, pelagic	98.6	441.4	.0	.0	.6	2.2	65.7	690.0
		Sablefish	.1	.0	.0	.0	.4	.0	.0	.0
		Pacific cod	1,359.8	14.2	5.0	.1	144.6	48.2	3.9	.7
		Arrowtooth	199.6	.0	.0	.3	10.4	.8	1.7	.1
		Flathd. sole	244.2	1.0	.4	.0	267.7	132.3	.0	.5
		Rock sole	775.8	15.6	48.1	.0	393.3	596.1	.3	.0
		Turbot	2.9	.0	.0	.1	.1	.0	.0	.0
		Yellowfin	611.9	48.1	60.6	.2	747.7	2,520.0	.4	.5
		Flat, other	63.6	.1	.2	.0	5.7	.5	.1	.0
		Rockfish	17.3	.0	.6	5.6	.0	.0	.0	.0
		Atka mack.	95.7	.0	.1	.2	1.3	.0	.2	3.4
		Total	3,484.9	695.5	115.1	6.4	1,571.9	3,300.3	74.6	703.1
	All gear	Total	4,096.4	695.5	134.9	10.1	1,694.7	3,425.2	74.6	703.2

Notes: These estimates include only catches counted against federal TACs. Totals may include additional categories.
The target, calculated by AFSC staff, is based on processor, week, processing mode, NMFS area and gear.
The estimates of halibut bycatch mortality are based on the International Pacific Halibut Commission discard mortality rates that were used for in-season management. The halibut Individual Fishing Quota program allows retention of halibut in the hook-and-line groundfish fisheries, making true halibut bycatch numbers unavailable. This is particularly a problem in the Bering Sea and Aleutian Islands sablefish hook-and-line fishery. Therefore, estimates of halibut bycatch mortality are not included in this table for that fishery.

Source: Catch Accounting System, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 14. Prohibited species bycatch rates in the Gulf of Alaska by species, gear, and groundfish target fishery, 2004-05 (Metric tons per metric ton or numbers per metric ton).

			Halibut mortality (t/t)	Herring (t/t)	Red king crab (No./t)	Other king crab (No./t)	Bairdi (No./t)	Other tanner (No./t)	Chinook (No./t)	Other salmon (No./t)
2004	Hook & Line	Sablefish	n.a.	.000	.000	.008	.005	.016	.002	.026
		Pacific cod	n.a.	.000	.000	.000	.000	.000	.003	.002
		Total	n.a.	.000	.000	.005	.003	.009	.002	.016
	Pot	Pacific cod	.001	.000	.002	.000	.900	.000	.000	.000
		Total	.001	.000	.002	.000	.900	.000	.000	.000
	Trawl	Pollock, bottom	.001	.008	.005	.000	.103	.000	.486	.014
		Pollock, pelagic	.000	.004	.000	.000	.003	.000	.150	.008
		Sablefish	.008	.000	.000	.000	.000	.000	.000	.000
		Pacific cod	.058	.000	.000	.000	.072	.000	.060	.003
		Arrowtooth	.035	.000	.000	.000	3.898	.000	.038	.000
		Flathd. sole	.021	.000	.000	.000	2.411	.000	.456	.030
		Rex sole	.054	.000	.000	.000	2.565	.000	.141	.299
		Flat deep	.049	.000	.000	.000	.000	.000	.000	.002
		Flat shallow	.089	.000	.000	.000	2.486	.000	.132	.828
		Rockfish	.013	.000	.011	.014	.063	.000	.037	.021
		Total	.018	.002	.003	.003	.508	.000	.143	.045
	All gear	Total	.015	.002	.002	.002	.518	.001	.118	.039
2005	Hook & Line	Sablefish	n.a.	.000	.014	.012	.051	.000	.000	.025
		Pacific cod	n.a.	.000	.000	.000	.377	.000	.000	.000
		Total	n.a.	.000	.009	.008	.168	.000	.000	.016
	Pot	Pacific cod	.002	.000	.000	.000	6.071	.000	.000	.000
		Total	.002	.000	.000	.000	6.071	.000	.000	.000
	Trawl	Pollock, bottom	.000	.000	.000	.000	.000	.000	.782	.006
		Pollock, pelagic	.000	.000	.000	.000	.000	.000	.205	.011
		Pacific cod	.053	.000	.000	.000	.102	.000	.003	.011
		Arrowtooth	.034	.000	.000	.000	4.659	.000	.122	.028
		Flathd. sole	.011	.000	.000	.000	10.617	.000	.005	.000
		Rex sole	.016	.000	.000	.000	2.439	.000	.162	.030
		Flat shallow	.068	.000	.011	.000	.746	.002	.007	.221
		Rockfish	.012	.000	.000	.000	.072	.000	.021	.154
		Total	.014	.000	.001	.000	.812	.000	.210	.046
	All gear	Total	.012	.000	.001	.000	1.345	.000	.175	.039

Notes: These estimates include only catches counted against federal TACs. Totals may include additional categories. The target, calculated by AFSC staff, is based on processor, week, processing mode, NMFS area and gear. The estimates of halibut bycatch mortality are based on the International Pacific Halibut Commission discard mortality rates that were used for in-season management. The halibut Individual Fishing Quota program allows retention of halibut in the hook-and-line groundfish fisheries, making true halibut bycatch numbers unavailable. Therefore, estimates of halibut bycatch mortality are not included in this table for those fisheries.

Source: Catch Accounting System, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 15. Prohibited species bycatch rates in the Bering Sea and Aleutian Islands by species, gear, and groundfish target fishery, 2004-05 (Metric tons per metric ton or numbers per metric ton).

			Halibut mortality (t/t)	Herring (t/t)	Red king crab (No./t)	Other king crab (No./t)	Bairdi (No./t)	Other tanner (No./t)	Chinook (No./t)	Other salmon (No./t)
2004	Hook & Line	Sablefish	n.a.	.000	.000	.426	.000	.000	.000	.015
		Pacific cod	.004	.000	.110	.007	.077	.328	.000	.001
		Turbot	.013	.000	.000	.113	.007	.000	.010	.049
		Total	.004	.000	.109	.010	.076	.323	.000	.001
	Pot	Sablefish	.001	.000	.012	73.918	.054	.000	.000	.000
		Pacific cod	.000	.000	.017	.001	1.569	5.339	.000	.000
		Total	.000	.000	.017	3.533	1.496	5.083	.000	.000
	Trawl	Pollock, bottom	.000	.002	.001	.000	.001	.000	.035	.102
		Pollock, pelagic	.000	.001	.000	.000	.001	.000	.034	.276
		Sablefish	.013	.006	.000	.000	.806	.000	.000	.000
		Pacific cod	.014	.000	.017	.018	2.029	.803	.056	.059
		Arrowtooth	.027	.000	.017	.210	.981	.287	.300	.000
		Flathd. sole	.016	.000	.002	.005	5.793	4.579	.014	.083
		Rock sole	.011	.000	.916	.009	3.728	4.009	.014	.000
		Turbot	.014	.000	.000	.447	.000	.447	.000	.000
		Yellowfin	.004	.001	.371	.000	2.459	13.200	.000	.003
		Flat, other	.021	.000	.000	.000	3.566	.298	.000	.037
		Rockfish	.005	.000	.000	.236	.021	.000	.000	.000
		Atka mack.	.001	.000	.001	.000	.005	.002	.010	.002
		Total	.002	.001	.043	.003	.426	.923	.032	.227
	All gear	Total	.002	.001	.047	.034	.413	.920	.030	.210

Table 15. Continued.

			Halibut mortality (t/t)	Herring (t/t)	Red king crab (No./t)	Other king crab (No./t)	Bairdi (No./t)	Other tanner (No./t)	Chinook (No./t)	Other salmon (No./t)
2005	Hook & Line	Sablefish	n.a.	.000	.053	.323	.000	.000	.000	.000
		Pacific cod	.004	.000	.113	.008	.089	.357	.000	.000
		Arrowtooth	.018	.000	.000	.000	.000	.000	.000	.000
		Turbot	.007	.000	.004	.020	.000	.003	.004	.023
		Total	.004	.000	.111	.009	.088	.351	.000	.001
	Pot	Sablefish	.001	.000	.000	1.473	.204	.066	.000	.000
		Pacific cod	.000	.000	.201	.029	6.158	4.137	.000	.000
		Total	.000	.000	.188	.121	5.776	3.876	.000	.000
	Trawl	Pollock, bottom	.000	.006	.000	.000	.000	.003	.069	.248
		Pollock, pelagic	.000	.000	.000	.000	.000	.001	.042	.437
		Sablefish	.003	.000	.000	1.297	14.295	.000	.000	.000
		Pacific cod	.017	.000	.061	.001	1.780	.594	.048	.009
		Arrowtooth	.036	.000	.000	.046	1.848	.136	.298	.026
		Flathd. sole	.010	.000	.018	.001	11.341	5.606	.002	.020
		Rock sole	.018	.000	1.119	.000	9.148	13.868	.008	.000
		Turbot	.035	.000	.000	1.442	1.442	.000	.000	.000
		Yellowfin	.005	.000	.481	.001	5.939	20.016	.003	.004
		Flat, other	.032	.000	.126	.000	2.888	.266	.069	.000
		Rockfish	.002	.000	.082	.764	.000	.000	.000	.000
		Atka mack.	.001	.000	.001	.003	.018	.000	.003	.047
		Total	.002	.000	.058	.003	.797	1.673	.038	.356
	All gear	Total	.002	.000	.063	.005	.793	1.602	.035	.329

Notes: These estimates include only catches counted against federal TACs. Totals may include additional categories. The target, calculated by AFSC staff, is based on processor, week, processing mode, NMFS area and gear. The estimates of halibut bycatch mortality are based on the International Pacific Halibut Commission discard mortality rates that were used for in-season management. The halibut Individual Fishing Quota program allows retention of halibut in the hook-and-line groundfish fisheries, making true halibut bycatch numbers unavailable. This is particularly a problem in the Bering Sea and Aleutian Islands sablefish hook-and-line fishery. Therefore, estimates of halibut bycatch mortality are not included in this table for that fishery.

Source: Catch Accounting System, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 16. Real ex-vessel value of the catch in the domestic commercial fisheries off Alaska by species group, 1984-2005 ($ millions, base year = 2005)

	Shellfish	Salmon	Herring	Halibut	Groundfish	Total
1984	172.1	571.0	34.0	32.6	46.4	856.2
1985	173.2	631.1	59.8	60.7	70.3	995.0
1986	289.8	640.0	60.8	111.0	105.5	1,207.1
1987	331.5	728.7	64.2	117.6	211.2	1,453.3
1988	350.0	1,106.7	83.2	98.2	359.8	1,997.9
1989	400.4	726.7	26.8	121.0	485.2	1,760.1
1990	489.7	753.9	33.1	119.8	619.9	2,016.4
1991	401.8	400.5	38.2	122.2	623.2	1,586.0
1992	437.8	711.4	35.3	62.7	801.4	2,048.7
1993	419.6	499.5	18.0	68.5	519.7	1,525.2
1994	401.4	530.3	27.0	105.8	620.9	1,685.4
1995	346.8	607.8	47.9	72.9	707.9	1,783.3
1996	210.9	417.2	53.9	89.3	607.6	1,379.0
1997	203.8	293.4	18.8	126.1	682.0	1,324.2
1998	256.1	284.2	12.6	110.2	450.8	1,114.0
1999	313.0	399.0	16.4	134.9	533.7	1,397.0
2000	160.9	278.2	10.8	152.1	674.7	1,276.8
2001	136.1	207.7	11.5	131.4	644.5	1,131.2
2002	161.3	140.8	9.9	139.8	671.4	1,123.2
2003	186.1	178.4	9.4	176.0	646.0	1,195.9
2004	170.5	232.3	14.1	173.9	644.5	1,235.4
2005	159.2	292.4	13.4	170.1	740.0	1,375.1

Note: The value added by at-sea processing is not included in these estimates of ex-vessel value. The data have been adjusted to 2005 dollars by applying the GDP implicit price deflators presented in Table 57.

Source: Blend and Catch-Accounting System estimates, CFEC fishtickets, Commercial Operators Annual Reports (COAR), weekly processor reports. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 17. Percentage distribution of ex-vessel value of the catch in the domestic commercial fisheries off Alaska by species group, 1984-2005.

	Shellfish	Salmon	Herring	Halibut	Groundfish
1984	20.1%	66.7%	4.0%	3.8%	5.4%
1985	17.4%	63.4%	6.0%	6.1%	7.1%
1986	24.0%	53.0%	5.0%	9.2%	8.7%
1987	22.8%	50.1%	4.4%	8.1%	14.5%
1988	17.5%	55.4%	4.2%	4.9%	18.0%
1989	22.7%	41.3%	1.5%	6.9%	27.6%
1990	24.3%	37.4%	1.6%	5.9%	30.7%
1991	25.3%	25.3%	2.4%	7.7%	39.3%
1992	21.4%	34.7%	1.7%	3.1%	39.1%
1993	27.5%	32.7%	1.2%	4.5%	34.1%
1994	23.8%	31.5%	1.6%	6.3%	36.8%
1995	19.4%	34.1%	2.7%	4.1%	39.7%
1996	15.3%	30.3%	3.9%	6.5%	44.1%
1997	15.4%	22.2%	1.4%	9.5%	51.5%
1998	23.0%	25.5%	1.1%	9.9%	40.5%
1999	22.4%	28.6%	1.2%	9.7%	38.2%
2000	12.6%	21.8%	.8%	11.9%	52.8%
2001	12.0%	18.4%	1.0%	11.6%	57.0%
2002	14.4%	12.5%	.9%	12.4%	59.8%
2003	15.6%	14.9%	.8%	14.7%	54.0%
2004	13.8%	18.8%	1.1%	14.1%	52.2%
2005	11.6%	21.3%	1.0%	12.4%	53.8%

Source: Blend and Catch-Accounting System estimates, CFEC fishtickets,
Commercial Operators Annual Reports (COAR), weekly processor reports.
National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 18. Ex-vessel prices in the groundfish fisheries off Alaska by area, gear, and species, 2001-05 ($/lb, round weight).

		Gulf of Alaska		Bering Sea and Aleutians		All Alaska
		Fixed	Trawl	Fixed	Trawl	All gear
Pollock	2001	.081	.127	-	.109	.111
	2002	.068	.107	-	.116	.115
	2003	.081	.095	.049	.107	.106
	2004	.060	.102	-	.106	.106
	2005	.086	.124	.074	.125	.125
Sablefish	2001	2.248	1.769	1.843	.888	2.148
	2002	2.148	1.682	2.177	.934	2.112
	2003	2.440	1.749	2.229	.951	2.372
	2004	2.122	1.691	1.827	.837	2.056
	2005	2.258	1.708	2.033	.900	2.183
Pacific cod	2001	.299	.258	.244	.234	.260
	2002	.287	.234	.213	.193	.245
	2003	.304	.282	.292	.268	.283
	2004	.267	.251	.254	.219	.245
	2005	.297	.269	.294	.232	.269
Flatfish	2001	-	.161	.255	.124	.127
	2002	-	.124	.157	.143	.142
	2003	-	.116	.188	.144	.142
	2004	-	.085	-	.165	.160
	2005	-	.117	-	.198	.192
Rockfish	2001	.642	.095	.577	.122	.134
	2002	.714	.132	.609	.125	.156
	2003	.707	.145	.614	.128	.157
	2004	.746	.159	.737	.153	.178
	2005	.693	.230	.738	.229	.246
Atka mackerel	2001	-	.174	-	.167	.167
	2002	-	.217	-	.134	.134
	2003	-	.169	-	.105	.106
	2004	-	.129	-	.115	.115
	2005	-	.155	-	.119	.120

Notes: 1) Prices do not include the value added by at-sea processing; therefore they reflect prices prior to processing. Prices do reflect the value added by dressing fish at sea, where the fish have not been frozen. Except where noted, unfrozen landings price is calculated as landed value divided by estimated or actual round weight.
2) Trawl-caught sablefish and flatfish in the BSAI and trawl-caught Atka mackerel and rockfish in both the BSAI and the GOA are not well represented by on-shore landings. A price was calculated for these categories from product-report prices; the price in this case is the value of the product divided by the calculated round weight and multiplied by a constant 0.4 to correct for value added by processing.
3) The "All Alaska/All gear" column is the weighted average of the other columns.

Source: Blend estimates (2001-02), Catch Accounting System (2003-05), CFEC fish tickets, Commercial Operators Annual Report (COAR), weekly processor reports, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 19. Ex-vessel value of the groundfish catch off Alaska by area, vessel category, gear, and species, 2001-05, ($ millions).

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Catcher vessels	Catcher processors	Total	Catcher vessels	Catcher processors	Total	Catcher vessels	Catcher processors	Total
All gear	All species	2001	97.5	16.5	114.1	200.1	270.5	470.6	297.6	287.0	584.6
		2002	106.5	19.5	126.0	223.2	270.1	493.2	329.6	289.6	619.2
		2003	107.6	21.0	128.6	216.4	263.5	479.9	323.9	284.5	608.4
		2004	106.5	17.5	124.0	209.1	291.8	500.9	315.6	309.4	624.9
		2005	119.8	18.6	138.4	240.9	360.9	601.8	360.7	379.5	740.2
	Pollock	2001	19.1	.0	19.1	177.0	138.8	315.8	196.1	138.8	334.9
		2002	11.9	.0	12.0	197.5	149.6	347.2	209.5	149.7	359.2
		2003	10.3	.1	10.4	181.3	120.8	302.1	191.5	120.9	312.4
		2004	12.1	.0	12.2	185.5	149.6	335.1	197.6	149.7	347.3
		2005	21.5	.1	21.6	216.8	175.9	392.7	238.2	176.0	414.3
	Sablefish	2001	47.9	7.4	55.2	4.5	2.2	6.7	52.3	9.6	61.9
		2002	48.6	8.9	57.5	4.5	2.4	6.9	53.0	11.3	64.4
		2003	62.4	9.8	72.2	6.4	2.7	9.1	68.8	12.5	81.3
		2004	60.2	9.1	69.2	1.9	1.9	3.8	62.1	11.0	73.1
		2005	63.4	9.9	73.3	3.6	2.8	6.4	66.9	12.7	79.6
	Pacific cod	2001	24.9	5.6	30.4	17.8	78.7	96.4	42.6	84.2	126.9
		2002	39.4	5.8	45.2	20.4	70.2	90.6	59.8	76.0	135.8
		2003	27.5	5.2	32.6	27.8	91.2	119.0	55.3	96.3	151.6
		2004	27.4	3.8	31.2	20.0	82.6	102.5	47.4	86.3	133.8
		2005	26.3	1.3	27.6	18.9	94.5	113.5	45.2	95.9	141.1
	Flatfish	2001	2.3	1.4	3.6	.6	27.1	27.7	2.9	28.4	31.3
		2002	2.0	1.5	3.5	.5	33.5	34.0	2.5	35.0	37.5
		2003	1.4	2.3	3.7	.6	34.1	34.7	1.9	36.4	38.4
		2004	1.4	.6	2.0	.7	39.2	39.9	2.1	39.9	41.9
		2005	2.7	1.4	4.2	1.0	57.2	58.2	3.8	58.6	62.4
	Rockfish	2001	3.3	2.2	5.5	.2	2.6	2.8	3.5	4.8	8.3
		2002	4.4	3.1	7.5	.2	3.0	3.3	4.6	6.2	10.8
		2003	4.7	3.2	7.9	.2	3.8	4.0	4.8	7.1	11.9
		2004	4.8	3.7	8.5	.2	3.8	4.0	4.9	7.5	12.5
		2005	5.3	5.6	10.9	.3	5.1	5.4	5.6	10.7	16.3
	Atka mackerel	2001	-	.0	.0	.0	21.0	21.0	.0	21.1	21.1
		2002	.0	.0	.0	.1	11.1	11.1	.1	11.1	11.2
		2003	.0	.1	.1	.1	10.3	10.4	.1	10.5	10.6
		2004	.0	.1	.1	.2	12.2	12.3	.2	12.3	12.5
		2005	.0	.2	.2	.1	15.1	15.3	.1	15.3	15.5

Table 19. Continued.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Catcher vessels	Catcher processors	Total	Catcher vessels	Catcher processors	Total	Catcher vessels	Catcher processors	Total
Trawl	All species	2001	35.2	6.5	41.7	187.5	201.6	389.1	222.7	208.1	430.8
		2002	25.0	7.4	32.4	209.6	210.1	419.7	234.6	217.6	452.1
		2003	31.9	8.4	40.3	200.2	189.2	389.5	232.1	197.6	429.7
		2004	27.6	6.7	34.3	198.5	222.2	420.7	226.1	228.9	455.0
		2005	36.4	9.3	45.7	229.1	266.3	495.4	265.6	275.5	541.1
	Pollock	2001	19.1	.0	19.1	177.0	137.7	314.7	196.1	137.7	333.8
		2002	11.9	.0	12.0	197.5	148.1	345.7	209.5	148.2	357.6
		2003	10.3	.1	10.3	181.3	119.7	300.9	191.5	119.8	311.3
		2004	12.1	.0	12.2	185.5	148.6	334.0	197.6	148.6	346.2
		2005	21.5	.1	21.6	216.8	174.7	391.4	238.2	174.7	413.0
	Sablefish	2001	1.0	1.4	2.4	.0	.7	.7	1.0	2.1	3.1
		2002	1.0	2.4	3.3	.0	.5	.6	1.0	2.9	3.9
		2003	1.9	1.9	3.8	.0	.4	.4	1.9	2.2	4.2
		2004	2.6	1.6	4.1	.0	.4	.4	2.6	2.0	4.6
		2005	1.9	1.6	3.5	.0	.7	.7	1.9	2.3	4.2
	Pacific cod	2001	11.3	1.7	13.0	9.9	14.0	23.9	21.2	15.7	36.9
		2002	7.6	.5	8.1	11.5	14.8	26.3	19.0	15.4	34.4
		2003	14.6	1.0	15.6	18.2	21.8	39.9	32.8	22.7	55.5
		2004	8.2	.7	9.0	11.9	18.7	30.7	20.2	19.5	39.6
		2005	6.1	.5	6.7	10.9	14.6	25.5	17.1	15.1	32.1
	Flatfish	2001	2.3	1.4	3.6	.5	25.9	26.4	2.8	27.2	30.0
		2002	2.0	1.5	3.5	.4	32.6	33.0	2.5	34.1	36.5
		2003	1.4	2.3	3.7	.6	33.2	33.8	1.9	35.5	37.5
		2004	1.4	.6	2.0	.7	38.5	39.2	2.1	39.2	41.2
		2005	2.7	1.4	4.2	1.0	56.3	57.3	3.8	57.7	61.4
	Rockfish	2001	1.4	2.0	3.5	.0	2.4	2.4	1.5	4.4	5.9
		2002	2.4	3.0	5.4	.1	2.9	2.9	2.5	5.8	8.3
		2003	3.2	2.9	6.1	.0	3.6	3.6	3.2	6.5	9.7
		2004	3.0	3.5	6.5	.1	3.6	3.7	3.1	7.1	10.3
		2005	3.8	5.3	9.2	.2	4.9	5.1	4.0	10.2	14.2
	Atka mackerel	2001	-	.0	.0	.0	21.0	21.0	.0	21.0	21.0
		2002	.0	.0	.0	.1	11.1	11.1	.1	11.1	11.2
		2003	.0	.1	.1	.1	10.3	10.4	.1	10.5	10.6
		2004	.0	.1	.1	.2	12.2	12.3	.2	12.3	12.5
		2005	.0	.2	.2	.1	15.1	15.3	.1	15.3	15.5

Table 19. Continued.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Catcher vessels	Catcher processors	Total	Catcher vessels	Catcher processors	Total	Catcher vessels	Catcher processors	Total
Hook and line	All species	2001	53.9	9.0	62.9	5.6	67.2	72.7	59.4	76.2	135.6
		2002	71.7	11.8	83.5	7.7	58.7	66.4	79.4	70.5	149.9
		2003	67.5	12.6	80.0	3.9	73.3	77.2	71.4	85.9	157.3
		2004	65.0	10.7	75.7	2.4	67.8	70.2	67.4	78.5	145.9
		2005	68.0	9.2	77.2	4.2	92.1	96.2	72.1	101.3	173.5
	Sablefish	2001	46.9	6.0	52.9	4.4	1.5	6.0	51.3	7.5	58.8
		2002	47.6	6.6	54.2	4.4	1.8	6.3	52.0	8.4	60.5
		2003	60.5	8.0	68.5	3.4	2.3	5.7	63.9	10.3	74.2
		2004	57.6	7.5	65.1	1.9	1.5	3.4	59.5	9.0	68.5
		2005	61.5	8.3	69.7	3.6	2.1	5.7	65.0	10.3	75.4
	Pacific cod	2001	5.1	2.9	8.0	.9	63.0	63.8	5.9	65.8	71.8
		2002	22.2	5.0	27.1	3.0	54.4	57.4	25.2	59.3	84.5
		2003	4.7	4.1	8.8	.4	68.4	68.8	5.1	72.6	77.6
		2004	5.4	2.9	8.3	.5	62.0	62.5	5.8	64.9	70.7
		2005	4.9	.7	5.6	.5	77.8	78.3	5.4	78.5	83.9
	Flatfish	2001	-	.0	.0	.1	1.2	1.3	.1	1.2	1.3
		2002	-	.0	.0	.0	1.0	1.0	.0	1.0	1.0
		2003	-	.0	.0	-	.9	.9	-	.9	.9
		2004	-	.0	.0	-	.7	.7	-	.7	.7
		2005	-	.0	.0	-	.9	.9	-	1.0	1.0
	Rockfish	2001	1.9	.2	2.1	.2	.2	.4	2.1	.4	2.5
		2002	2.0	.2	2.1	.2	.2	.3	2.1	.3	2.5
		2003	1.5	.4	1.8	.1	.2	.3	1.6	.6	2.2
		2004	1.7	.2	2.0	.1	.2	.3	1.8	.4	2.2
		2005	1.5	.2	1.7	.1	.2	.3	1.6	.5	2.0
Pot	Pacific cod	2001	8.4	1.0	9.4	7.0	1.7	8.7	15.5	2.7	18.2
		2002	9.6	.3	9.9	5.9	1.0	6.9	15.5	1.3	16.8
		2003	8.2	.1	8.2	9.2	1.0	10.2	17.4	1.0	18.4
		2004	13.9	.2	14.0	7.6	1.8	9.4	21.4	2.0	23.4
		2005	15.3	.1	15.4	7.5	2.2	9.7	22.8	2.3	25.1

Note: These estimates include only catch counted against federal TACs. Ex-vessel value is calculated using prices on Table 18. Please refer to Table 18 for a description of the price derivation. All groundfish includes additional species categories. The value added by at-sea processing is not included in these estimates of ex-vessel value.

Source: Blend estimates (2001-02), Catch Accounting System (2003-05), CFEC fish tickets, Commercial Operators Annual Report (COAR), weekly processor reports. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 20. Ex-vessel value of Alaska groundfish delivered to shoreside processors by area, gear and catcher-vessel length, 1996-2005. ($ millions)

		Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
		<60	60-125	>=125	<60	60-125	>=125	<60	60-125	>=125
Fixed	1996	40.2	28.3	.2	1.5	8.1	.9	41.7	36.4	1.1
	1997	43.3	27.7	.1	.9	5.8	1.3	44.3	33.4	1.4
	1998	31.4	20.0	.1	1.0	3.6	.8	32.4	23.5	.9
	1999	41.0	22.1	-	1.0	5.9	2.1	42.0	27.9	2.1
	2000	49.9	28.2	.7	2.0	6.6	3.0	52.0	34.7	3.7
	2001	38.6	18.5	-	3.4	7.6	1.2	41.9	26.0	1.2
	2002	40.2	17.3	-	4.0	6.1	1.2	44.2	23.4	1.2
	2003	50.8	23.8	-	4.0	10.3	1.5	54.8	34.1	1.5
	2004	49.0	24.7	-	3.7	7.9	1.4	52.7	32.6	1.4
	2005	49.3	25.6	-	4.0	9.6	1.1	53.3	35.2	1.1
Trawl	1996	9.1	19.0	1.3	-	43.3	43.8	9.1	62.3	45.1
	1997	11.5	28.1	4.2	-	42.1	56.6	11.5	70.2	60.8
	1998	8.0	23.9	3.9	.2	26.2	38.0	8.2	50.1	41.9
	1999	8.5	32.1	2.0	.2	43.1	61.3	8.8	75.1	63.2
	2000	8.7	30.5	-	-	64.5	78.2	8.7	95.0	78.2
	2001	8.5	27.1	-	.3	59.7	82.3	8.8	86.8	82.3
	2002	4.2	18.9	-	1.6	67.3	88.8	5.8	86.2	88.8
	2003	2.6	20.3	-	1.3	59.2	73.3	3.9	79.5	73.3
	2004	4.0	23.1	-	.6	64.9	89.8	4.6	88.0	89.8
	2005	7.0	28.8	-	-	71.4	108.7	7.0	100.3	108.7
All gear	1996	49.3	47.3	1.5	1.5	51.4	44.7	50.8	98.7	46.2
	1997	54.8	55.8	4.3	.9	47.8	57.9	55.7	103.6	62.2
	1998	39.4	43.8	4.0	1.2	29.8	38.8	40.6	73.6	42.8
	1999	49.5	54.1	2.0	1.2	48.9	63.4	50.8	103.1	65.4
	2000	58.7	58.7	.7	2.0	71.0	81.2	60.7	129.7	81.9
	2001	47.1	45.5	-	3.6	67.3	83.5	50.7	112.9	83.5
	2002	44.4	36.1	-	5.6	73.5	89.9	50.0	109.6	89.9
	2003	53.3	44.1	-	5.4	69.4	74.8	58.7	113.6	74.8
	2004	53.0	47.8	-	4.3	72.8	91.2	57.3	120.6	91.2
	2005	56.3	54.4	-	4.0	81.1	109.8	60.3	135.5	109.8

Note: These estimates include only catch counted against federal TACs.

Source: CFEC Fishtickets, NMFS permits, CFEC permits. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 21. Ex-vessel value per catcher vessel for Alaska groundfish delivered to shoreside processors by area, gear and catcher-vessel length, 1996-2005. ($ thousands)

		Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
		<60	60-124	>=125	<60	60-124	>=125	<60	60-124	>=125
Fixed	1996	47	168	34	26	72	59	47	177	72
	1997	49	186	16	19	61	88	49	184	74
	1998	39	135	16	21	44	39	40	134	40
	1999	50	128	-	26	64	92	51	137	92
	2000	61	171	73	39	73	125	61	175	124
	2001	53	166	-	48	101	82	56	168	82
	2002	61	160	-	62	108	84	66	171	84
	2003	76	231	-	61	146	113	80	235	113
	2004	75	220	-	65	124	98	78	219	98
	2005	83	244	-	69	179	115	87	255	115
Trawl	1996	152	246	83	-	541	1,509	152	582	1,555
	1997	188	319	167	-	592	1,825	188	638	1,960
	1998	143	265	177	29	403	1,187	141	451	1,308
	1999	174	396	75	62	567	1,915	175	696	1,976
	2000	178	462	-	-	859	2,443	178	863	2,443
	2001	184	392	-	39	807	2,839	190	796	2,839
	2002	110	331	-	148	922	3,061	142	845	3,061
	2003	85	350	-	103	811	2,618	126	803	2,618
	2004	181	428	-	156	914	3,098	200	936	3,098
	2005	279	554	-	-	1,051	3,881	279	1,102	3,881
All gear	1996	56	200	70	26	268	994	56	327	1,028
	1997	60	245	142	19	290	1,259	60	367	1,243
	1998	48	190	142	22	214	826	49	272	873
	1999	60	226	75	30	298	1,153	61	349	1,188
	2000	71	268	73	39	433	1,449	71	440	1,321
	2001	63	263	-	47	452	1,942	66	439	1,942
	2002	67	229	-	75	565	2,092	74	472	2,092
	2003	79	281	-	69	486	1,824	84	473	1,824
	2004	80	293	-	72	543	2,121	85	505	2,121
	2005	93	358	-	69	670	2,890	98	608	2,890

Note: These estimates include only catch counted against federal TACs.

Source: CFEC Fishtickets, NMFS permits, CFEC permits. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 22. Ex-vessel value of the groundfish catch off Alaska by area, residency, and species, 2001-05, ($ millions).

		Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
		Alaska	Other	Unknown	Alaska	Other	Unknown	Alaska	Other	Unknown
All groundfish	2001	54.9	58.9	.3	18.5	451.6	.5	73.4	510.6	.8
	2002	67.0	58.5	.5	16.4	476.3	.5	83.4	534.8	1.0
	2003	63.8	64.8	.0	19.1	460.8	.0	82.9	525.6	.0
	2004	61.9	62.1	.0	15.1	485.8	.0	77.0	548.0	.0
	2005	65.6	72.8	.0	12.3	589.5	.0	77.8	662.3	.0
Pollock	2001	7.7	11.5	.0	3.7	311.7	.5	11.4	323.1	.5
	2002	4.4	7.5	.0	3.9	342.8	.4	8.4	350.3	.4
	2003	3.7	6.6	.0	3.1	299.0	.0	6.8	305.7	.0
	2004	4.6	7.6	.0	3.1	331.9	.0	7.7	339.6	.0
	2005	8.1	13.5	.0	3.4	389.3	.0	11.5	402.8	.0
Sablefish	2001	28.3	26.8	.1	2.7	4.0	.0	31.0	30.8	.1
	2002	30.0	27.3	.2	2.8	4.1	.0	32.8	31.4	.2
	2003	36.7	35.5	.0	2.9	6.2	.0	39.6	41.7	.0
	2004	35.3	34.0	.0	1.3	2.6	.0	36.5	36.6	.0
	2005	35.6	37.6	.0	1.5	4.9	.0	37.1	42.5	.0
Pacific cod	2001	16.4	13.9	.1	9.3	87.1	.0	25.8	101.0	.1
	2002	29.2	15.8	.2	8.5	82.0	.1	37.7	97.9	.2
	2003	19.0	13.6	.0	10.9	108.1	.0	29.9	121.7	.0
	2004	18.7	12.6	.0	9.2	93.3	.0	27.9	105.9	.0
	2005	18.4	9.3	.0	7.3	106.2	.0	25.6	115.5	.0
Flatfish	2001	1.0	2.6	.0	.7	27.0	.0	1.7	29.6	.0
	2002	1.1	2.4	.0	1.1	32.9	.0	2.2	35.3	.0
	2003	.9	2.8	.0	1.8	32.8	.0	2.7	35.6	.0
	2004	.7	1.3	.0	1.0	38.9	.0	1.7	40.2	.0
	2005	.9	3.3	.0	.0	58.2	.0	.9	61.4	.0
Rockfish	2001	1.5	4.1	.0	.5	2.3	.0	2.0	6.3	.0
	2002	2.3	5.2	.0	.1	3.2	.0	2.3	8.4	.0
	2003	2.4	5.5	.0	.1	3.9	.0	2.5	9.4	.0
	2004	2.4	6.1	.0	.1	3.9	.0	2.5	10.0	.0
	2005	2.4	8.5	.0	.0	5.3	.0	2.5	13.8	.0
Atka mackerel	2001	.0	.0	.0	1.5	19.5	.0	1.5	19.6	.0
	2002	.0	.0	.0	.0	11.1	.0	.0	11.1	.0
	2003	.0	.1	.0	.2	10.2	.0	.3	10.3	.0
	2004	.0	.1	.0	.2	12.1	.0	.2	12.2	.0
	2005	.0	.2	.0	.0	15.3	.0	.0	15.5	.0

Note: These estimates include only catches counted against federal TACs. Ex-vessel value is calculated using prices on Table 18. Please refer to Table 18 for a description of the price derivation. Catch delivered to motherships is classified by the residence of the owner of the mothership. All other catch is classified by the residence of the owner of the fishing vessel. All groundfish include additional species categories.

Source: Blend estimates (2001-02), Catch Accounting System (2003-05), Commercial Operators Annual Report (COAR), ADFG fish tickets, weekly processor reports. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 23. Ex-vessel value of groundfish delivered to shoreside processors by processor group, 1999-2005. ($ millions)

	1999	2000	2001	2002	2003	2004	2005
Bering Sea Pollock	103.2	153.7	157.6	174.7	173.3	166.1	191.1
AK Peninsula/Aleutians	23.7	25.8	25.7	28.2	34.9	29.5	34.1
Kodiak	32.3	36.6	30.9	40.5	27.0	28.7	40.5
South Central	18.3	25.0	18.1	18.1	24.3	23.9	24.1
Southeastern	33.6	39.5	30.9	29.6	34.7	35.0	32.9
TOTAL	211.2	280.6	263.2	291.2	294.1	283.1	322.7

Table 24. Ex-vessel value of groundfish as a percentage of the ex-vessel value of all species delivered to shoreside processors by processor group, 1999-2005. (percent)

	1999	2000	2001	2002	2003	2004	2005
Bering Sea Pollock	56.2	77.1	81.5	77.9	75.1	74.3	76.7
AK Peninsula/Aleutians	10.2	16.1	22.1	23.1	21.0	16.1	16.6
Kodiak	40.1	48.0	45.3	55.8	41.6	39.9	40.0
South Central	15.2	23.1	19.6	18.8	20.9	17.5	15.0
Southeastern	18.6	23.3	18.9	22.5	24.1	18.7	18.5
TOTAL	25.5	38.3	40.8	44.6	40.3	34.6	35.3

Note: These tables include the value of groundfish purchases reported by processing plants, as well as by other entities, such as markets and restaurants, that normally would not report sales of groundfish products. Keep this in mind when comparing ex-vessel values in this table to gross processed-product values in Table 34. The data are for catch from the EEZ and State waters.
The processor groups are defined as follows:
"Bering Sea Pollock" are the AFA inshore pollock processors including the two AFA floating processors.
"AK Peninsula/Aleutian" are other processors on the Alaska Peninsula or in the Aleutian Islands.
"Kodiak" are processors on Kodiak Island.
"South Central" are processors west of Yakutat and on the Kenai Peninsula.
"Southeastern" are processors located from Yakutat south.

Source: ADFG Commercial Operators Annual Report, ADFG intent to process. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 25. Production and gross value of groundfish products in the fisheries off Alaska by species, 2001-05 (1,000 metric tons product weight and million dollars).

		2001		2002		2003		2004		2005	
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Pollock	Whole fish	1.59	$1.0	1.79	$2.4	4.30	$2.9	3.58	$2.7	1.45	$1.2
	Head & gut	10.58	$9.6	10.50	$8.9	8.35	$9.8	18.27	$17.9	21.08	$23.4
	Roe	24.99	$383.7	26.49	$298.5	22.80	$270.1	26.37	$345.7	25.47	$346.2
	Deep-skin fill.	27.06	$71.5	26.59	$63.2	47.08	$118.1	46.87	$120.9	40.40	$111.0
	Other fillets	87.65	$163.9	97.94	$211.3	112.53	$223.4	115.60	$242.7	116.05	$287.5
	Surimi	200.17	$323.3	204.81	$324.8	203.56	$317.8	187.14	$290.5	200.35	$425.7
	Minced fish	21.54	$30.0	24.92	$30.2	15.53	$18.6	19.84	$25.8	17.41	$24.7
	Fish meal	54.69	$39.7	55.07	$38.1	47.24	$36.1	56.24	$43.4	65.46	$48.8
	Other products	12.70	$5.7	21.35	$9.5	20.49	$10.2	18.52	$11.3	25.64	$15.7
	All products	440.97	$1,028.2	469.45	$987.0	481.88	$1,007.0	492.43	$1,100.9	513.31	$1,284.2
Pacific cod	Whole fish	2.28	$2.5	2.26	$1.8	4.13	$4.8	2.34	$2.5	2.05	$2.6
	Head & gut	72.39	$170.0	72.73	$155.6	72.44	$177.9	90.58	$215.9	81.67	$238.1
	Salted/split	3.29	$10.3	-	-	-	-	-	-	-	-
	Fillets	10.06	$40.1	12.31	$58.2	16.61	$80.4	9.44	$44.3	9.34	$54.9
	Other products	11.89	$30.0	15.82	$30.2	17.74	$25.2	10.62	$20.3	11.66	$25.8
	All products	99.90	$253.0	103.12	$245.8	110.93	$288.2	112.98	$283.1	104.72	$321.4
Sablefish	Head & gut	9.36	$79.5	9.23	$80.8	10.18	$93.4	11.05	$93.7	10.85	$98.1
	Other products	.25	$1.8	.24	$.7	.21	$.8	.21	$1.1	.38	$3.6
	All products	9.61	$81.3	9.47	$81.5	10.39	$94.2	11.27	$94.8	11.23	$101.7

Table 25. Continued.

		2001		2002		2003		2004		2005	
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Flatfish	Whole fish	11.64	$12.2	16.53	$14.8	14.27	$15.2	14.08	$14.3	23.67	$30.5
	Head & gut	39.66	$45.7	50.00	$60.9	54.67	$65.4	56.29	$78.8	66.94	$112.1
	Kirimi	6.60	$4.5	2.86	$3.5	3.68	$4.3	1.81	$2.5	1.62	$1.7
	Fillets	1.10	$3.7	1.33	$5.8	1.02	$4.0	1.01	$2.8	.43	$2.3
	Other products	.54	$.4	.83	$1.1	.74	$1.0	1.39	$1.6	1.14	$1.5
	All products	59.55	$66.5	71.55	$86.1	74.39	$89.9	74.58	$100.1	93.80	$148.0
Rockfish	Whole fish	1.48	$1.5	1.85	$3.1	1.67	$4.1	2.37	$2.9	2.16	$4.2
	Head & gut	8.93	$12.4	9.78	$14.1	11.09	$15.4	10.77	$18.2	11.31	$27.2
	Other products	3.48	$3.9	1.71	$5.3	2.06	$5.9	1.40	$4.1	.83	$2.8
	All products	13.89	$17.8	13.35	$22.5	14.83	$25.3	14.54	$25.1	14.31	$34.2
Atka mackerel	Whole fish	5.02	$4.0	3.27	$2.3	7.13	$4.0	5.00	$3.1	.89	$.6
	Head & gut	27.48	$42.0	18.55	$22.5	20.89	$20.1	24.90	$26.0	32.99	$36.0
	All products	32.51	$46.1	21.82	$24.9	28.02	$24.1	29.90	$29.1	33.88	$36.5
All species	Total	674.14	$1,517.2	704.01	$1,483.3	737.05	$1,556.3	758.89	$1,665.8	790.36	$1,962.6

Notes: Total includes additional species not listed in the production details as well as confidential data from Tables 28 and 29. For shoreside processors, these estimates include production resulting from catch from federal and state of Alaska fisheries. For at-sea processors, they include production only from catch counted against federal TACs.

Source: Weekly processor report and commercial operators annual report. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 26. Price per pound of groundfish products in the fisheries off Alaska by species and processing mode, 2001-05 (dollars).

		2001		2002		2003		2004		2005	
		At-sea	Shoreside	At-sea	Shoreside	At-sea	Shoreside	At-sea	Shoreside	At-sea	Shoreside
Pollock	Whole fish	$.24	$.48	$.64	$.32	$.33	$.26	$.34	$.38	$.39	$.29
	H&G	$.40	$.45	$.36	$.52	$.53	-	$.45	$.44	$.53	$.44
	Roe	$8.30	$5.54	$6.16	$3.94	$6.12	$4.31	$6.68	$4.91	$6.77	$5.42
	Deep-skin	$1.20	-	$1.08	-	$1.15	$1.11	$1.21	$1.04	$1.25	-
	Other fillets	$.87	$.83	$.88	$1.06	$.85	$.94	$.97	$.94	$1.12	$1.12
	Surimi	$.82	$.66	$.81	$.64	$.71	$.70	$.75	$.66	$1.03	$.90
	Minced fish	$.63	-	$.53	$.59	$.54	-	$.59	-	$.64	-
	Fish meal	$.38	$.29	$.32	$.31	$.35	$.34	$.37	$.33	$.38	$.32
	Other products	$.35	$.17	$.30	$.19	$.31	$.22	$.17	$.29	$.48	$.25
	All products	$1.21	$.90	$1.09	$.82	$1.03	$.86	$1.16	$.87	$1.28	$1.00
Pacific cod	Whole fish	$.46	$.51	$.29	$.41	$.41	$.56	$.43	$.54	$.56	$.58
	H&G	$1.09	$.87	$.97	$.99	$1.13	$.98	$1.09	$1.04	$1.29	$1.50
	Salted/split	-	$1.42	-	-	-	-	-	-	-	-
	Fillets	$1.49	$1.86	$1.58	$2.28	$2.29	$2.18	$2.20	$2.13	$2.07	$2.72
	Other products	$1.39	$1.04	$1.03	$.79	$.89	$.56	$1.02	$.80	$1.32	$.81
	All products	$1.11	$1.24	$.98	$1.31	$1.14	$1.26	$1.09	$1.26	$1.29	$1.65
Sablefish	H&G	$3.50	$3.92	$3.59	$4.05	$3.67	$4.26	$3.41	$3.93	$3.75	$4.18
	Other products	$1.16	$3.97	$1.09	$1.52	$1.30	$1.94	$1.63	$2.63	$1.70	$4.72
	All products	$3.40	$3.92	$3.48	$4.00	$3.58	$4.22	$3.35	$3.91	$3.68	$4.20
Deep-water flatfish	Whole fish	-	-	-	-	$.19	-	-	-	-	-
	H&G	$.81	-	$1.09	-	$.32	-	-	-	$.31	-
	Fillets	-	$1.61	-	$1.57	-	$1.52	-	-	-	$1.97
	All products	$.81	$1.61	$1.09	$1.57	$.32	$1.52	-	-	$.31	$1.97

Table 26. Continued.

		2001		2002		2003		2004		2005	
		At-sea	Shoreside	At-sea	Shoreside	At-sea	Shoreside	At-sea	Shoreside	At-sea	Shoreside
Shallow-water flatfish	Whole fish	$.40	$.41	$.29	$.36	-	$.36	-	$.56	-	$.50
	H&G	$.52	-	$.49	-	$.30	-	$.54	-	$.75	-
	Fillets	-	$1.55	-	$2.13	-	$2.02	-	$2.10	-	$2.46
	Other products	$1.20	-	-	-	$1.10	-	$.88	-	$1.23	-
	All products	$.47	$1.43	$.40	$1.64	$.33	$1.82	$.55	$1.21	$.76	$.98
Other flatfish	Whole fish	$.95	-	$.83	-	$.96	-	$.97	-	$1.15	-
	H&G	$.88	-	$.15	-	$.23	-	$.43	-	$.67	-
	Other products	$.34	-	$.31	-	$.30	-	$.32	-	$.26	-
	All products	$.92	-	$.78	-	$.90	-	$.92	-	$1.09	-
Arrowtooth	Whole fish	-	-	-	-	$.25	-	-	-	-	-
	H&G	$.27	-	$.38	-	$.39	-	$.54	-	$.72	$.63
	Fillets	-	-	-	-	-	-	-	$.72	-	-
	Other products	$.30	-	$.31	-	$.15	-	$.32	$.48	$.25	-
	All products	$.27	-	$.38	-	$.38	-	$.54	$.60	$.72	$.63
Flathead sole	Whole fish	$.40	-	$.40	$.36	-	$.44	-	-	$.53	$.38
	H&G	$.47	-	$.56	-	$.57	-	$.68	-	$.87	$.49
	Fillets	-	$1.67	-	$1.87	-	$2.00	-	$2.16	-	$2.56
	Other products	$1.06	-	$.90	-	$.89	-	$.83	-	$.99	-
	All products	$.58	$1.67	$.67	$1.73	$.62	$1.58	$.73	$2.16	$.87	$.91
Rock sole	Whole fish	$.40	-	$.27	-	-	-	-	-	$.50	-
	H&G	$.41	-	$.42	-	$.43	-	$.52	-	$.76	-
	H&G with roe	$1.20	-	$1.07	-	$1.09	-	$1.04	-	$1.19	-
	Kirimi	$.79	-	-	-	-	-	-	-	-	-
	Other products	$.30	-	$.33	-	$.30	-	$.46	-	$.25	-
	All products	$.74	-	$.80	-	$.76	-	$.84	-	$.95	-

Table 26. Continued.

		2001		2002		2003		2004		2005	
		At-sea	Shoreside	At-sea	Shoreside	At-sea	Shoreside	At-sea	Shoreside	At-sea	Shoreside
Rex sole	Whole fish	$.99	-	$.85	-	$.92	-	$1.03	$.50	$1.19	$.75
	H&G	$.77	-	-	-	$.42	-	-	-	-	-
	Fillets	-	$1.64	-	$1.59	-	-	-	-	-	-
	All products	$.99	$1.64	$.85	$1.59	$.92	-	$1.03	$.50	$1.19	$.75
Yellowfin sole	Whole fish	$.28	-	$.29	-	$.30	-	$.35	-	$.49	-
	H&G	$.39	-	$.39	-	$.46	-	$.47	-	$.65	-
	Kirimi	$.30	-	$.55	-	$.53	-	$.63	-	$.48	-
	Other products	$.30	-	$.26	-	$.36	-	$.35	-	$.35	-
	All products	$.34	-	$.37	-	$.43	-	$.45	-	$.59	-
Greenland turbot	H&G	$.73	$1.09	$1.05	-	$1.29	-	$1.46	-	$1.83	-
	Other products	$.37	-	$.84	-	$.86	-	$.77	-	$.99	-
	All products	$.70	$1.09	$1.01	-	$1.19	-	$1.29	-	$1.60	-
Rockfish	Whole fish	$.32	$.65	$.85	$.66	$1.02	$1.36	$.69	$.47	$1.24	$.72
	H&G	$.53	$1.85	$.58	$2.17	$.60	$1.22	$.75	$.88	$1.11	$.96
	Other products	$1.09	$.51	$1.09	$1.40	$1.00	$1.30	$.75	$1.33	$.84	$1.55
	All products	$.52	$.71	$.61	$1.31	$.64	$1.29	$.75	$.88	$1.12	$.99
Atka mackerel	Whole fish	$.36	-	$.33	-	$.25	-	$.28	-	$.29	-
	H&G	$.69	-	$.55	-	$.44	-	$.47	-	$.49	-
	Other products	$.78	-	$.50	-	$.30	-	$.32	-	$.16	-
	All products	$.64	-	$.52	-	$.39	-	$.44	-	$.49	-

Note: Prices based on confidential data have been excluded.

Source: Weekly production reports and Commercial Operators Annual Reports (COAR). National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 27. Total product value per round metric ton of retained catch in the groundfish fisheries off Alaska by processor type, species, area and year, 2001-05, (dollars).

		Bering Sea and Aleutians					Gulf of Alaska				
		2001	2002	2003	2004	2005	2001	2002	2003	2004	2005
Motherships	Pacific cod	1,261	981	828	1,046	1,142	-	-	-	-	-
	Pollock	689	619	531	594	443	-	-	-	-	-
Catcher/ processors	Atka mackerel	806	662	533	603	630	1,170	1,243	837	370	558
	Flatfish	564	669	691	845	986	1,028	713	714	1,364	1,263
	Other species	280	358	463	363	334	184	524	533	484	576
	Pacific cod	1,127	978	1,143	1,160	1,391	1,196	1,047	1,137	1,202	1,277
	Pollock	809	697	730	816	962	502	329	353	346	396
	Rockfish	614	640	695	795	1,213	499	702	834	869	1,264
	Sablefish	4,564	4,925	4,616	5,099	4,618	4,509	4,213	5,032	5,059	5,201
Shoreside processors	Flatfish	178	66	100	-	141	410	699	619	521	684
	Other species	-	-	2,070	1,535	400	647	549	822	584	619
	Pacific cod	1,097	1,101	1,077	959	1,334	1,596	1,881	1,275	1,247	1,371
	Pollock	648	635	624	681	815	741	795	794	750	865
	Rockfish	3,241	562	1,237	664	1,082	754	856	743	768	988
	Sablefish	6,643	6,007	6,047	5,870	5,262	5,920	5,953	5,990	5,231	6,315

Notes: For shoreside processors, these estimates include the product value of catch from both federal and state of Alaska fisheries. For at-sea processors, they include only the product value from catch counted against federal TACs. A dash indicates that data were not available or were withheld to preserve confidentiality.

Source: Weekly processor reports, commercial operators annual report (COAR), blend (2001-02) and catch accounting system (2003-05) estimates of retained catch. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 28. Production of groundfish products in the fisheries off Alaska by species, product and area, 2001-05 (1,000 metric tons product weight).

		Bering Sea and Aleutians					Gulf of Alaska				
		2001	2002	2003	2004	2005	2001	2002	2003	2004	2005
Pollock	Whole fish	1.39	1.67	3.37	3.33	1.32	.20	.12	.92	.25	.13
	Head & gut	8.23	8.96	8.17	11.06	14.40	2.34	1.54	.18	7.21	6.68
	Roe	22.65	24.99	21.73	25.37	23.90	2.34	1.50	1.08	1.00	1.56
	Fillets	109.68	121.15	154.71	156.52	148.56	5.03	3.38	4.90	5.94	7.89
	Surimi	190.45	195.19	194.89	179.97	191.45	9.72	9.62	8.67	7.17	8.91
	Minced fish	21.54	24.92	15.53	19.84	17.41	-	-	-	-	-
	Fish meal	54.69	55.07	47.24	56.24	65.46	-	-	-	-	-
	Other products	12.07	20.46	19.43	17.72	23.85	.64	.89	1.06	.81	1.79
Pacific cod	Whole fish	.49	1.22	1.96	1.54	1.15	1.79	1.05	2.18	.80	.90
	Head & gut	63.35	65.65	67.98	80.32	75.29	9.03	7.08	4.46	10.26	6.38
	Salted/split	3.29	-	-	-	-	-	-	-	-	-
	Fillets	4.02	5.60	8.03	2.92	3.45	6.04	6.71	8.58	6.52	5.89
	Other products	7.63	9.69	10.37	5.56	6.65	4.26	6.13	7.37	5.06	5.02
Sablefish	Head & gut	1.27	1.37	1.14	1.30	1.50	8.09	7.86	9.04	9.76	9.35
	Other products	.01	.01	.06	.01	.01	.24	.23	.14	.21	.38
Flatfish	Whole fish	8.75	13.10	10.41	12.02	20.60	2.89	3.42	3.86	2.05	3.08
	Head & gut	37.63	45.84	49.27	54.93	60.72	2.03	4.16	5.41	1.37	6.22
	Kirimi	6.60	2.86	3.68	1.81	1.62	-	-	-	-	-
	Fillets	-	-	.00	-	-	1.10	1.33	1.02	1.01	.43
	Other products	.54	.74	.74	.83	1.14	-	.09	-	.55	-
Rockfish	Whole fish	.49	.71	.67	.33	.40	.99	1.14	1.00	2.04	1.76
	Head & gut	3.86	4.58	6.02	5.00	4.63	5.07	5.20	5.08	5.76	6.68
	Other products	2.14	.00	.04	.02	.02	1.34	1.71	2.02	1.38	.82
Atka mackerel	Whole fish	5.02	3.27	7.13	5.00	.89	-	-	-	-	-
	Head & gut	27.44	18.53	20.72	24.75	32.74	.04	.02	.18	.15	.25

Notes: For shoreside processors, these estimates include production resulting from catch from federal and state of Alaska fisheries. For at-sea processors, they include production only from catch counted against federal TACs. A dash indicates that data were not available or were withheld to preserve confidentiality. Confidential data withheld from this table are included in the grand totals in Table 25.

Source: Weekly processor report and commercial operators annual report. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 29. Production of groundfish products in the fisheries off Alaska by species, product and processing mode, 2001-05 (1,000 metric tons product weight).

		At-sea					On-shore				
		2001	2002	2003	2004	2005	2001	2002	2003	2004	2005
Pollock	Whole fish	1.39	1.67	2.90	3.34	1.32	.20	.12	1.40	.24	.13
	Head & gut	8.29	9.05	8.35	11.17	14.48	2.29	1.45	-	7.10	6.59
	Roe	12.92	13.95	13.41	15.43	13.99	12.07	12.55	9.40	10.95	11.47
	Fillets	61.50	70.29	86.48	82.10	82.71	53.20	54.24	73.13	80.37	73.74
	Surimi	94.37	97.77	99.04	93.33	98.56	105.81	107.04	104.53	93.81	101.79
	Minced fish	21.54	17.13	15.53	19.84	17.41	-	7.79	-	-	-
	Fish meal	23.76	21.08	22.84	22.10	21.36	30.93	33.98	24.40	34.13	44.10
	Other products	2.15	1.71	1.82	2.00	2.56	10.56	19.64	18.67	16.52	23.08
Pacific cod	Whole fish	.24	.94	1.09	1.23	.85	2.04	1.32	3.04	1.11	1.20
	Head & gut	65.02	63.94	66.37	74.17	69.30	7.37	8.79	6.07	16.41	12.37
	Salted/split	-	-	-	-	-	3.29	-	-	-	-
	Fillets	1.43	2.35	2.56	.64	.76	8.63	9.96	14.05	8.80	8.58
	Other products	3.58	4.73	4.75	3.47	4.37	8.31	11.09	13.00	7.16	7.29
Sablefish	Head & gut	1.51	1.64	1.67	1.87	1.88	7.86	7.59	8.51	9.18	8.97
	Other products	.07	.07	.07	.06	.07	.18	.17	.14	.15	.32
Flatfish	Whole fish	11.51	16.02	13.93	13.11	22.31	.13	.51	.34	.97	1.37
	Head & gut	39.55	50.00	54.67	56.29	63.35	.10	-	-	-	3.60
	Kirimi	6.60	2.86	3.68	1.81	1.62	-	-	-	-	-
	Fillets	-	-	.00	-	-	1.10	1.33	1.02	1.01	.43
	Other products	.54	.75	.74	.83	1.14	-	.08	-	.55	-
Rockfish	Whole fish	.80	1.06	1.26	.90	.67	.67	.79	.41	1.47	1.50
	Head & gut	8.29	9.35	10.48	9.67	9.59	.64	.43	.61	1.09	1.71
	Other products	.02	.02	.09	.03	.03	3.46	1.69	1.97	1.37	.81
Atka mackerel	Whole fish	5.02	3.27	7.13	5.00	.89	-	-	-	-	-
	Head & gut	27.48	18.55	20.89	24.90	32.99	-	-	-	-	-
	Other products	.00	.00	.00	.00	.00	-	-	-	-	-

Notes: For shoreside processors, these estimates include production resulting from catch from federal and state of Alaska fisheries. For at-sea processors, they include production only from catch counted against federal TACs. A dash indicates that data were not available or were withheld to preserve confidentiality. Confidential data withheld from this table are included in the grand totals in Table 25.

Source: Weekly processor report and commercial operators annual report. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 30. Production and gross value of non-groundfish products in the commercial fisheries of Alaska by species group and area of processing, 2002-05 (1,000 metric tons product weight and millions of dollars).

		Bering Sea & Aleutians		Gulf of Alaska		All Alaska	
		Quantity	Value	Quantity	Value	Quantity	Value
2002	Salmon	22.6	103.0	152.9	400.4	175.5	503.5
	Halibut	4.9	25.1	16.5	111.2	21.4	136.3
	Herring	17.3	17.7	7.5	13.0	24.8	30.7
	Crab	12.2	146.7	4.5	47.4	16.7	194.1
	Other	.1	.9	2.1	12.8	2.2	13.7
	Total	57.0	293.4	183.5	584.9	240.5	878.3
2003	Salmon	32.6	137.1	173.4	446.6	206.0	583.7
	Halibut	4.3	31.7	15.1	124.8	19.4	156.5
	Herring	19.9	21.0	6.9	11.7	26.8	32.7
	Crab	12.3	174.2	3.7	48.1	16.1	222.3
	Other	.1	.8	3.9	15.1	4.0	15.9
	Total	69.3	364.7	202.9	646.4	272.3	1,011.1
2004	Salmon	50.1	202.7	181.0	524.4	231.1	727.1
	Halibut	3.4	27.8	17.8	148.7	21.2	176.5
	Herring	16.9	18.7	11.5	19.5	28.4	38.2
	Crab	11.4	158.4	4.0	50.1	15.4	208.5
	Other	11.7	16.3	3.5	16.8	15.1	33.2
	Total	93.5	423.9	217.7	759.6	311.2	1,183.5
2005	Salmon	57.4	256.9	194.7	584.6	252.1	841.5
	Halibut	3.0	29.2	18.7	171.1	21.8	200.3
	Herring	19.8	23.0	12.6	19.6	32.5	42.6
	Crab	12.6	158.3	4.2	46.1	16.9	204.3
	Other	1.2	.4	2.2	19.4	3.5	19.8
	Total	94.1	467.8	232.6	840.8	326.7	1,308.5

Note: These estimates include production resulting from catch in both federal and state of Alaska fisheries. Complete estimates are not available for earlier years because catcher-processors that process only their own catch were not required to file the Commercial Operators Annual Report before 2002.

Source: ADF&G Commercial Operators Annual Report. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 31. Gross product value of Alaska groundfish by area and processing mode, 1999-2005 ($ millions).

	Gulf of Alaska		Bering Sea and Aleutians			All Alaska
	At-sea	Shoreside	Motherships	Catcher/ processors	Shoreside	Total
1999	43.0	207.6	58.1	579.9	289.4	1,178.1
2000	41.8	199.1	79.6	611.0	399.4	1,331.0
2001	31.0	176.9	101.8	774.9	432.6	1,517.2
2002	36.5	170.0	99.0	711.2	466.5	1,483.3
2003	39.5	180.6	90.1	773.6	471.5	1,555.3
2004	32.2	194.5	89.3	863.5	485.7	1,665.2
2005	37.6	224.7	65.0	1,042.9	592.0	1,962.1

Note: For shoreside processors, these estimates include production resulting from catch from federal and state of Alaska fisheries. For at-sea processors, they include production only from catch counted against federal TACs. Catcher/processors that at times during a year act like motherships are classified as catcher/processors for the entire year. For shoreside processors the area represents the location of the plant, not necessarily the area of the catch.

Source: NMFS weekly production reports and ADFG Commercial Operators Annual Reports (COAR). National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 32. Gross product value of Alaska groundfish by catcher/processor category, vessel length, and area, 1999-2005 ($ millions).

		Gulf of Alaska		Bering Sea and Aleutians		
		Vessel length		Vessel length		
		<125	>=125	<125	125-165	>165
Fixed Gear	1999	11.4	8.5	21.8	51.6	46.3
	2000	11.9	3.8	24.9	55.9	52.1
	2001	9.7	3.9	23.5	57.3	51.1
	2002	11.3	5.5	20.1	51.7	38.4
	2003	9.2	6.0	27.0	69.0	45.4
	2004	9.4	5.6	27.8	70.9	43.6
	2005	7.9	4.0	33.4	87.6	54.2
Fillet Trawl	1999	-	-	-	-	68.8
	2000	-	-	-	-	74.6
	2001	-	-	-	-	86.7
	2002	-	-	-	-	74.3
	2003	-	-	-	-	82.7
	2004	-	-	-	-	92.5
	2005	-	-	-	-	100.4
H&G Trawl	1999	9.2	13.3	19.9	23.6	70.8
	2000	9.5	15.7	24.1	24.0	85.3
	2001	6.7	10.7	19.4	22.0	103.5
	2002	5.6	14.1	26.3	25.8	93.8
	2003	7.9	16.2	27.9	25.0	96.0
	2004	4.1	13.0	28.4	36.4	117.3
	2005	8.0	17.7	30.0	41.6	153.4
Surimi Trawl	1999	-	-	-	-	277.1
	2000	-	-	-	-	270.1
	2001	-	-	-	-	411.3
	2002	-	-	-	-	380.8
	2003	-	-	-	-	400.6
	2004	-	-	-	-	446.7
	2005	-	-	-	-	498.1
All Trawl	1999	9.2	13.3	19.9	23.6	416.8
	2000	9.5	15.7	24.1	24.0	430.0
	2001	6.7	10.7	19.4	22.0	601.6
	2002	5.6	14.1	26.3	25.8	549.0
	2003	7.9	16.2	27.9	25.0	579.3
	2004	4.1	13.0	28.4	36.4	656.5
	2005	8.0	17.7	30.0	41.6	752.0

Note: These estimates include only catch counted against federal TACs.

Source: NMFS weekly production reports, Commercial Operators Annual Reports (COAR), and NMFS permits. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 33. Gross product value per vessel of Alaska groundfish by catcher/processor category, vessel length, and area 1999-2005 ($ millions).

		Gulf of Alaska		Bering Sea and Aleutians		
		Vessel length		Vessel length		
		<125	>=125	<125	125-165	>165
Fixed Gear	1999	.6	.4	1.3	2.7	3.9
	2000	.8	.4	1.8	2.7	3.7
	2001	.8	.4	1.5	3.0	3.4
	2002	.9	.5	1.4	2.6	3.0
	2003	.8	.4	2.1	3.6	4.1
	2004	.9	.6	2.5	3.5	4.0
	2005	.8	.4	3.0	4.4	4.9
Fillet Trawl	1999	-	-	-	-	17.2
	2000	-	-	-	-	18.7
	2001	-	-	-	-	21.7
	2002	-	-	-	-	18.6
	2003	-	-	-	-	20.7
	2004	-	-	-	-	23.1
	2005	-	-	-	-	25.1
H&G Trawl	1999	1.5	1.2	2.2	5.9	6.4
	2000	1.9	1.2	3.0	6.0	7.8
	2001	1.1	.9	2.8	5.5	9.4
	2002	1.4	1.2	3.8	6.5	8.5
	2003	1.1	1.2	4.0	6.2	8.7
	2004	1.0	1.1	4.1	7.3	10.7
	2005	2.0	1.6	5.0	8.3	13.9
Surimi Trawl	1999	-	-	-	-	23.1
	2000	-	-	-	-	24.6
	2001	-	-	-	-	34.3
	2002	-	-	-	-	29.3
	2003	-	-	-	-	30.8
	2004	-	-	-	-	34.4
	2005	-	-	-	-	38.3
All Trawl	1999	1.5	1.2	2.2	5.9	15.4
	2000	1.9	1.2	3.0	6.0	16.5
	2001	1.1	.9	2.8	5.5	22.3
	2002	1.4	1.2	3.8	6.5	19.6
	2003	1.1	1.2	4.0	6.2	20.7
	2004	1.0	1.1	4.1	7.3	23.4
	2005	2.0	1.6	5.0	8.3	26.9

Note: These estimates include only catch counted against federal TACs.

Source: NMFS weekly production reports, Commercial Operators Annual Reports (COAR), and NMFS permits. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 34. Gross product value of groundfish processed by shoreside processors by processor group, 1999-2005. ($ millions)

	1999	2000	2001	2002	2003	2004	2005
Bering Sea Pollock	293.0	396.7	421.8	450.5	454.3	468.0	557.8
AK Peninsula/Aleutians	59.0	46.3	49.6	61.8	67.9	65.6	90.8
Kodiak	71.0	73.9	69.1	58.9	54.4	67.0	88.9
South Central	24.9	29.5	28.0	24.4	29.8	27.7	33.8
Southeastern	49.2	52.1	41.1	41.0	46.7	52.6	45.9
TOTAL	497.1	598.6	609.5	636.5	653.1	680.9	817.2

Table 35. Groundfish gross product value as a percentage of all-species gross product value by shoreside processor group, 1999-2005. (percent)

	1999	2000	2001	2002	2003	2004	2005
Bering Sea Pollock	70.4	86.8	89.0	87.3	86.0	86.3	88.3
AK Peninsula/Aleutians	12.8	15.2	20.4	24.3	21.8	18.3	20.8
Kodiak	42.1	46.4	44.6	48.1	40.5	41.5	39.9
South Central	11.3	13.8	15.2	12.2	15.0	12.0	11.7
Southeastern	13.4	16.4	12.8	14.5	16.0	14.5	14.2
TOTAL	29.4	40.0	43.3	45.6	43.9	40.2	42.0

Note: The data are for catch from the EEZ and State waters. The processor groups are defined as follows:
"Bering Sea Pollock" are the AFA inshore pollock processors including the two AFA floating processors.
"AK Peninsula/Aleutian" are other processors on the Alaska Peninsula or in the Aleutian Islands.
"Kodiak" are processors on Kodiak Island.
"South Central" are processors west of Yakutat and on the Kenai Peninsula.
"Southeastern" are processors located from Yakutat south.

Source: ADFG Commercial Operators Annual Report, ADFG intent to process. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 36. Number of vessels that caught or caught and processed more than $4.0 million ex-vessel value or product value of groundfish by area, vessel type and gear, 1999-2005.

		Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
		Catcher Vessels	Catcher/ Process	All Vessels	Catcher Vessels	Catcher/ Process	All Vessels	Catcher Vessels	Catcher/ Process	All Vessels
1999	All gear	0	24	24	1	50	51	1	50	51
	Hook & line	0	8	8	0	16	16	0	16	16
	Pot	0	1	1	0	2	2	0	2	2
	Trawl	0	15	15	1	35	36	1	35	36
2000	All gear	0	25	25	3	52	55	3	52	55
	Hook & line	0	10	10	0	22	22	0	22	22
	Pot	0	0	0	0	2	2	0	2	2
	Trawl	0	15	15	3	32	35	3	32	35
2001	All gear	0	18	18	6	46	52	6	46	52
	Hook & line	0	4	4	0	13	13	0	13	13
	Trawl	0	14	14	6	33	39	6	33	39
2002	All gear	0	17	17	8	43	51	8	43	51
	Hook & line	0	4	4	0	8	8	0	8	8
	Trawl	0	13	13	8	35	43	8	35	43
2003	All gear	0	29	29	5	58	63	5	58	63
	Hook & line	0	11	11	0	21	21	0	21	21
	Trawl	0	18	18	5	37	42	5	37	42
2004	All gear	0	24	24	5	58	63	5	58	63
	Hook & line	0	11	11	0	21	21	0	21	21
	Pot	0	0	0	0	1	1	0	1	1
	Trawl	0	13	13	5	37	42	5	37	42
2005	All gear	1	24	25	9	66	75	9	66	75
	Hook & line	0	11	11	0	28	28	0	28	28
	Pot	0	0	0	0	2	2	0	2	2
	Trawl	1	13	14	9	37	46	9	37	46

Note: Includes only vessels that fished part of federal TACs.

Source: CFEC fish tickets, weekly processor reports, NMFS permits, Commercial Operators Annual Report (COAR), ADFG intent-to-operate listings. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 37. Number of vessels that caught or caught and processed less than $4.0 million ex-vessel value or product value of groundfish by area, vessel type and gear, 1999-2005.

		Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
		Catcher Vessels	Catcher/ Process	All Vessels	Catcher Vessels	Catcher/ Process	All Vessels	Catcher Vessels	Catcher/ Process	All Vessels
1999	All gear	1,000	32	1,032	282	38	320	1,113	40	1,153
	Hook & line	716	20	736	69	25	94	738	27	765
	Pot	234	10	244	95	12	107	286	12	298
	Trawl	163	3	166	125	5	130	209	5	214
2000	All gear	1,007	19	1,026	298	35	333	1,172	38	1,210
	Hook & line	733	11	744	81	21	102	762	22	784
	Pot	258	5	263	115	9	124	328	11	339
	Trawl	125	3	128	112	6	118	202	7	209
2001	All gear	861	21	882	284	44	328	1,022	45	1,067
	Hook & line	658	15	673	92	32	124	690	32	722
	Pot	160	4	164	78	7	85	218	9	227
	Trawl	119	4	123	118	6	124	195	7	202
2002	All gear	795	25	820	258	43	301	929	44	973
	Hook & line	628	18	646	80	34	114	644	34	678
	Pot	130	4	134	63	5	68	173	6	179
	Trawl	109	3	112	119	4	123	187	4	191
2003	All gear	795	18	813	267	25	292	938	28	966
	Hook & line	651	14	665	74	19	93	673	21	694
	Pot	134	1	135	84	3	87	194	3	197
	Trawl	90	3	93	116	3	119	158	4	162
2004	All gear	785	12	797	248	24	272	920	25	945
	Hook & line	621	8	629	63	19	82	644	20	664
	Pot	151	1	152	82	3	85	203	3	206
	Trawl	78	3	81	111	3	114	147	3	150
2005	All gear	725	11	736	223	15	238	845	17	862
	Hook & line	566	7	573	64	12	76	584	13	597
	Pot	147	1	148	69	1	70	196	1	197
	Trawl	78	3	81	99	2	101	140	3	143

Note: Includes only vessels that fished part of federal TACs.

Source: CFEC fish tickets, weekly processor reports, NMFS permits, Commercial Operators Annual Report (COAR), ADFG intent-to-operate listings. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 38. Average revenue of vessels that caught or caught and processed more than $4.0 million ex-vessel value or product value of groundfish, by area, vessel type, and gear, 1999-2005. ($ millions)

		Gulf of Alaska		Bering Sea & Aleutians			All Alaska		
		Catcher/ Process	All Vessels	Catcher Vessels	Catcher/ Process	All Vessels	Catcher Vessels	Catcher/ Process	All Vessels
1999	All gear	5.98	5.98	-	10.98	10.98	-	10.98	10.98
	Hook & line	5.28	5.28	-	5.04	5.04	-	5.04	5.04
	Trawl	6.36	6.36	-	13.51	13.51	-	13.51	13.51
2000	All gear	6.92	6.92	-	11.29	11.29	-	11.29	11.29
	Hook & line	5.18	5.18	-	5.35	5.35	-	5.35	5.35
	Trawl	8.08	8.08	-	15.17	15.17	-	15.17	15.17
2001	All gear	8.43	8.43	5.03	15.53	14.32	5.03	15.53	14.32
	Hook & line	5.63	5.63	-	5.17	5.17	-	5.17	5.17
	Trawl	9.23	9.23	5.03	19.61	17.37	5.03	19.61	17.37
2002	All gear	8.08	8.08	5.17	15.06	13.51	5.17	15.06	13.51
	Hook & line	4.99	4.99	-	4.78	4.78	-	4.78	4.78
	Trawl	9.03	9.03	5.17	17.40	15.13	5.17	17.40	15.13
2003	All gear	7.13	7.13	4.65	12.96	12.30	4.65	12.96	12.30
	Hook & line	4.86	4.86	-	4.83	4.83	-	4.83	4.83
	Trawl	8.52	8.52	4.65	17.58	16.04	4.65	17.58	16.04
2004	All gear	7.91	7.91	5.71	14.36	13.67	5.71	14.36	13.67
	Hook & line	4.86	4.86	-	4.80	4.80	-	4.80	4.80
	Trawl	10.48	10.48	5.71	19.79	18.11	5.71	19.79	18.11
2005	All gear	9.87	9.87	5.94	15.23	14.10	5.94	15.23	14.10
	Hook & line	5.71	5.71	-	5.33	5.33	-	5.33	5.33
	Trawl	13.39	13.39	5.94	22.71	19.43	5.94	22.71	19.43

Notes: Includes only vessels that fished part of federal TACs. Categories with fewer than four vessels are not reported. Averages are obtained by adding the total revenues, across all areas and gear types, of all the vessels in the category, and dividing that sum by the number of vessels in the category.

Source: CFEC fish tickets, weekly processor reports, NMFS permits, commercial operators annual report (COAR), ADFG intent-to-operate listings. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 39. Average revenue of vessels that caught or caught and processed less than $4.0 million ex-vessel value or product value of groundfish, by area, vessel type, and gear, 1999-2005. ($ millions)

		Gulf of Alaska			Bering Sea & Aleutians			All Alaska		
		Catcher Vessels	Catcher/ Process	All Vessels	Catcher Vessels	Catcher/ Process	All Vessels	Catcher Vessels	Catcher/ Process	All Vessels
1999	All gear	.19	1.89	.23	.55	1.93	.72	.20	1.84	.26
	Hook & line	.08	2.19	.14	.18	2.27	.74	.08	2.10	.15
	Pot	.17	1.23	.21	.15	1.38	.29	.16	1.38	.21
	Trawl	.74	-	.74	1.07	2.00	1.10	.76	2.00	.79
2000	All gear	.15	1.62	.17	.62	1.76	.74	.23	1.68	.28
	Hook & line	.10	1.89	.12	.22	2.00	.58	.10	1.92	.15
	Pot	.16	1.03	.18	.15	.49	.18	.16	.62	.18
	Trawl	.56	-	.56	1.37	2.58	1.43	.92	2.58	.96
2001	All gear	.13	2.21	.18	.56	2.03	.76	.22	2.03	.30
	Hook & line	.09	2.40	.14	.15	2.27	.70	.08	2.27	.18
	Pot	.12	1.82	.16	.13	.78	.18	.12	1.13	.16
	Trawl	.47	1.94	.52	1.16	1.84	1.19	.82	1.90	.86
2002	All gear	.14	2.20	.19	.64	2.33	.88	.24	2.28	.33
	Hook & line	.09	2.60	.16	.18	2.52	.88	.09	2.52	.21
	Pot	.15	.38	.16	.18	.62	.21	.14	.52	.15
	Trawl	.44	-	.44	1.18	2.90	1.24	.83	2.90	.88
2003	All gear	.16	2.36	.20	.65	2.76	.79	.26	2.53	.31
	Hook & line	.11	2.36	.16	.23	2.76	.74	.11	2.53	.18
	Pot	.16	-	.16	.23	-	.23	.17	-	.17
	Trawl	.59	-	.59	1.20	-	1.20	.97	-	.97
2004	All gear	.17	2.62	.19	.73	2.72	.87	.28	2.63	.33
	Hook & line	.11	2.62	.14	.19	2.72	.78	.11	2.63	.18
	Pot	.17	-	.17	.21	-	.21	.17	-	.17
	Trawl	.73	-	.73	1.39	-	1.39	1.17	-	1.17
2005	All gear	.20	2.33	.22	.84	2.68	.93	.32	2.54	.35
	Hook & line	.12	2.33	.15	.22	2.68	.61	.12	2.54	.18
	Pot	.19	-	.19	.27	-	.27	.20	-	.20
	Trawl	.84	-	.84	1.60	-	1.60	1.30	-	1.30

Notes: Includes only vessels that fished part of federal TACs. Categories with fewer than four vessels are not reported. Averages are obtained by adding the total revenues, across all areas and gear types, of all the vessels in the category, and dividing that sum by the number of vessels in the category.

Source: CFEC fish tickets, weekly processor reports, NMFS permits, commercial operators annual report (COAR), ADFG intent-to-operate listings. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 40. Number and total registered net tons of vessels that caught groundfish off Alaska by area and gear, 1999-2005.

		Gulf of Alaska		Bering Sea and Aleutians		All Alaska	
		Number of Vessels	Registered net tons	Number of Vessels	Registered net tons	Number of Vessels	Registered net tons
Hook & Line	1999	744	28,899	110	15,064	781	33,802
	2000	754	25,087	124	17,258	806	35,107
	2001	677	24,003	137	16,194	735	32,872
	2002	650	24,262	122	16,167	686	32,510
	2003	676	26,346	114	14,695	715	32,475
	2004	640	24,447	103	14,536	685	31,698
	2005	584	23,232	104	14,637	625	30,651
Pot	1999	245	19,239	109	17,130	300	27,456
	2000	263	20,395	126	18,230	341	30,768
	2001	164	9,211	85	11,901	227	18,666
	2002	134	7,964	68	9,214	179	14,556
	2003	135	7,708	87	10,947	197	15,877
	2004	152	9,066	86	11,086	207	17,249
	2005	148	8,875	72	9,488	199	16,396
Trawl	1999	181	26,620	166	55,389	250	61,074
	2000	143	19,510	153	53,571	244	59,932
	2001	137	18,537	163	52,016	241	57,491
	2002	125	16,657	166	52,648	234	57,189
	2003	111	17,851	161	54,540	204	57,902
	2004	94	15,246	156	52,931	192	55,814
	2005	94	15,386	147	51,871	189	55,219
All gear	1999	1,056	66,903	371	84,117	1,204	111,949
	2000	1,051	58,437	388	86,263	1,265	116,315
	2001	900	47,133	380	79,685	1,119	103,860
	2002	837	44,773	352	77,837	1,024	100,040
	2003	842	47,997	355	79,746	1,029	101,844
	2004	821	45,264	335	77,434	1,008	99,994
	2005	760	43,705	313	74,908	937	97,334

Note: These estimates include only vessels fishing federal TACs. Registered net tons totals exclude mainly smaller vessels for which data were unavailable. The percent of vessels missing are: 1999 - 4%, 2000 - 6%, 2001 - 5%, 2002 - 5%, 2003 - 3%, 2004 - 2%, 2005 - 2%.

Source: Blend estimates, Catch Accounting System, fish tickets, Norpac data, federal permit file, CFEC vessel data, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 41. Number of vessels that caught groundfish off Alaska by area, vessel category, gear and target, 2001-05.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Catcher vessels	Catcher/ processors	Total	Catcher vessels	Catcher/ processors	Total	Catcher vessels	Catcher/ processors	Total
All Gear	All groundfish	2001	861	39	900	290	90	380	1,028	91	1,119
		2002	795	42	837	266	86	352	937	87	1,024
		2003	795	47	842	272	83	355	943	86	1,029
		2004	785	35	820	253	82	335	925	83	1,008
		2005	725	35	760	232	81	313	854	83	937
Hook & Line	Sablefish	2001	407	13	420	53	8	61	429	16	445
		2002	402	11	413	48	12	60	415	16	431
		2003	375	14	389	52	8	60	391	16	407
		2004	364	12	376	41	6	47	377	14	391
		2005	337	15	352	41	11	52	352	17	369
	Pacific cod	2001	283	13	296	55	42	97	308	42	350
		2002	243	16	259	37	40	77	259	40	299
		2003	271	16	287	32	39	71	290	39	329
		2004	263	11	274	31	39	70	283	39	322
		2005	250	6	256	34	39	73	267	39	306
	Flatfish	2001	0	1	1	12	21	33	12	21	33
		2002	0	1	1	2	17	19	2	17	19
		2003	1	1	2	7	13	20	7	13	20
		2004	0	0	0	1	13	14	1	13	14
		2005	0	2	2	1	12	13	1	14	15
	Rockfish	2001	121	1	122	9	1	10	129	2	131
		2002	131	2	133	5	2	7	134	4	138
		2003	125	1	126	4	2	6	128	3	131
		2004	121	0	121	1	2	3	122	2	124
		2005	103	0	103	1	3	4	104	3	107
	All groundfish	2001	658	19	677	92	45	137	690	45	735
		2002	628	22	650	80	42	122	644	42	686
		2003	651	25	676	74	40	114	673	42	715
		2004	621	18	639	63	40	103	644	41	685
		2005	566	18	584	64	40	104	584	41	625
Pot	Pacific cod	2001	157	4	161	74	6	80	211	8	219
		2002	129	4	133	60	5	65	171	6	177
		2003	134	1	135	74	3	77	184	3	187
		2004	151	1	152	73	3	76	194	3	197
		2005	147	1	148	59	2	61	187	2	189

Table 41. Continued.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Catcher vessels	Catcher/ processors	Total	Catcher vessels	Catcher/ processors	Total	Catcher vessels	Catcher/ processors	Total
Trawl	Pollock	2001	95	0	95	106	29	135	172	29	201
		2002	80	0	80	98	31	129	155	31	186
		2003	74	0	74	91	19	110	141	19	160
		2004	69	0	69	93	19	112	139	19	158
		2005	69	0	69	90	22	112	135	22	157
	Pacific cod	2001	95	6	101	70	21	91	153	22	175
		2002	83	5	88	76	22	98	144	22	166
		2003	66	6	72	83	20	103	121	21	142
		2004	60	6	66	75	21	96	114	21	135
		2005	63	4	67	61	19	80	107	20	127
	Flatfish	2001	41	11	52	0	26	26	41	27	68
		2002	41	9	50	1	26	27	41	26	67
		2003	30	16	46	1	26	27	31	27	58
		2004	29	8	37	4	27	31	33	27	60
		2005	27	8	35	2	27	29	28	28	56
	Rockfish	2001	33	12	45	1	8	9	33	15	48
		2002	34	12	46	0	8	8	34	15	49
		2003	33	13	46	1	11	12	33	17	50
		2004	33	13	46	1	10	11	33	16	49
		2005	26	10	36	0	6	6	26	13	39
	Atka mackerel	2001	0	0	0	0	12	12	0	12	12
		2002	0	0	0	0	11	11	0	11	11
		2003	0	0	0	0	15	15	0	15	15
		2004	0	0	0	1	19	20	1	19	20
		2005	0	0	0	0	19	19	0	19	19
	All groundfish	2001	119	18	137	124	39	163	201	40	241
		2002	109	16	125	127	39	166	195	39	234
		2003	90	21	111	121	40	161	163	41	204
		2004	78	16	94	116	40	156	152	40	192
		2005	78	16	94	108	39	147	149	40	189

Note: The target is determined based on vessel, week, catching mode, NMFS area, and gear. These estimates include only vessels that fished part of federal TACs.

Source: Blend and Catch Accounting System estimates, fish tickets, Norpac data, federal permit file, CFEC vessel data, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 42. Number of vessels, mean length and mean net tonnage for vessels that caught groundfish off Alaska by area, vessel-length class (feet), and gear, 2001-05 (excluding catcher-processors).

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Vessel length class			Vessel length class			Vessel length class		
			<60	60-125	>=125	<60	60-125	>=125	<60	60-125	>=125
Number of vessels	Hook & Line	2001	577	81	0	71	21	0	605	85	0
		2002	546	82	0	62	17	1	560	83	1
		2003	570	81	0	59	15	0	588	85	0
		2004	542	79	0	49	13	1	562	81	1
		2005	491	75	0	49	15	0	506	78	0
	Pot	2001	118	41	1	6	56	16	121	81	16
		2002	98	31	1	9	40	14	102	57	14
		2003	101	30	3	11	57	16	106	72	16
		2004	106	44	1	14	51	17	111	75	17
		2005	105	41	1	13	43	13	109	74	13
	Trawl	2001	51	68	0	16	81	27	59	115	27
		2002	49	59	1	19	83	25	58	112	25
		2003	30	59	1	14	82	25	31	107	25
		2004	22	55	1	8	82	26	24	102	26
		2005	25	51	2	5	78	25	25	99	25

Note: If the permit files do not report a length for a vessel, the vessel is counted in the "less than 60 feet" class.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Vessel length class			Vessel length class			Vessel length class		
			<60	60-125	>=125	<60	60-125	>=125	<60	60-125	>=125
Mean vessel length (feet)	Hook & Line	2001	45	72	-	44	77	-	45	73	-
		2002	46	74	-	47	73	126	46	74	126
		2003	45	73	-	47	76	-	45	74	-
		2004	45	74	-	49	75	177	45	74	177
		2005	46	74	-	48	78	-	46	75	-
	Pot	2001	53	89	134	46	104	133	53	97	133
		2002	54	91	126	54	101	134	53	97	134
		2003	53	90	132	49	102	133	53	98	133
		2004	53	95	126	57	102	134	53	99	134
		2005	53	95	126	55	104	132	53	98	132
	Trawl	2001	56	90	-	54	105	158	55	99	158
		2002	56	90	149	49	104	158	55	99	158
		2003	57	92	155	58	105	158	57	100	158
		2004	58	91	149	58	106	158	58	101	158
		2005	58	92	152	58	106	158	58	101	158

Table 42. Continued.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Vessel length class			Vessel length class			Vessel length class		
			<60	60-125	>=125	<60	60-125	>=125	<60	60-125	>=125
Mean registered net tons	Hook & Line	2001	25	63	-	25	81	-	25	65	-
		2002	26	65	-	29	74	134	26	65	134
		2003	25	64	-	30	83	-	25	66	-
		2004	25	66	-	33	77	172	25	67	172
		2005	26	68	-	32	82	-	26	70	-
	Pot	2001	39	101	119	30	129	164	39	117	164
		2002	41	107	134	53	126	158	40	118	158
		2003	39	102	178	40	120	164	39	113	164
		2004	40	104	134	50	121	160	40	115	160
		2005	39	110	134	50	125	164	39	117	164
	Trawl	2001	55	106	-	51	124	234	54	115	234
		2002	56	94	130	49	117	238	53	111	238
		2003	62	98	267	65	117	238	61	111	238
		2004	67	97	130	68	118	241	66	113	241
		2005	64	99	221	64	118	238	64	113	238

Note: These estimates include only vessels that fished part of federal TACs.

Source: Blend estimates (2001-02), Catch Accounting System (2003-05), ADFG fish tickets, Norpac, NMFS permits. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115- 0070.

Table 43. Number of smaller hook-and-line vessels that caught groundfish off Alaska, by area and vessel-length class (feet), 2001-05 (excluding catcher-processors).

			Vessel length class							
			<26	26-30	30-35	35-40	40-45	45-50	50-55	55-60
Number of vessels	Gulf of Alaska	2001	22	11	56	53	140	104	61	130
		2002	22	4	53	54	121	102	66	124
		2003	16	4	60	58	129	109	67	127
		2004	12	5	70	51	108	105	67	124
		2005	12	3	60	49	95	93	57	122
	Bering Sea and Aleutian Islands	2001	8	1	14	7	13	4	4	20
		2002	5	0	11	3	5	8	7	23
		2003	1	0	12	4	7	4	4	27
		2004	2	0	9	3	4	4	4	23
		2005	2	0	8	1	6	2	6	24
	All Alaska	2001	29	12	65	56	144	104	64	131
		2002	26	4	58	54	122	102	68	126
		2003	17	4	64	60	132	110	68	133
		2004	14	5	75	53	109	107	69	130
		2005	13	3	66	49	96	94	59	126

Note: If the permit files do not report a length for a vessel, the vessel is counted in the "<26" class.

Source: Blend estimates (2001-02), Catch Accounting System (2003-05), ADFG fish tickets, Norpac, NMFS permits. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 44. Number of vessels, mean length and mean net tonnage for vessels that caught and processed groundfish off Alaska by area, vessel-length class (feet), and gear, 2001-05.

			Gulf of Alaska					Bering Sea and Aleutians					All Alaska				
			Vessel length class					Vessel length class					Vessel length class				
			<125	125-164	165-234	235-259	>260	<125	125-164	165-234	235-259	>260	<125	125-164	165-234	235-259	>260
Number of vessels	Hook & Line	2001	11	3	5	0	0	15	16	13	1	0	15	16	13	1	0
		2002	11	5	6	0	0	12	18	12	0	0	12	18	12	0	0
		2003	11	6	8	0	0	11	18	11	0	0	13	18	11	0	0
		2004	9	3	7	0	0	10	19	11	0	0	11	19	11	0	0
		2005	9	4	5	0	0	10	19	11	0	0	11	19	11	0	0
	Pot	2001	1	2	1	0	0	2	4	1	0	0	2	6	1	0	0
		2002	2	1	1	0	0	2	2	1	0	0	2	3	1	0	0
		2003	1	0	0	0	0	2	1	0	0	0	2	1	0	0	0
		2004	1	0	0	0	0	1	2	1	0	0	1	2	1	0	0
		2005	1	0	0	0	0	1	1	1	0	0	1	1	1	0	0
	Trawl	2001	6	2	8	1	1	8	4	10	3	14	9	4	10	3	14
		2002	4	2	8	1	1	7	4	10	3	15	7	4	10	3	15
		2003	7	3	9	1	1	7	4	10	3	16	8	4	10	3	16
		2004	4	2	8	1	1	7	5	10	3	15	7	5	10	3	15
		2005	4	2	8	1	1	6	5	10	3	15	7	5	10	3	15

Note: If the permit files do not report a length for a vessel, the vessel is counted in the "less than 125 feet" class.

Table 44. Continued.

			Gulf of Alaska					Bering Sea and Aleutians					All Alaska				
			Vessel length class					Vessel length class					Vessel length class				
			<125	125-164	165-234	235-259	>260	<125	125-164	165-234	235-259	>260	<125	125-164	165-234	235-259	>260
Mean vessel length (feet)	Hook & Line	2001	107	141	175	-	-	103	144	177	245	-	103	144	177	245	-
		2002	111	140	175	-	-	107	145	178	-	-	107	145	178	-	-
		2003	104	146	176	-	-	111	145	178	-	-	107	145	178	-	-
		2004	103	158	175	-	-	112	145	178	-	-	107	145	178	-	-
		2005	103	154	175	-	-	112	145	178	-	-	107	145	178	-	-
	Pot	2001	116	146	180	-	-	118	146	180	-	-	118	146	180	-	-
		2002	96	126	180	-	-	96	163	180	-	-	96	150	180	-	-
		2003	76	-	-	-	-	96	165	-	-	-	96	165	-	-	-
		2004	76	-	-	-	-	76	165	174	-	-	76	165	174	-	-
		2005	76	-	-	-	-	76	165	174	-	-	76	165	174	-	-
	Trawl	2001	113	155	211	238	295	117	152	207	245	305	116	152	207	245	305
		2002	113	155	211	238	295	117	152	207	245	303	117	152	207	245	303
		2003	115	150	208	238	295	117	152	207	245	306	116	152	207	245	306
		2004	111	146	207	238	295	116	148	207	245	303	116	148	207	245	303
		2005	111	146	207	238	295	118	148	207	245	303	116	148	207	245	303

Table 44. Continued.

			Gulf of Alaska					Bering Sea and Aleutians					All Alaska				
			Vessel length class					Vessel length class					Vessel length class				
			<125	125-164	165-234	235-259	>260	<125	125-164	165-234	235-259	>260	<125	125-164	165-234	235-259	>260
Mean registered net tons	Hook & Line	2001	127	153	583	-	-	125	262	508	200	-	125	262	508	200	-
		2002	129	223	454	-	-	130	302	508	-	-	130	302	508	-	-
		2003	159	233	481	-	-	128	302	442	-	-	153	302	442	-	-
		2004	133	261	513	-	-	134	296	442	-	-	136	296	442	-	-
		2005	140	269	583	-	-	134	296	442	-	-	136	296	442	-	-
	Pot	2001	130	129	243	-	-	128	348	243	-	-	128	275	243	-	-
		2002	132	147	243	-	-	132	546	243	-	-	132	413	243	-	-
		2003	134	-	-	-	-	132	793	-	-	-	132	793	-	-	-
		2004	134	-	-	-	-	134	464	414	-	-	134	464	414	-	-
		2005	134	-	-	-	-	134	793	414	-	-	134	793	414	-	-
	Trawl	2001	115	256	732	533	1085	139	194	724	1130	1620	133	194	724	1130	1620
		2002	123	256	732	611	1085	143	194	724	1156	1590	143	194	724	1156	1590
		2003	144	214	735	611	1085	150	194	724	1156	1598	143	194	724	1156	1598
		2004	125	256	702	611	1085	144	181	724	1156	1590	144	181	724	1156	1590
		2005	125	256	702	611	1085	153	181	724	1156	1590	144	181	724	1156	1590

Note: These estimates include only vessels that fished part of federal TACs.

Source: Blend estimates (2001-02), Catch Accounting System (2003-05), NMFS permits. National Marine Fisheries Service, P.O. Box 15700, Seattle WA 98115-0070.

Table 45. Number of vessels that caught groundfish off Alaska by area, tonnage caught, and gear, 1999-2005.

		Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
		Tonnage caught			Tonnage caught			Tonnage caught		
		Less than 2t	2t to 25t	More than 25t	Less than 2t	2t to 25t	More than 25t	Less than 2t	2t to 25t	More than 25t
Hook & Line	1999	173	341	230	21	35	54	177	348	256
	2000	157	352	245	27	38	59	170	359	277
	2001	129	297	251	27	44	66	139	309	287
	2002	125	292	233	24	37	61	125	296	265
	2003	106	306	264	24	35	55	112	317	286
	2004	95	284	261	19	31	53	101	292	292
	2005	84	255	245	21	28	55	91	257	277
Pot	1999	21	56	168	7	22	80	25	57	218
	2000	13	54	196	3	21	102	15	54	272
	2001	10	37	117	3	10	72	10	41	176
	2002	7	19	108	2	5	61	8	22	149
	2003	5	20	110	3	9	75	7	26	164
	2004	3	16	133	2	12	72	5	20	182
	2005	2	26	120	4	5	63	6	30	163
Trawl	1999	2	4	175	1	5	160	2	3	245
	2000	0	9	134	1	3	149	1	10	233
	2001	0	7	130	0	3	160	0	5	236
	2002	1	11	113	0	3	163	1	9	224
	2003	2	2	107	1	0	160	0	1	203
	2004	1	1	92	0	4	152	0	2	190
	2005	0	2	92	0	1	146	0	2	187
All gear	1999	172	370	514	26	58	287	175	374	655
	2000	151	381	519	27	53	308	163	380	722
	2001	124	316	460	28	55	297	133	328	658
	2002	121	300	416	24	44	284	120	305	599
	2003	100	295	447	24	42	289	102	309	618
	2004	94	270	457	18	42	275	100	276	632
	2005	72	257	431	18	32	263	79	258	600

Note: These estimates include only vessels fishing part of federal TACs.

Source: Blend estimates, Catch Accounting System, fish tickets, Norpac data, federal permi file, CFEC vessel data. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 46. Number of vessels that caught groundfish off Alaska by area, residency, gear, and target, 2001-05.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Alaska	Other	Unk.	Alaska	Other	Unk.	Alaska	Other	Unk.
All Gear	All groundfish	2001	634	246	20	106	261	13	669	419	31
		2002	590	224	23	94	247	11	616	375	33
		2003	612	230	0	95	260	0	641	388	0
		2004	600	220	1	79	254	2	625	380	3
		2005	552	208	0	78	235	0	571	366	0
Hook & Line	Sablefish	2001	295	120	5	37	24	0	314	126	5
		2002	296	112	5	30	28	2	304	120	7
		2003	273	116	0	34	26	0	284	123	0
		2004	270	106	0	27	20	0	281	110	0
		2005	244	108	0	27	25	0	256	113	0
	Pacific cod	2001	242	50	4	46	47	4	262	81	7
		2002	205	45	9	33	44	0	219	71	9
		2003	239	48	0	27	44	0	254	75	0
		2004	230	44	0	21	47	2	244	76	2
		2005	219	37	0	32	41	0	235	71	0
	Flatfish	2001	0	1	0	13	18	2	13	18	2
		2002	0	1	0	4	14	1	4	14	1
		2003	1	1	0	4	16	0	4	16	0
		2004	0	0	0	4	10	0	4	10	0
		2005	1	1	0	2	11	0	3	12	0
	Rockfish	2001	103	18	1	7	3	0	109	21	1
		2002	114	19	0	4	3	0	116	22	0
		2003	108	18	0	3	3	0	110	21	0
		2004	106	15	0	2	1	0	108	16	0
		2005	85	18	0	1	3	0	86	21	0
	All groundfish	2001	505	162	10	71	60	6	532	188	15
		2002	485	151	14	58	61	3	498	171	17
		2003	523	153	0	55	59	0	542	173	0
		2004	500	140	0	44	57	2	519	164	2
		2005	447	137	0	49	55	0	461	164	0
Pot	Pacific cod	2001	123	31	7	20	59	1	131	81	7
		2002	107	23	3	19	44	2	116	56	5
		2003	117	18	0	26	51	0	128	59	0
		2004	122	29	1	25	51	0	128	68	1
		2005	130	18	0	22	39	0	136	53	0
	All groundfish	2001	126	31	7	20	64	1	134	86	7
		2002	108	23	3	20	46	2	117	57	5
		2003	117	18	0	29	58	0	131	66	0
		2004	122	29	1	26	60	0	129	77	1
		2005	130	18	0	27	45	0	140	59	0

Table 46. Continued.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Alaska	Other	Unk.	Alaska	Other	Unk.	Alaska	Other	Unk.
Trawl	Pollock	2001	39	55	1	12	116	7	40	153	8
		2002	33	45	2	11	114	4	37	143	6
		2003	30	44	0	8	102	0	32	128	0
		2004	26	43	0	7	105	0	27	131	0
		2005	25	44	0	5	107	0	25	132	0
	Pacific cod	2001	49	50	2	7	84	0	51	122	2
		2002	46	39	3	8	88	2	50	111	5
		2003	27	45	0	12	91	0	30	112	0
		2004	26	40	0	7	89	0	27	108	0
		2005	27	40	0	5	75	0	27	100	0
	Flatfish	2001	17	35	0	1	25	0	17	51	0
		2002	19	30	1	2	25	0	19	47	1
		2003	14	32	0	2	25	0	14	44	0
		2004	12	25	0	2	29	0	12	48	0
		2005	7	28	0	0	29	0	7	49	0
	Rockfish	2001	13	32	0	1	8	0	14	34	0
		2002	17	29	0	0	8	0	17	32	0
		2003	17	29	0	1	11	0	17	33	0
		2004	14	32	0	1	10	0	14	35	0
		2005	9	27	0	0	6	0	9	30	0
	Atka mackerel	2001	0	0	0	1	11	0	1	11	0
		2002	0	0	0	0	11	0	0	11	0
		2003	0	0	0	2	13	0	2	13	0
		2004	0	0	0	2	18	0	2	18	0
		2005	0	0	0	0	19	0	0	19	0
	All groundfish	2001	56	78	3	16	140	7	57	174	10
		2002	54	65	6	17	143	6	58	165	11
		2003	40	71	0	16	145	0	40	164	0
		2004	32	62	0	12	144	0	33	159	0
		2005	31	63	0	8	139	0	31	158	0

Note: The target is determined based on vessel, week, processing mode, NMFS area, and gear. Vessels are classified by the residency of the owner of the fishing vessel. These estimates include only vessels fishing part of federal TACs.

Source: Blend estimates, Catch Accounting System, fish tickets, Norpac data, federal permit file, CFEC vessel data. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 47. Number of vessels that caught groundfish off Alaska by month, area, vessel type, and gear, 2001-05.

				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Gulf of Alaska	Catcher-vessels (excluding C/Ps)	Hook & line	2001	128	131	105	215	278	286	107	94	168	100	73	13	658
			2002	90	73	159	244	237	211	106	112	167	82	78	7	628
			2003	94	71	181	298	310	139	103	119	144	80	82	1	651
			2004	126	92	228	302	241	129	121	103	159	124	53	3	621
			2005	93	69	183	308	201	138	111	90	136	107	60	24	566
		Pot	2001	38	75	114	99	28	11	0	0	23	16	9	14	160
			2002	37	69	99	36	29	5	0	0	19	12	25	17	130
			2003	53	87	103	15	0	0	0	0	40	5	1	1	134
			2004	86	117	60	17	15	0	0	0	29	25	22	6	151
			2005	56	114	58	26	12	0	0	0	38	33	15	12	147
		Trawl	2001	76	99	99	38	14	8	35	45	66	69	4	0	119
			2002	32	78	79	33	21	0	35	59	34	56	15	0	109
			2003	63	63	37	37	16	8	35	50	43	47	0	0	90
			2004	58	48	50	27	16	9	32	49	58	46	1	0	78
			2005	57	51	54	24	11	6	26	35	54	45	1	0	78
		All gear	2001	241	302	288	343	319	302	142	137	256	185	86	27	861
			2002	156	214	315	311	284	216	141	171	218	149	118	24	795
			2003	202	219	305	348	326	147	138	169	225	131	83	2	795
			2004	256	248	329	346	269	138	153	152	244	191	76	9	785
			2005	203	221	285	358	224	144	136	125	227	180	75	36	725
	Catcher/ Processors	Hook & line	2001	9	6	9	8	6	9	0	3	3	1	0	0	19
			2002	6	9	13	10	7	1	3	3	2	4	5	0	22
			2003	9	6	15	7	8	4	3	3	3	0	0	0	25
			2004	8	2	9	10	9	5	2	2	5	4	1	0	19
			2005	2	2	9	14	4	2	2	2	5	0	0	2	18
		Pot	2001	0	0	0	4	3	0	0	0	0	0	1	1	4
			2002	0	0	2	1	0	0	0	0	2	3	1	0	4
			2003	1	1	1	0	0	0	0	0	1	0	0	0	1
			2004	1	1	0	0	0	0	0	0	0	0	1	1	1
			2005	1	1	0	0	0	0	0	0	0	0	0	0	1
		Trawl	2001	2	3	4	7	9	0	13	2	4	5	0	0	18
			2002	1	2	4	6	8	1	14	7	0	6	1	0	16
			2003	0	3	2	10	9	0	13	6	7	13	0	0	21
			2004	1	1	4	6	4	2	15	2	6	0	0	0	16
			2005	0	2	7	5	4	2	15	2	5	0	0	0	16
		All gear	2001	11	9	13	19	18	9	13	5	7	6	1	1	39
			2002	7	11	19	17	15	2	17	10	4	13	7	0	42
			2003	10	10	18	17	17	4	16	9	11	13	0	0	47
			2004	10	4	13	16	13	7	17	4	11	4	2	1	36
			2005	3	5	16	19	8	4	17	4	10	0	0	2	35

Table 47. Continued.

				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Bering Sea & Aleutian Islands	Catcher-vessels (excluding C/Ps)	Hook & line	2001	2	3	3	9	16	42	43	47	33	18	12	5	92
			2002	2	3	4	12	27	37	27	35	20	11	5	0	80
			2003	0	0	6	9	26	34	27	33	29	17	6	0	74
			2004	0	8	9	14	25	24	28	22	16	11	8	2	63
			2005	3	5	10	17	17	17	27	20	19	12	14	4	64
		Pot	2001	3	5	61	3	7	7	3	4	25	18	6	3	78
			2002	5	30	45	6	7	8	5	5	20	21	6	1	63
			2003	9	51	60	10	7	8	10	8	30	39	21	5	84
			2004	21	55	10	16	18	9	7	5	28	31	8	0	82
			2005	19	44	9	14	6	3	3	5	20	24	6	3	69
		Trawl	2001	52	94	105	55	7	8	59	82	92	52	0	0	124
			2002	65	109	108	57	6	19	60	92	81	52	6	0	127
			2003	66	109	115	71	13	31	73	91	76	47	0	0	121
			2004	77	100	105	45	2	39	70	82	79	58	15	0	116
			2005	78	100	96	39	1	48	72	74	63	51	10	0	108
		All gear	2001	57	102	169	67	30	57	105	133	150	88	17	8	290
			2002	72	142	157	75	40	64	92	132	121	84	17	1	266
			2003	75	160	181	90	46	73	109	130	135	102	27	5	272
			2004	98	163	122	75	45	72	105	109	123	100	31	2	253
			2005	99	149	115	70	24	67	101	97	102	87	30	7	232
	Catcher/ Processors	Hook & line	2001	33	37	41	17	25	11	8	37	39	40	38	35	45
			2002	34	35	37	13	11	5	11	37	39	40	39	18	42
			2003	32	39	39	14	11	11	15	35	37	37	37	31	40
			2004	34	37	37	13	12	9	16	38	39	39	38	37	40
			2005	38	39	14	9	5	8	17	38	39	38	38	38	40
		Pot	2001	1	1	5	1	1	0	0	0	3	3	2	0	7
			2002	0	3	4	0	0	0	0	0	3	3	3	0	5
			2003	0	2	2	0	0	0	0	0	3	2	2	1	3
			2004	2	2	3	0	1	0	0	0	1	1	1	0	4
			2005	1	1	2	2	1	0	0	0	1	1	1	0	3
		Trawl	2001	35	37	38	35	9	15	33	35	36	34	14	5	39
			2002	35	38	37	22	18	22	32	37	36	26	6	0	39
			2003	37	38	38	24	16	29	34	37	37	15	3	1	40
			2004	38	39	39	24	23	32	37	31	32	18	3	0	40
			2005	38	39	38	25	22	27	37	36	24	18	3	0	39
		All gear	2001	69	75	84	53	35	26	41	72	78	77	54	40	90
			2002	69	76	78	35	29	27	43	74	78	69	48	18	86
			2003	69	79	79	38	27	40	49	72	77	54	42	33	83
			2004	74	78	78	37	35	41	53	69	72	58	42	37	82
			2005	77	79	54	36	27	35	54	74	64	57	42	38	81

Table 47. Continued.

				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
All Alaska	Catcher-vessels (excluding C/Ps)	Hook & line	2001	130	134	108	224	289	315	145	137	193	115	84	18	690
			2002	92	76	162	252	259	240	128	137	184	91	81	7	644
			2003	94	71	186	305	332	171	123	144	167	94	88	1	673
			2004	126	99	236	314	259	149	143	121	170	129	59	5	644
			2005	96	71	191	321	214	153	129	108	147	112	71	25	584
		Pot	2001	41	80	166	101	34	18	3	4	46	34	14	17	218
			2002	42	96	137	42	36	12	5	5	39	33	31	18	173
			2003	62	134	157	25	7	8	10	8	63	42	22	6	194
			2004	105	160	70	33	33	9	7	5	52	53	30	6	203
			2005	75	152	67	37	18	3	3	5	54	55	21	15	196
		Trawl	2001	124	178	188	92	21	16	86	122	145	119	4	0	201
			2002	97	170	169	90	27	19	88	130	108	104	21	0	195
			2003	128	150	138	104	28	39	98	125	112	90	0	0	163
			2004	133	139	139	71	18	47	91	118	127	100	16	0	152
			2005	135	144	137	63	12	53	92	106	112	96	11	0	149
		All gear	2001	294	389	432	408	343	346	234	261	381	268	101	35	1,028
			2002	228	336	446	379	319	270	221	272	329	227	133	25	937
			2003	276	353	465	431	367	218	230	275	340	224	110	7	943
			2004	350	389	434	418	306	205	241	244	347	278	105	11	925
			2005	302	354	385	421	244	208	222	217	312	257	102	40	854
	Catcher/ Processors	Hook & line	2001	34	40	42	20	25	17	8	38	40	41	38	35	45
			2002	36	38	39	18	14	6	14	38	39	41	39	18	42
			2003	40	39	40	18	14	14	16	35	38	37	37	31	42
			2004	36	37	38	18	16	13	17	38	40	39	39	37	41
			2005	39	39	20	17	8	10	18	39	40	38	38	38	41
		Pot	2001	1	1	5	5	4	0	0	0	3	3	2	1	9
			2002	0	3	5	1	0	0	0	0	4	4	3	0	6
			2003	1	3	3	0	0	0	0	0	3	2	2	1	3
			2004	2	2	3	0	1	0	0	0	1	1	2	1	4
			2005	2	2	2	2	1	0	0	0	1	1	1	0	3
		Trawl	2001	37	39	39	37	15	15	35	36	37	35	14	5	40
			2002	35	39	39	25	21	22	37	37	36	27	6	0	39
			2003	37	39	39	28	19	29	37	38	38	27	3	1	41
			2004	39	39	39	26	23	32	38	32	34	18	3	0	40
			2005	38	40	40	26	23	28	38	38	28	18	3	0	40
		All gear	2001	72	80	86	62	44	32	43	74	80	79	54	41	91
			2002	71	80	83	44	35	28	51	75	79	72	48	18	87
			2003	78	81	82	46	33	43	53	73	79	66	42	33	86
			2004	77	78	79	44	39	45	55	70	75	58	44	38	83
			2005	79	81	62	45	31	38	56	77	69	57	42	38	83

Note: These estimates include only vessels fishing part of federal TACs.

Source: Blend estimates, Catch Accounting System, fish tickets, Norpac data, federal permit file, CFEC vessel data.
National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 48. Catcher vessel (excluding catcher-processors) weeks of fishing groundfish off Alaska by area, vessel-length class (feet), gear, and target, 2001-05.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Vessel length class			Vessel length class			Vessel length class		
			<60	60-124	>=125	<60	60-124	>=125	<60	60-124	>=125
Hook & line	Sablefish	2001	1089	354	-	141	53	-	1230	407	-
		2002	1097	329	-	144	49	-	1241	378	-
		2003	1090	340	-	174	27	-	1264	367	-
		2004	1123	349	-	115	25	1	1238	374	1
		2005	1104	323	-	102	39	-	1205	362	-
	Pacific cod	2001	1324	22	-	166	25	-	1490	46	-
		2002	1071	20	-	98	10	1	1169	30	1
		2003	1073	21	-	92	4	-	1165	25	-
		2004	1359	45	-	147	4	-	1506	49	-
		2005	1209	46	-	142	3	-	1351	49	-
	Flatfish	2001	-	-	-	21	3	-	21	3	-
		2002	-	-	-	1	-	-	1	-	-
		2003	1	-	-	6	5	-	6	5	-
		2004	-	-	-	1	-	-	1	-	-
		2005	-	-	-	1	-	-	1	-	-
	Rockfish	2001	261	17	-	5	3	-	267	20	-
		2002	261	26	-	4	1	-	265	27	-
		2003	240	18	-	3	1	-	243	19	-
		2004	258	15	-	1	-	-	259	15	-
		2005	168	13	-	1	-	-	169	13	-
	All groundfish	2001	2686	393	-	334	84	-	3020	477	-
		2002	2429	375	-	247	59	1	2676	434	1
		2003	2560	388	-	275	38	-	2835	426	-
		2004	2808	412	-	264	29	1	3073	441	1
		2005	2504	383	-	246	42	-	2750	425	-
Pot	Pacific cod	2001	728	215	1	27	259	76	754	474	77
		2002	754	206	3	35	190	66	789	396	69
		2003	630	144	10	42	241	77	672	385	87
		2004	831	227	3	87	206	70	918	433	73
		2005	687	286	1	50	171	58	737	457	59
	All groundfish	2001	752	215	2	32	295	78	784	509	80
		2002	755	207	3	48	247	66	803	454	69
		2003	630	144	10	57	348	77	687	492	87
		2004	831	228	3	88	305	77	919	533	80
		2005	687	286	1	63	243	58	750	529	59

Table 48. Continued.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Vessel length class			Vessel length class			Vessel length class		
			<60	60-124	>=125	<60	60-124	>=125	<60	60-124	>=125
Trawl	Pollock	2001	211	426	-	1	999	501	212	1425	501
		2002	87	289	0	3	953	476	90	1242	476
		2003	69	259	0	-	1009	524	69	1268	524
		2004	92	309	-	-	1014	531	92	1323	531
		2005	133	343	0	-	997	574	133	1340	574
	Pacific cod	2001	177	234	-	20	323	29	197	556	29
		2002	117	159	-	68	405	29	185	564	29
		2003	57	160	-	91	443	40	148	603	40
		2004	40	139	-	31	283	35	71	422	35
		2005	56	102	-	15	261	30	71	363	30
	Flatfish	2001	21	172	-	-	-	-	21	172	-
		2002	11	211	-	-	0	-	11	212	-
		2003	4	149	-	2	0	-	6	149	-
		2004	5	145	-	-	4	-	5	149	-
		2005	1	140	-	-	7	-	1	147	-
	Rockfish	2001	-	89	-	-	0	-	-	89	-
		2002	1	87	-	-	-	-	1	87	-
		2003	3	110	-	-	1	-	3	111	-
		2004	2	94	0	-	1	-	2	95	0
		2005	-	76	-	-	-	-	-	76	-
	All groundfish	2001	409	921	-	21	1322	530	430	2243	530
		2002	217	746	0	71	1358	505	288	2105	505
		2003	133	691	0	93	1454	564	226	2145	564
		2004	140	696	0	31	1311	566	171	2007	566
		2005	191	662	0	15	1265	604	205	1927	604
All gear	All groundfish	2001	3847	1528	2	387	1701	608	4234	3229	610
		2002	3401	1329	3	366	1664	572	3767	2993	575
		2003	3323	1224	10	425	1839	641	3748	3063	651
		2004	3779	1335	3	383	1646	644	4162	2981	647
		2005	3382	1331	1	323	1550	662	3705	2881	663

Notes: A vessel that fished more than one category in a week is apportioned a partial week based on catch weight. A target is determined based on vessel, week, processing mode, NMFS area, and gear. All groundfish include additional target categories.

Source: Blend estimates (2001-02), Catch Accounting System (2003-05), fish tickets, Norpac data, federa permit file, CFEC vessel data, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 49. Catcher/processor vessel weeks of fishing groundfish off Alaska by area, vessel-length class (feet), gear, and target, 2001-05.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Vessel length class			Vessel length class			Vessel length class		
			<60	60-124	125-230	<60	60-124	125-230	<60	60-124	125-230
Hook & line	Sablefish	2001	8	45	15	-	30	7	8	75	22
		2002	7	37	18	1	35	6	8	72	25
		2003	3	44	24	-	28	8	3	72	33
		2004	7	53	21	-	30	6	7	83	27
		2005	7	46	25	-	23	11	7	68	36
	Pacific cod	2001	-	42	2	21	250	852	21	291	854
		2002	-	52	21	22	186	775	22	238	797
		2003	7	31	23	5	241	867	12	272	890
		2004	4	24	16	7	229	845	11	253	861
		2005	4	6	4	4	243	857	8	249	861
	Flatfish	2001	-	0	-	2	23	49	2	23	49
		2002	-	-	1	2	25	34	2	25	35
		2003	-	0	-	-	11	46	-	11	46
		2004	-	-	-	-	22	31	-	22	31
		2005	-	0	2	-	23	34	-	23	36
	All groundfish	2001	8	88	17	23	305	908	31	393	925
		2002	7	89	41	25	246	817	32	335	858
		2003	10	78	48	5	280	924	15	358	972
		2004	12	77	37	7	281	887	19	358	924
		2005	11	52	31	4	289	906	15	341	937
Pot	Pacific cod	2001	-	8	23	-	8	35	-	16	58
		2002	-	3	9	-	14	24	-	17	33
		2003	-	7	-	-	12	13	-	19	13
		2004	-	10	-	-	6	20	-	16	20
		2005	-	6	-	-	2	22	-	8	22
	All groundfish	2001	-	8	23	-	8	39	-	16	62
		2002	-	3	9	-	14	24	-	17	33
		2003	-	7	-	-	12	13	-	19	13
		2004	-	10	-	-	6	21	-	16	21
		2005	-	6	-	-	2	22	-	8	22

Table 49. Continued.

			Gulf of Alaska			Bering Sea and Aleutians			All Alaska		
			Vessel length class			Vessel length class			Vessel length class		
			60-124	125-230	>230	60-124	125-230	>230	60-124	125-230	>230
Trawl	Pollock	2001	-	-	-	1	45	380	1	45	380
		2002	-	-	-	2	42	333	2	42	333
		2003	-	-	-	0	30	353	0	30	353
		2004	-	-	-	0	27	335	0	27	335
		2005	-	-	-	2	27	325	2	27	325
	Pacific cod	2001	12	7	-	32	48	14	44	54	14
		2002	4	0	-	61	57	16	65	57	16
		2003	5	1	-	63	55	17	69	56	17
		2004	8	4	-	89	101	14	97	104	14
		2005	3	-	-	56	71	12	60	71	12
	Flatfish	2001	57	14	3	126	283	47	183	297	49
		2002	57	24	5	121	286	47	177	310	53
		2003	72	38	4	101	243	41	173	281	45
		2004	29	8	0	87	256	44	116	264	44
		2005	56	10	2	79	276	55	135	286	57
	Rockfish	2001	4	18	0	0	8	6	4	26	6
		2002	3	20	0	-	8	6	3	29	6
		2003	2	22	0	0	14	6	3	36	7
		2004	3	20	1	-	8	4	3	28	5
		2005	2	21	1	-	6	5	2	27	5
	Atka mackerel.	2001	-	-	-	0	81	26	0	81	26
		2002	-	-	-	0	54	16	0	54	16
		2003	-	-	-	2	67	24	2	67	24
		2004	-	-	-	4	75	23	4	75	23
		2005	-	-	-	6	84	23	6	84	23
	All groundfish	2001	73	39	3	160	465	473	233	504	476
		2002	63	44	5	184	448	419	247	492	424
		2003	83	61	4	168	411	441	252	472	445
		2004	41	31	1	180	467	421	221	498	422
		2005	61	31	3	144	465	419	205	496	422

Table 49. Continued.

			Gulf of Alaska				Bering Sea and Aleutians				All Alaska			
			Vessel length class				Vessel length class				Vessel length class			
			<60	60-124	125-230	>230	<60	60-124	125-230	>230	<60	60-124	125-230	>230
All gear	All groundfish	2001	8	170	78	3	23	472	1413	474	31	642	1491	477
		2002	7	155	95	5	25	444	1288	419	32	599	1383	424
		2003	10	168	109	4	5	461	1348	441	15	629	1457	445
		2004	12	128	68	1	7	467	1375	421	19	595	1443	422
		2005	11	119	62	3	4	435	1393	419	15	554	1455	422

Notes: A vessel that fished more than one category in a week is apportioned a partial week based on catch weight. A target is determined based on vessel, week, processing mode, NMFS area, and gear. All groundfish include additional target categories.

Source: Blend estimates (2001-02), Catch Accounting System (2003-05), fish tickets, Norpac data, federal permit file, CFEC vessel data, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 50. Total at-sea processor vessel crew weeks in the groundfish fisheries off Alaska by month and area, 2001-05.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Gulf of Alaska	2001	339	388	274	997	945	333	941	84	85	274	-	-	4,770
	2002	234	431	582	783	790	-	1,425	311	88	426	189	-	5,287
	2003	470	265	493	991	1,023	101	922	417	279	631	-	-	5,591
	2004	452	155	348	629	366	95	1,097	96	304	33	-	-	3,599
	2005	76	72	618	919	144	77	1,306	68	264	-	-	-	3,580
Bering Sea and Aleutian Islands	2001	5,628	16,364	19,578	7,691	1,672	2,282	7,893	12,019	16,210	9,525	4,525	2,043	105,428
	2002	5,639	16,502	16,514	3,634	1,785	3,593	9,680	15,570	12,997	7,028	3,607	894	97,440
	2003	5,830	16,110	18,259	3,771	2,255	5,263	10,479	15,807	12,408	5,579	4,236	1,778	101,775
	2004	9,596	16,032	12,849	3,855	4,393	5,098	13,020	11,495	11,468	6,877	3,450	1,446	99,577
	2005	10,252	16,293	11,127	4,305	2,807	4,889	13,048	12,101	10,861	7,175	3,377	2,602	98,835
All Alaska	2001	5,966	16,752	19,852	8,687	2,616	2,615	8,833	12,103	16,295	9,798	4,589	2,091	110,197
	2002	5,872	16,933	17,095	4,417	2,575	3,606	11,104	15,880	13,085	7,453	3,795	912	102,727
	2003	6,300	16,375	18,751	4,761	3,278	5,364	11,400	16,224	12,687	6,210	4,236	1,778	107,365
	2004	10,047	16,187	13,196	4,484	4,758	5,192	14,117	11,590	11,772	6,910	3,465	1,458	103,175
	2005	10,327	16,364	11,745	5,224	2,951	4,966	14,353	12,169	11,124	7,175	3,377	2,639	102,414

Note: Crew weeks are calculated by summing weekly reported crew size over vessels and time period. These estimates include only vessels targeting groundfish counted toward federal TACs. Catcher processors accounted for the following proportions of the total crew weeks in all areas: 2001 - 90%, 2002 - 89%, 2003 - 92%, 2004 - 91%, 2005 - 92%.

Source: Weekly Processor Reports. National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 51. Numbers of vessels and plants with observers, observer-deployment days, and estimated observer costs ($1,000) by year, type of operation, gear and vessel length, 2004-05.

			2004			2005		
			Count	Obs. days	Cost	Count	Obs. days	Cost
Catcher vessels	Hook & line	60-125	43	665	233	42	623	218
	Pot	60-125	54	950	333	48	1,130	396
		>=125	14	193	68	12	114	40
		Total	68	1,143	400	60	1,244	435
	Trawl	60-125	95	3,930	1,376	92	3,534	1,237
		>=125	27	4,058	1,420	26	4,578	1,602
		Total	122	7,988	2,796	118	8,112	2,839
CV Total			233	9,796	3,429	220	9,979	3,493
Catcher/ processors	Hook & line	60-125	9	1,679	588	9	1,601	560
		>=125	30	7,395	2,588	30	7,185	2,515
		Total	39	9,074	3,176	39	8,786	3,075
	Surimi trawler	>=125	12	3,798	1,329	12	3,719	1,302
	Fillet trawler	>=125	5	1,520	532	5	1,496	524
	H&G trawler	60-125	7	640	224	7	674	236
		>=125	16	4,647	1,626	16	4,676	1,637
		Total	23	5,287	1,850	23	5,350	1,873
	Trawl Total		40	10,605	3,712	40	10,565	3,698
C/P Total			79	19,679	6,888	79	19,351	6,773
Motherships			3	1,111	389	3	1,006	352
All vessels			315	30,586	10,705	302	30,336	10,618
Shore plants			21	4,312	1,509	24	4,713	1,650
Grand totals			336	34,898	12,214	326	35,049	12,267

Note: The cost estimates are based on an estimated average cost per day of $350. This includes the payment to observer providers and the cost of transportation and board.

Source: Fisheries Monitoring and Analysis Division (FMA) observer data, Alaska Fisheries Science Center, National Marine Fisheries Service, P.O. Box 15700, Seattle, WA 98115-0070.

Table 52. Monthly Japanese landing market price of selected groundfish by species, 1991-2005, in yen/kilogram (weighted average).

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flatfish, fresh	1991	695	840	785	640	548	598	684	699	535	737	752	688
	1992	739	799	749	687	567	558	605	584	556	587	600	570
	1993	638	746	681	611	487	515	475	651	486	576	512	490
	1994	603	592	534	573	585	467	541	542	508	474	454	505
	1995	499	510	485	540	478	473	523	511	464	362	415	424
	1996	501	556	543	472	431	385	477	550	419	403	418	490
	1997	473	500	424	417	472	405	445	605	438	476	387	474
	1998	434	482	403	337	391	432	505	567	451	397	404	486
	1999	433	446	427	397	372	394	417	506	366	346	365	467
	2000	447	469	474	391	335	323	446	497	436	464	441	490
	2001	567	587	565	459	398	401	452	506	466	495	483	572
	2002	596	531	523	477	417	441	541	526	405	532	547	499
	2003	643	562	508	420	335	314	379	349	327	366	395	445
	2004	484	573	451	346	344	268	265	373	316	359	465	459
	2005	439	498	446	403	326	247	332	374	373	410	535	572
Cod, fresh	1991	296	279	216	148	124	137	136	128	173	261	398	366
	1992	332	316	180	164	128	119	135	134	175	221	366	299
	1993	281	285	207	167	118	128	154	215	175	305	319	366
	1994	261	272	170	132	98	129	117	115	204	311	288	287
	1995	244	185	188	103	64	110	146	146	197	257	401	315
	1996	296	235	153	83	68	72	176	149	205	273	304	289
	1997	235	174	157	111	105	82	192	177	134	330	269	311
	1998	234	167	150	104	88	94	173	172	115	211	289	368
	1999	284	276	180	153	109	115	148	154	103	225	315	352
	2000	299	256	205	146	104	103	169	162	143	238	329	370
	2001	418	246	176	134	96	91	124	254	195	305	387	499
	2002	453	398	253	156	135	142	216	185	223	434	542	476
	2003	407	335	293	203	126	166	218	180	232	309	306	462
	2004	402	261	200	151	130	95	215	247	202	341	358	447
	2005	257	169	165	185	130	110	192	178	175	300	350	449
Cod, frozen	1991	331	290	307	325	312	342	-	332	391	410	456	440
	1992	369	324	281	251	264	270	298	322	339	348	315	163
	1993	278	148	171	164	206	288	259	148	329	387	260	278
	1994	309	258	112	245	264	124	217	258	258	246	264	228
	1995	232	182	154	177	196	109	135	184	138	134	259	249
	1996	265	220	183	211	146	201	247	326	213	292	299	262
	1997	199	210	200	184	131	211	223	133	214	225	195	148
	1998	185	137	137	217	138	231	239	401	333	296	266	249
	1999	298	257	215	302	220	237	218	266	315	266	283	243
	2000	241	202	179	203	199	211	208	283	247	298	273	212

Note: Prices for frozen cod are not reported after year 2000.

Table 52. Continued.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alaska pollock, fresh	1990	121	121	76	64	57	58	55	57	50	53	66	94
	1991	150	172	168	108	81	87	91	111	89	115	135	146
	1992	144	201	132	68	35	33	59	64	51	57	64	74
	1993	107	157	141	91	54	56	51	51	37	60	62	72
	1994	76	125	118	88	45	46	52	51	44	55	67	74
	1995	104	132	131	101	40	38	66	59	40	47	74	72
	1996	90	120	110	77	33	27	63	46	42	41	54	91
	1997	126	122	110	97	69	65	55	48	33	45	51	70
	1998	80	85	91	86	35	26	37	35	26	33	56	52
	1999	73	86	76	78	42	36	40	24	21	31	46	53
	2000	96	79	96	87	51	51	81	55	27	46	109	129
	2001	109	127	91	90	60	46	60	80	34	62	105	111
	2002	93	108	104	64	56	56	100	106	36	60	93	105
	2003	114	99	71	61	59	69	116	82	35	46	55	79
	2004	91	112	64	48	46	48	141	119	36	49	76	95
	2005	142	112	76	79	71	64	159	121	47	60	86	120
Atka mackerel, fresh	1990	42	54	45	50	42	48	59	61	57	64	79	85
	1991	65	93	111	90	101	120	168	143	93	79	80	57
	1992	47	36	65	85	88	91	136	95	87	94	84	48
	1993	66	41	33	33	24	44	57	56	40	66	46	26
	1994	25	28	21	20	28	30	49	50	42	49	35	30
	1995	35	31	29	29	37	49	109	98	39	36	27	19
	1996	21	22	29	40	51	40	95	69	40	46	69	28
	1997	36	40	40	44	55	59	114	79	48	44	27	30
	1998	23	31	23	22	26	26	25	28	23	32	35	27
	1999	43	44	32	36	38	57	78	88	40	35	29	17
	2000	26	23	22	20	27	34	52	44	42	43	47	49
	2001	44	38	32	32	51	58	106	75	54	35	34	31
	2002	28	28	29	38	57	60	67	66	32	30	36	28
	2003	30	28	28	26	40	47	55	32	20	21	20	15
	2004	16	21	20	26	37	33	26	28	33	17	25	27
	2005	47	29	33	38	70	105	133	80	39	35	36	35
Rockfish, fresh	1990	2058	1975	1919	1896	1803	2049	2316	1961	1643	1948	2017	2231
	1991	2328	2054	2074	1937	2035	2145	2553	2328	2003	2320	2513	2630
	1992	2992	2653	3281	2204	1951	2174	2383	2307	1786	2177	2808	2613
	1993	2847	2987	2452	2480	2053	2004	2050	2140	1783	2010	2445	2633
	1994	2687	2861	1944	2363	2205	2433	2230	2118	2069	2075	2323	2778
	1995	3214	2725	2360	2545	2142	1993	2234	2189	2149	2373	3179	3119
	1996	3471	3586	3510	2630	2321	2188	2234	2374	2419	3012	3073	3414
	1997	3770	4240	3281	2699	2760	2384	2472	2475	2873	3117	2943	3433
	1998	3348	3753	3365	2721	2729	2790	2675	2574	2636	2831	2238	2181
	1999	4518	3750	3872	2935	2992	3041	3324	2634	2951	2512	1736	3035
	2000	4049	3932	2934	3061	2645	2620	3292	2419	2734	2777	3112	3270

Note: Prices for fresh rockish are not reported after year 2000.

Source: Monthly Statistics of Agriculture, Forestry & Fisheries, Stat. and Info. Dept., Ministry of Agriculture, Forestry & Fisheries, Government of Japan. Available from Alaska Fisheries Science Center P.O. Box 15700, Seattle, WA 98115-0070.

Table 53. Monthly Tokyo wholesale prices of selected products, 1992-2005, in yen/kilogram (weighted average).

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flatfish, frozen	1992	499	486	517	511	530	491	423	433	499	437	460	413
	1993	412	386	404	427	431	447	431	406	418	423	407	414
	1994	423	426	403	450	460	433	470	394	414	433	422	455
	1995	446	435	450	455	427	443	447	464	440	466	475	500
	1996	478	478	467	520	532	544	575	550	562	550	565	580
	1997	538	535	535	536	506	533	512	530	509	508	528	540
	1998	482	473	511	505	519	514	509	544	524	518	457	447
	1999	471	460	475	516	516	490	524	533	469	484	507	514
	2000	468	467	456	491	483	483	522	448	492	470	476	509
	2001	464	466	470	486	478	477	505	530	513	499	509	521
	2002	467	493	516	521	527	531	507	547	546	504	521	530
	2003	544	522	563	551	580	606	603	607	610	600	626	632
	2004	579	593	567	604	610	586	585	612	596	578	602	599
	2005	586	598	595	596	598	604	648	653	670	691	684	677
Cod, frozen	1992	798	741	774	770	764	741	750	726	734	665	658	647
	1993	643	663	670	671	666	707	614	602	604	587	639	644
	1994	610	612	635	648	625	614	665	700	633	652	656	656
	1995	644	646	628	649	623	583	571	605	614	527	458	567
	1996	586	603	636	689	657	677	715	561	584	624	545	590
	1997	484	539	598	613	651	560	610	638	609	555	484	503
	1998	452	469	508	532	578	596	589	616	598	571	520	565
	1999	603	574	624	678	691	751	728	667	567	559	520	542
	2000	477	545	616	629	610	621	628	555	641	516	508	512
	2001	489	501	582	609	634	573	606	627	619	573	618	530
	2002	579	589	641	756	674	625	761	806	814	714	671	710
	2003	670	679	591	599	657	620	706	796	717	684	669	719
	2004	216	442	558	719	252	314	712	737	733	655	515	603
	2005	620	576	733	837	872	972	984	925	810	826	814	727
Surimi	1992	683	624	591	541	576	555	504	438	443	438	445	415
	1993	360	340	347	348	364	350	367	326	332	295	295	309
	1994	322	315	309	302	311	320	309	316	310	319	333	350
	1995	340	337	332	335	338	341	356	343	368	353	348	335
	1996	334	319	314	330	303	342	334	286	308	309	347	321
	1997	356	345	340	351	374	388	383	381	402	391	401	402
	1998	389	339	354	337	329	339	333	328	313	313	319	334
	1999	315	331	328	339	340	346	337	323	339	351	339	330
	2000	321	312	298	307	303	297	304	275	289	276	286	294
	2001	276	281	282	273	271	272	275	267	268	290	297	298
	2002	301	299	303	299	311	317	303	316	302	318	324	339
	2003	313	294	295	296	285	272	276	274	272	272	282	271
	2004	275	275	262	258	269	266	278	262	257	275	273	297
	2005	282	291	295	303	310	297	300	310	319	345	381	357

Note: From 1992-95 prices are for six large cities wholesale market, and from 1996-2005 prices are for ten large cities wholesale market.

Source: Monthly Statistics of Agriculture, Forestry & Fisheries, Stat. and Info. Dept., Ministry of Agriculture, Forestry & Fisheries, Government of Japan. Available from Alaska Fisheries Science Center P.O. Box 15700, Seattle, WA 98115-0070.

Table 54. U.S. imports of groundfish fillets, steaks and blocks, 1976-2005, quantity in million lb. product weight and value in million dollars.

Year	Fillets & Steaks		Blocks		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1976	337	$273	379	$211	716	$484
1977	321	305	385	292	706	597
1978	333	341	406	325	739	666
1979	340	385	408	337	748	722
1980	297	341	336	289	633	630
1981	346	415	344	301	690	716
1982	371	458	319	274	690	732
1983	355	449	384	339	739	788
1984	373	459	316	263	689	722
1985	388	500	334	275	722	775
1986	366	542	364	380	730	922
1987	408	759	403	539	812	1,298
1988	323	568	303	382	626	950
1989	333	578	282	325	616	903
1990	262	482	264	373	526	856
1991	255	526	290	444	545	970
1992	221	437	229	304	450	741
1993	236	452	212	219	447	671
1994	229	433	200	184	428	617
1995	232	437	210	213	442	650
1996	223	407	234	213	457	620
1997	219	426	234	231	453	657
1998	236	460	233	271	469	731
1999	272	550	214	250	486	801
2000	284	545	204	209	488	753
2001	243	462	147	159	389	621
2002	283	531	147	165	430	695
2003	292	531	129	139	422	670
2004	326	571	135	153	462	724
2005	341	615	139	169	480	784

Source: National Marine Fisheries Service, Office of Science and Technology, Fisheries Statistics Division. www.st.nmfs.noaa.gov/st1/trade/documents/TRADE2005.pdf

Table 55. U.S. per capita consumption of fish and shellfish, 1974-2005, population in millions and consumption in pounds, edible weight.

Year	Total civilian population	Per capita consumption			
		Fresh and Frozen	Canned	Cured	Total
1974	211.6	6.9	4.7	.5	12.1
1975	213.8	7.5	4.3	.4	12.2
1976	215.9	8.2	4.2	.5	12.9
1977	218.1	7.7	4.6	.4	12.7
1978	220.5	8.1	5.0	.3	13.4
1979	223.0	7.8	4.8	.4	13.0
1980	225.6	7.9	4.3	.3	12.5
1981	227.8	7.8	4.6	.3	12.7
1982	230.0	7.9	4.3	.3	12.5
1983	232.1	8.4	4.7	.3	13.4
1984	234.1	9.0	4.9	.3	14.2
1985	236.2	9.8	5.0	.3	15.1
1986	238.4	9.8	5.4	.3	15.5
1987	240.6	10.7	5.2	.3	16.2
1988	242.8	10.0	4.9	.3	15.2
1989	245.1	10.2	5.1	.3	15.6
1990	247.8	9.6	5.1	.3	15.0
1991	250.5	9.7	4.9	.3	14.9
1992	253.5	9.9	4.6	.3	14.8
1993	256.4	10.2	4.5	.3	15.0
1994	259.2	10.4	4.5	.3	15.2
1995	261.4	10.0	4.7	.3	15.0
1996	264.0	10.0	4.5	.3	14.8
1997	266.4	9.9	4.4	.3	14.6
1998	269.1	10.2	4.4	.3	14.9
1999	271.5	10.4	4.7	.3	15.4
2000	280.9	10.2	4.7	.3	15.2
2001	283.6	10.3	4.2	.3	14.8
2002	287.1	11.0	4.3	.3	15.6
2003	289.6	11.4	4.6	.3	16.3
2004	292.4	11.8	4.5	.3	16.6
2005	295.3	11.6	4.3	.3	16.2

Note: Per capita consumption represents pounds of edible meat consumed from domestically caught and imported fish and shellfish adjusted for beginning and ending inventories (through 2002) and exports, divided by the civilian resident population of the United States as of 1 July of each year. Population estimates for 1980-91 were revised to reflect changes from the 1990 decennial population enumeration. Changes did not significantly alter pounds per capita.

Source: U.S. Department of Commerce, Bureau of the Census, Washington, D.C. 20233; and Fisheries of the United States, National Marine Fisheries Service, Fisheries Statistics Division, 1315 East-West Highway, Silver Spring, MD 20910, various issues.

Table 56. U.S. consumption of all fillets and steaks, and fish sticks and portions, total in 1,000 lb. and per capita in pounds, product weight, 1980-2005.

Year	Fillets and steaks[1]		Fish sticks and portions	
	Total[2]	Per capita	Total[2]	Per capita
1980	541,440	2.4	451,200	2.0
1981	546,720	2.4	410,040	1.8
1982	575,000	2.5	391,000	1.7
1983	626,670	2.7	417,780	1.8
1984	702,300	3.0	421,380	1.8
1985	755,840	3.2	425,160	1.8
1986	810,560	3.4	429,120	1.8
1987	866,160	3.6	409,020	1.7
1988	776,960	3.2	364,200	1.5
1989	759,810	3.1	367,650	1.5
1990	768,180	3.1	371,700	1.5
1991	751,500	3.0	300,600	1.2
1992	735,150	2.9	228,150	0.9
1993	743,560	2.9	256,400	1.0
1994	803,520	3.1	233,280	0.9
1995	758,060	2.9	313,680	1.2
1996	792,000	3.0	264,000	1.0
1997	799,200	3.0	266,400	1.0
1998	861,120	3.2	242,190	0.9
1999	868,800	3.2	271,500	1.0
2000	1,011,240	3.6	252,810	0.9
2001	1,049,320	3.7	226,880	0.8
2002	1,177,110	4.1	229,680	0.8
2003	1,245,280	4.3	202,720	0.7
2004	1,345,040	4.6	204,680	0.7
2005	1,476,500	5.0	265,770	0.9

[1] Series revised in 1993 to reflect deduction of fillet production used to produce blocks, exports of foreign fillets and steaks, and changes in population estimates from 1990 decennial population enumeration.

[2] Per capita multiplied by total U.S. population.

Source: Computed from data from U.S. Department of Commerce, Bureau of the Census; and Fisheries of the United States, National Marine Fisheries Service, Fisheries Statistics Division, 1315 East-West Highway, Silver Spring, MD 20910, various issues.

Table 57. Annual U.S. economic indicators: Selected producer and consumer price indexes and gross domestic product implicit price deflator, 1976-2005.

Year	Producer Price Index[1]					Consumer Price Index[2]				GDP Deflator[3]
	All items	Meat	Poultry	Fish	Petrol. Products	All Items	Meat	Poultry	Fish	
1976	61.1	69.3	93.0	64.5	36.3	56.9	66.4	76.4	60.2	40.39
1977	64.9	68.1	97.0	69.7	40.5	60.6	64.9	76.9	66.6	42.92
1978	69.9	83.6	108.6	74.1	42.2	65.2	77.0	84.9	73.0	46.07
1979	78.7	93.3	105.6	90.9	58.4	72.6	90.1	89.1	80.1	50.12
1980	89.8	94.1	108.2	87.8	88.6	82.4	92.7	93.7	87.5	54.56
1981	98.0	95.4	108.2	89.4	105.9	90.9	96.0	97.5	94.8	59.64
1982	100.0	100.0	100.0	100.0	100.0	96.5	100.7	95.8	98.2	63.18
1983	101.3	94.3	103.7	105.4	89.9	99.6	99.5	97.0	99.3	65.52
1984	103.7	94.5	115.3	112.7	87.4	103.9	99.8	107.3	102.5	67.95
1985	103.2	90.9	110.4	114.6	83.2	107.6	98.9	106.2	107.5	69.84
1986	100.2	93.9	116.8	124.9	53.2	109.6	102.0	114.2	117.4	71.43
1987	102.8	100.4	103.5	140.0	56.8	113.6	109.6	112.6	129.9	73.43
1988	106.9	99.9	111.6	148.7	53.9	118.3	112.2	120.7	139.4	76.14
1989	112.2	104.8	120.4	142.9	61.2	124.0	116.7	132.7	143.6	78.88
1990	116.3	117.0	113.6	147.2	74.8	130.7	128.5	132.5	146.7	82.03
1991	116.5	113.5	109.9	149.5	67.2	136.2	132.5	131.5	148.3	84.76
1992	117.2	106.7	109.0	156.1	64.7	140.3	130.7	131.4	151.7	86.58
1993	118.9	110.6	111.7	156.5	62.0	144.5	134.6	136.9	156.6	88.57
1994	120.4	104.7	114.7	161.4	59.1	148.2	135.4	141.5	163.7	90.53
1995	124.7	102.9	114.2	170.8	60.8	152.4	135.5	143.5	171.6	92.29
1996	127.7	109.0	119.7	165.9	70.1	156.9	140.2	152.4	173.1	93.95
1997	127.6	111.6	117.4	178.1	68.0	160.5	144.4	156.6	177.1	95.53
1998	124.4	101.3	120.8	183.2	51.3	163.0	141.6	157.1	181.7	96.60
1999	125.5	104.6	114.0	190.9	60.9	166.6	142.3	157.9	185.3	98.01
2000	132.7	114.3	112.9	198.1	91.3	172.2	150.7	159.8	190.4	100.26
2001	134.2	120.3	116.8	190.8	85.3	177.1	159.3	164.9	191.1	102.68
2002	131.1	113.4	111.3	191.2	79.5	179.9	160.3	167.0	188.1	104.33
2003	138.1	128.2	116.6	195.3	97.7	184.0	169.0	169.1	190.0	106.61
2004	146.7	134.9	130.2	206.3	119.9	188.9	183.2	181.7	194.3	109.73
2005	157.4	139.0	128.6	222.6	165.0	195.3	187.5	185.3	200.1	113.12

[1] Index 1982 = 100.
[2] Index 1982-84 = 100.
[3] Index 2000 = 100. GDP deflators are the values published for 1 July (second quarter) of each year.

Source: Producer prices and price indexes, and consumer price indexes: U.S. Department of Labor, Bureau of Labor Statistics, http://www.bls.gov/data/sa.htm; GDP deflators: U.S. Department of Commerce, Bureau of Economic Analysis, http://research.stlouisfed.org/fred2/series/GDPDEF

Table 58. Monthly U.S. economic indicators: Selected producer and consumer price indexes, 2003-05.

Month	Producer Price Index[1]					Consumer Price Index[2]			
	All Items	Meat	Poultry	Fish	Petrol. Products	All Items	Meat	Poultry	Fish
2003									
Jan	135.3	118.0	109.6	190.5	93.1	181.7	159.5	165.4	187.8
Feb	137.6	119.6	112.8	192.6	110.6	183.1	163.2	167.2	189.4
Mar	141.2	120.4	113.9	197.6	118.4	184.2	163.6	167.6	186.8
Apr	136.8	121.6	113.1	214.5	95.7	183.8	164.1	168.2	187.3
May	136.7	123.9	114.4	199.7	88.1	183.5	164.0	165.9	189.6
Jun	138.0	131.3	115.6	196.0	92.3	183.7	166.6	167.7	191.2
Jul	137.7	126.5	116.8	192.9	95.1	183.9	168.0	168.9	189.5
Aug	138.0	128.1	118.3	194.5	100.0	184.6	169.2	169.0	191.8
Sep	138.5	131.2	120.0	197.2	97.8	185.2	171.0	169.7	191.0
Oct	139.3	144.4	120.6	190.5	96.3	185.0	174.6	172.5	190.5
Nov	138.9	138.8	121.2	185.7	91.6	184.5	181.3	172.5	192.5
Dec	139.5	134.4	122.2	191.7	92.8	184.3	182.7	174.4	192.5
2004									
Jan	141.4	124.8	122.5	208.5	103.6	185.2	180.6	174.5	194.1
Feb	142.1	124.5	130.9	207.2	103.7	186.2	180.2	174.1	193.2
Mar	143.1	128.6	132.5	215.8	108.0	187.4	179.0	177.8	190.6
Apr	144.8	134.5	133.6	201.2	114.2	188.0	179.0	178.1	192.8
May	146.8	141.8	137.8	197.2	123.4	189.1	182.1	181.6	193.9
Jun	147.2	143.8	137.7	189.9	115.7	189.7	184.2	182.6	193.4
Jul	147.4	138.6	136.7	198.6	122.2	189.4	185.8	184.9	195.6
Aug	148.0	136.5	132.7	206.6	122.9	189.5	185.7	186.8	194.1
Sep	147.7	133.7	127.5	205.6	125.2	189.9	185.9	186.4	195.1
Oct	150.0	137.5	123.8	207.3	142.8	190.9	185.0	186.9	195.8
Nov	151.4	136.0	123.1	219.2	136.6	191.0	185.2	183.4	196.5
Dec	150.2	138.8	124.1	218.9	120.8	190.3	185.6	183.3	196.9
2005									
Jan	150.9	139.5	124.0	209.1	126.2	190.7	185.9	183.8	199.4
Feb	151.6	141.5	128.6	226.2	133.0	191.8	187.2	182.0	196.9
Mar	153.7	143.0	128.4	236.1	148.6	193.3	187.6	185.0	196.2
Apr	155.0	141.9	127.9	221.3	155.3	194.6	188.3	184.1	199.4
May	154.3	145.5	130.0	222.9	151.3	194.4	189.1	183.7	198.6
Jun	154.3	139.9	129.5	200.3	156.9	194.5	189.2	184.9	199.5
Jul	156.3	135.4	131.5	210.1	169.6	195.4	187.7	185.9	199.7
Aug	157.6	134.2	131.4	212.1	179.5	196.4	187.0	186.9	200.4
Sep	162.2	135.0	132.7	220.4	200.7	198.8	186.8	188.9	200.4
Oct	166.2	137.3	131.5	241.8	214.9	199.2	186.6	186.5	202.0
Nov	163.7	136.6	126.2	229.1	171.5	197.6	187.3	187.6	204.1
Dec	163.0	138.2	121.5	242.3	172.1	196.8	187.8	183.8	204.4

[1] Index 1982 = 100.
[2] Index 1982-84 = 100.

Source: U.S. Department of Labor, Bureau of Labor Statistics, http://www.bls.gov/data/sa.htm

Table 59. Annual foreign exchange rates for selected countries, 1976-2005, in national currency units per U.S.dollar.

Year	Canada (dollar)	Denmark (kroner)	Japan (yen)	ROK (won)	New Zealand (dollar)	Iceland (kronur)	Norway (kroner)	U.K. (pound)
1976	0.9860	6.0450	296.55	484.00	1.0036	1.822	5.4565	0.5536
1977	1.0635	6.0032	268.51	484.00	1.0301	1.989	5.3235	.5729
1978	1.1407	5.5146	210.44	484.00	.9636	2.711	5.2423	.5210
1979	1.1714	5.2610	219.14	484.00	.9776	3.526	5.0641	.4713
1980	1.1692	5.6359	226.74	607.43	1.0265	4.798	4.9392	.4299
1981	1.1989	7.1234	220.54	681.03	1.4194	7.224	5.7395	.4931
1982	1.2337	8.3324	249.08	731.08	1.3300	12.352	6.4540	.5713
1983	1.2324	9.1450	237.51	775.75	1.4952	24.843	7.2964	.6592
1984	1.2951	10.3566	237.52	805.98	1.7286	31.694	8.1615	.7483
1985	1.3655	10.5964	238.54	870.02	2.0064	41.508	8.5970	.7714
1986	1.3895	8.0910	168.52	881.45	1.9088	41.104	7.3947	.6971
1987	1.3260	6.8400	144.64	822.57	1.6886	38.677	6.7375	.6102
1988	1.2307	6.7320	128.15	731.47	1.5244	43.104	6.5170	.5614
1989	1.1840	7.3100	137.96	671.46	1.6708	57.042	6.9045	.6099
1990	1.1668	6.1890	144.79	707.76	1.6750	58.284	6.2597	.5603
1991	1.1457	6.3960	134.71	733.35	1.7265	58.996	6.4829	.5652
1992	1.2087	6.0360	126.65	780.65	1.8580	57.546	6.2145	.5664
1993	1.2901	6.4840	111.20	802.67	1.8494	67.603	7.0941	.6658
1994	1.3656	6.3610	102.21	803.44	1.6844	69.944	7.0576	.6529
1995	1.3724	5.6020	94.06	771.27	1.5235	64.692	6.3352	.6335
1996	1.3635	5.7990	108.78	804.45	1.4540	66.500	6.4498	.6400
1997	1.3849	6.6092	121.06	950.77	1.5094	70.904	7.0857	.6106
1998	1.4835	6.7008	130.91	1401.44	1.8683	70.958	7.5451	.6038
1999	1.4858	6.9900	113.73	1189.84	1.8889	72.474	7.8071	.6184
2000	1.4855	8.0953	107.80	1130.90	2.1805	78.896	8.8131	.6598
2001	1.5487	8.3323	121.57	1292.01	2.3798	97.690	8.9964	.6946
2002	1.5704	7.8862	125.22	1250.31	2.1529	91.669	7.9839	.6656
2003	1.4013	6.5800	115.97	1192.08	1.7185	76.780	7.0819	.6120
2004	1.3017	5.9891	108.15	1145.24	1.5053	70.261	6.7399	.5456
2005	1.2115	5.9953	110.11	1023.75	1.4186	62.919	6.4412	.5493

ROK – Republic of Korea; U.K. – United Kingdom.

Source: Through 1998: International Financial Statistics, International Monetary Fund, Washington, D.C.; 1999-2005 (except Iceland): U.S. Federal Reserve Board, www.federalreserve.gov; Iceland, 1999-2005: www.oanda.com

Table 60. Monthly foreign exchange rates for selected countries, 2003-05, in national currency units per U.S. dollar.

Month	Canada (dollar)	Denmark (kroner)	Japan (yen)	ROK (won)	New Zealand (dollar)	Iceland (kronur)	Norway (kroner)	U.K. (pound)
2003								
Jan	1.541	7.00	118.8	1176.5	1.853	79.87	6.91	.618
Feb	1.512	6.89	119.3	1190.4	1.805	77.76	7.00	.622
Mar	1.476	6.88	118.7	1237.2	1.806	78.22	7.28	.632
Apr	1.458	6.84	119.9	1231.1	1.812	76.97	7.20	.635
May	1.384	6.43	117.4	1201.2	1.737	73.23	6.81	.616
Jun	1.353	6.36	118.3	1194.1	1.720	74.06	7.01	.602
Jul	1.382	6.54	118.7	1181.2	1.705	77.19	7.29	.616
Aug	1.396	6.67	118.7	1178.6	1.716	79.76	7.41	.627
Sep	1.363	6.60	114.8	1165.4	1.711	79.16	7.28	.619
Oct	1.322	6.34	109.5	1169.3	1.661	76.27	7.03	.596
Nov	1.313	6.35	109.2	1186.4	1.591	75.81	7.01	.592
Dec	1.314	6.06	107.8	1192.4	1.546	73.14	6.72	.571
2004								
Jan	1.2958	5.8952	106.27	1183.4	1.484	69.71	6.81	.548
Feb	1.3299	5.8956	106.71	1167.5	1.446	68.73	6.95	.536
Mar	1.3286	6.0757	108.52	1166.3	1.514	71.28	6.96	.548
Apr	1.3420	6.2104	107.66	1152.9	1.559	72.91	6.93	.555
May	1.3789	6.2021	112.20	1177.9	1.626	73.48	6.84	.560
Jun	1.3578	6.1220	109.43	1159.0	1.591	72.12	6.83	.547
Jul	1.3225	6.0631	109.49	1158.7	1.546	71.56	6.91	.542
Aug	1.3127	6.1007	110.23	1158.0	1.524	71.50	6.84	.549
Sep	1.2881	6.0866	110.09	1148.7	1.517	71.83	6.84	.558
Oct	1.2469	5.9486	108.78	1141.6	1.461	70.10	6.58	.553
Nov	1.1968	5.7178	104.70	1086.4	1.427	67.09	6.27	.537
Dec	1.2189	5.5449	103.81	1050.4	1.399	62.83	6.14	.519
2005								
Jan	1.2248	5.6699	103.34	1038.0	1.415	62.56	6.27	.532
Feb	1.2401	5.7195	104.94	1023.1	1.398	62.16	6.40	.530
Mar	1.2160	5.6488	105.25	1007.8	1.370	60.07	6.21	.525
Apr	1.2359	5.7554	107.19	1010.1	1.387	62.24	6.31	.527
May	1.2555	5.8628	106.60	1001.8	1.391	64.90	6.37	.539
Jun	1.2402	6.1247	108.75	1012.5	1.412	65.26	6.49	.550
Jul	1.2229	6.1943	111.95	1036.6	1.473	65.21	6.58	.571
Aug	1.2043	6.0665	110.61	1021.7	1.438	63.82	6.44	.557
Sep	1.1777	6.0973	111.24	1029.8	1.431	62.20	6.38	.554
Oct	1.1774	6.2064	114.87	1045.9	1.432	60.98	6.51	.567
Nov	1.1815	6.3277	118.45	1040.8	1.450	61.87	6.64	.576
Dec	1.1615	6.2844	118.46	1022.4	1.439	63.68	6.72	.573

ROK – Republic of Korea; U.K. – United Kingdom.

Source: U.S. Federal Reserve Board, www.federalreserve.gov, except that exchange rates for Iceland are from www.oanda.com

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Ongoing Work: Project Summaries and Reports

The Nonconsumptive Value of Steller Sea Lion Protection

Dan Lew*
*For further information, contact Dan.Lew@NOAA.gov

Steller sea lions (*Eumetopias jubatus*) live in the North Pacific Ocean and consist of two distinct populations, the Western stock and Eastern stock, which are separated at 144° W longitude. As a result of large declines in the populations since at least the early 1970s, in April 1990 the Steller sea lion (SSL) was listed as threatened throughout its range under the Endangered Species Act (ESA) of 1973 (16 U.S.C. 35). The decline continued through 2000 for the Western stock in Alaska, which was declared endangered in 1997, while the Eastern stock remains listed as threatened. Both the Western and Eastern stocks are also listed as depleted under the Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. 1362).

NMFS is the primary agency responsible for the protection of marine mammals, including Steller sea lions. Multiple management actions have been taken (e.g., 68 FR 204, 68 FR 24615, 69 FR 75865), and are being contemplated, by NMFS and the North Pacific Fishery Management Council to protect and aid the recovery of the SSL populations. These actions differ in the form they take (limits on fishing to increase the stock of fish available for Steller sea lions to eat, area restrictions to minimize disturbances, etc.), which stock is helped, when and how much is done, and their costs. In deciding between these management actions, policy makers must balance the ESA and MMPA goals of protecting Steller sea lions from further declines with providing for sustainable and economically viable fisheries under the Magnuson-Stevens Fishery Conservation Act (P.L. 94-265). Since Steller sea lion protection is linked to fishery regulations, decision makers must comply with several federal laws and executive orders in addition to the ESA and MMPA, including Executive Order 12866 (58 FR 51735), which requires regulatory agencies to consider costs and benefits in deciding among alternative management actions, including changes to fishery management plans made to protect Steller sea lions.

Public preferences for providing protection to the endangered Western and threatened Eastern stocks of Steller sea lions are primarily the result of the non-consumptive value people attribute to Stellar sea lions. Little is known about these preferences, yet such information is needed for decision makers to more fully understand the trade-offs involved in choosing between management alternatives. The amount the public is willing to pay for increased Steller sea lion stock sizes or changes in listing status, as well as preferences for geographic distribution, is information that can aid decision makers to evaluate protection actions and more efficiently manage and protect these resources, but is not currently known.

NMFS is conducting a study to collect information that can provide insights into public values for protecting Steller sea lions. During 2004 and 2005, a survey instrument was developed with the assistance of experts in non-market valuation, environmental economics, and survey research, as well as fisheries scientists and researchers who study Steller sea lions. It was extensively tested using qualitative focus groups and one-on-one cognitive interviews conducted in Seattle, WA, Denver, CO, Sacramento, CA, Rockville, MD, and Anchorage, AK. During 2006, a formal pretest implementation was conducted and the survey instrument is currently being revised to reflect updated information about Steller sea lions. The final survey implementation will follow upon Office of Management and Budget (OMB) approval and will follow a modified Dillman Tailored

Design Method to maximize response.

Since threatened and endangered (T&E) species, like Steller sea lions, are not traded in observable markets, standard market-based approaches to estimate their economic value cannot be applied. As a result, studies that attempt to estimate these values must rely on survey-based non-market valuation methods, which involve asking individuals to reveal their preferences or values for non-market goods, such as the protection of T&E species, through their responses to questions in hypothetical market situations. One particular SP method, the contingent valuation (CV) method, has been the dominant approach for valuing T&E species. Although contingent valuation has been subject to much criticism, the NOAA Panel on Contingent Valuation found that despite its problems, "a well-conducted CV study provides an adequately reliable benchmark" (Arrow *et al.*, 1993) to begin discussions on appropriate values.

This study employs a choice experiment (CE), or stated choice, approach for eliciting economic values for Steller sea lions.[1] CE methods are relatively new to the valuation of environmental goods, despite having a long history in the marketing and transportation fields (e.g., Louviere [1992]).[2] A typical CE involves presenting respondents with two or more choice questions, each having a set of alternatives that differ in attributes. For each question, respondents are asked to select the alternative they like best. The choice responses are used to estimate a preference function that depends upon the levels of the attributes.

Stated choice data collected through the survey will be used by NMFS to estimate a preference function for explaining choices between protection programs that differ in the levels of population sizes, ESA listing status, geographic distribution, and costs. This estimated function will provide NMFS and the NPFMC with information on public preferences and values for alternative Steller sea lion protection programs, and how several factors affect these values. This information can then be compared with program costs and other impacts when evaluating protection alternatives.

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The Demand for Halibut Sport Fishing Trips in Alaska

Dan Lew*
**For further information, contact Dan.Lew@NOAA.gov*

The National Marine Fisheries Service (NMFS) is the agency responsible for collecting and analyzing scientific data on the Nation's living marine resources, and for managing the Alaska halibut sport fishery. Under the Magnuson-Stevens Fishery Conservation and Management Act (see Section 303), Executive Order 12962 (Marine Recreational Fishery Statistics, Section 1(h)), and Executive Order 12866 (Section 1(b)(6)), NMFS is required to provide economic analyses of Federal management actions and policies to improve the Nation's fisheries. This data collection project will meet these statutory and administrative requirements by providing resource managers with the information necessary to understand the likely future impacts of management actions on the Alaska halibut sport fishery.

The halibut sport fishery in Alaska is quite large. In 2000, for instance, over 400,000 halibut were harvested by sport anglers in the state (Walker, et al., 2003). In recent years, several regulatory changes have been proposed that could significantly impact the sport fishery. In August 2003, a guideline harvest limit (GHL) policy was implemented to regulate the Pacific halibut guided recreational fishery in Alaska. This policy sets a limit on the amount of halibut that can be harvested by the guided recreational fishery and establishes a process for the North Pacific Fishery Management Council (Council) to initiate harvest restrictions in the event that the limit is met or exceeded. Numerous harvest restrictions may be adopted by the Council in the event the GHL is surpassed, including reducing the allowable catch. Catch by non-charter boat recreational halibut anglers are not subject to the GHL and are accommodated through reductions in the commercial TAC. To assess the impacts of pending and potential regulatory changes on sport angler behavior, it is necessary to have estimates of the baseline demand for halibut fishing trips and an understanding of the factors that affect it.

To this end, a project is currently underway to develop and implement a survey that collects information about saltwater recreational fishing trips in Alaska. The project consists of three major phases. The first phase involves developing and pretesting the survey instrument. This phase includes testing the survey instrument using focus groups, cognitive interviews, and a formal pretest survey implementation. These activities were completed in 2006 following OMB approval. It is currently undergoing final revisions and will be implemented through a mail survey of Alaska sport anglers during the second phase of the project. The survey implementation will follow a modified Dillman Tailored Design Method to maximize response. In the final phase of the project, data will be analyzed and results reported.

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Integrating Trip and Haul-Level Fishing Data

Alan Haynie*

**For further information, contact Alan.Haynie@noaa.gov*

An important area of work for the AFSC ESSRP is the collection of economic data that allows us to better understand and predict the behavior of fishermen and fishing enterprises. One area of data improvement that we have been pursuing over the last few years is an effort to integrate Observer Program data, which is at the haul level, with other sources of data on fishing trips such as where vessels choose to go when they depart and return to port. The following four projects briefly describe our recent efforts in this area.

Combining fish ticket and observer data to describe trips for pollock catcher vessels

One component of these efforts involves linking observer and fish ticket data for observed catcher vessels. In some cases this is straightforward but there are complications because it is not always clear if a haul is associated with a trip before or after a landing. For example, if there is a haul on Friday and Trip 1 ends on Friday and trip 2 starts on Friday, it’s ambiguous where to assign the haul. For pollock, we’ve developed a dataset from 1991-2005 that excluded the ambiguous hauls. This year we will develop similar datasets for all fisheries and attempt to resolve some of the ambiguous hauls with additional information, such as VMS data.

Designed trip-level data collection program with FMA

In order to resolve the ambiguity of the process described above, we have worked with FMA to record the start and end of observed fishing trips. As well as allowing us to clearly assign observed hauls to trips, we will record information about that nature of time delays on trips (e.g. weather, mechanical problems).

Obtained Product Transfer Reports (PTR) from NMFS Enforcement

PTR are required when vessels transfer products to ports or trampers. This information allows us to observe when vessels return to port and to assign catch from catch-processor hauls to the appropriate vessel trip. Because CPs are not required to file fish tickets, this provides our first systematic record of CP trip-taking behavior.

Started examining fleet behavior with Vessel Monitoring System (VMS) data
VMS are required for vessels fishing for pollock, Pacific cod, and Atka mackerel and those vessels fishing in critical habitat in the Aleutians. VMS data provide very precise time-stamped location data that allows us to observe when vessels enter and depart port and how long they stay in port. Because there is such a large volume of data transmitted by the vessels it is a significant challenge to process the data. We have acquired funding from NMFS Office of Science and Technology to analyze the VMS data. This analysis will allow us to know the time spent and distance traveled for all trips, whether observed trips differ significantly form unobserved trips, and how long vessels remain in port during offloads.

Improving Price Data Collection

Alan Haynie*

**For further information, contact Alan.Haynie@noaa.gov*

The Economic SAFE has traditionally provided key information on ex-vessel and product prices and quantities. However, we recognize that there are many pieces of market data, especially from Japan, that would provide additional valuable insight into markets for Alaskan fisheries products. With the encouragement of the SSC and support from NMFS Headquarters, we have pursued several lines of research to improve our data collection and modeling.

Over the last year we contracted a UW economics graduate student who speaks and writes Japanese to translate select portions of the "Power Data Book" from Japanese. This data book comes out annually and has a large quantity of relevant price and quantity data from Japanese markets for Alaskan species and competing products. We are attempting to resolve copyright issues and to make select relevant data series available for researchers and industry. We are also pursuing contacts with the Japanese government to see if there are potentially mutually beneficial opportunities for data sharing.

As most people are aware, this last year we lost Bill Atkinson, who played an important role in providing Japanese market information to the Alaskan fishing industry. We have had discussions with a number of people in the industry to try to determine how we might help to fill the loss of the Bill Atkinson News Report. Conversations are on-going and we welcome input or suggestions from anyone.

One idea that we have been discussing recently with industry is the development of a near real-time market report, where interested enterprises could participate in sharing transactions data. This would provide everyone involved with a better sense of current market conditions and could improve market efficiency.

On the modeling side, UW graduate student and NMFS/Sea Grant Economics Fellow Harrison Fell has been conducting research on the impact of rationalization on the market conditions in the pollock and sablefish (joint with Alan Haynie) fisheries. Future work will examine market changes in other rationalized fisheries.

Our goal is to develop the market data resources to be able to better understand market conditions and to provide more information to the Council and other marine resource managers on changing market conditions. We welcome suggestions from anyone about what information would be valuable to you.

Experimental Design Construction for Stated Preference Choice Experiments

Dan Lew*

**For further information, contact Dan.Lew@NOAA.gov*

Stated preference choice experiments, which involve respondents choosing between alternatives that differ in attributes, have been used primarily in the marketing literature to understand consumer preferences for market goods. In recent years, however, their usefulness for gaining insights into preferences for non-market goods has become apparent, and stated preference researchers are increasingly turning to choice experiments to value public goods (Alpizar, Carlsson, and Martinsson, 2001).

Adamowicz, Louviere, and Williams (1994) were the first to apply choice experiments to value public goods in a study of recreational opportunities in Canada. Since then, several studies have used choice experiment approaches to estimate use values for activities like hunting (Adamowicz, et al., 1997), climbing (Hanley, Wright, and Koop, 2002) and recreational fishing (Hicks, 2002). Choice experiments have also been used to estimate non-consumptive use values associated with forests in the United Kingdom (Hanley, Wright, and Adamowicz, 1998), forest loss due to global climate change (Layton and Brown, 2000) and Woodland caribou habitat in Canada (Adamowicz, et al., 1998).

A typical CE involves presenting respondents with two or more choice questions, each having a set of alternatives that differ in attributes. For each question, respondents are asked to select the alternative they like best. The choice responses are used to estimate a preference function that depends upon the levels of the attributes.

In constructing choice experiment questions, researchers must determine the set of attributes and attribute levels that respondents see in each question. This is a critical judgment, as a poor experimental design can preclude estimating important marginal effects, or conversely, a good design can significantly increase the precision of estimated parameters or provide justification for reducing the sample size. The latter is particularly important in light of the cost of carefully-constructed and tested stated preference surveys.

Research is currently underway to determine ways to improve stated preference choice question experimental designs to enable efficient estimation of all relevant effects. Preliminary results from this research were presented at the Association of Environmental and Resource Economists (AERE) sessions at the 2006 annual conference of the American Agricultural Economics Association (AAEA) meeting in Long Beach, California, in July 2006. A working paper is attached in the “manuscripts” portion of the Economic SAFE.

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Protected Marine Species Economic Valuation Survey

Dan Lew*
**For further information, contact* Dan.Lew@NOAA.gov

Estimates of the economic benefits of protecting threatened and endangered marine species are often needed by resource managers and policy makers to assess the impacts of alternative management measures and policies that may affect these species. However, few estimates of the benefits of protecting marine species exist, and none exist for many species protected by NMFS. To begin filling this information gap, Dan Lew has begun working with several other NMFS economists on a non-market valuation survey research project to estimate the value of protecting several protected marine species.

Numerous cetacean, pinniped, sea turtle, and fish species have been selected for inclusion in the study, and preliminary survey materials are being developed. The survey will employ stated preference questions to gather information on public preferences for protecting these species. The first set of focus groups to test a preliminary set of materials was held in early November. Changes were made based on the results of these groups, and a second set of focus groups was held in early January to test the new versions and further develop materials. Due to the complexity of the issues and the number of species covered in the survey, it is anticipated that focus group groups and other qualitative pretest activities will continue through 2006 before the survey is ready to be field tested.

Groundfish Market Data Collection and Translation

Ron Felthoven*

**For further information, contact Ron.Felthoven@NOAA.gov*

There is a need to improve our ability to conduct market studies on Alaskan groundfish fisheries in order to better understand the effects of changes in TACs on prices and revenue. Most of the empirical market studies of fish and/or fish products concentrate on market demand estimation. There are two likely reasons that demand studies tend to dominate this field. First, the supply of fish is often assumed to be an exogenously determined fixed variable. The second is that cost data for suppliers at various stages of the market chain is not available, making it difficult to impossible to estimate theoretically consistent supply functions derived from a model based on profit maximization. Therefore, in many cases the data required for market analysis is price and quantity data for various species and products.

During the past quarter we have worked with individuals within NMFS, the University of Alaska, and Japan in order to identify new sources of price and quantity data for seafood exported from Alaska to foreign countries. Unfortunately, in many cases the available data are not in an electronic format and must be converted in order to facilitate data analysis. In other cases, the data are in another language and must be translated in order to be utilized. At present we are working with a translator and data entry personnel in order to catalog these new additional data sources and put them in useable, interpretable, electronic formats. The goal will be to collect data on groundfish species and products, as well as price and quantity data for other species which may be useful when modeling the roles of substitute products. The availability of new data will improve the type and caliber of models that can be estimated and will improve our ability to answer policy-relevant questions.

Collecting Regional Economic Data for Alaska Fisheries

Hans Geier and Chang Seung*

**For further information, contact Chang.Seung@NOAA.gov*

Regional or community economic analysis of proposed fishery management policies is required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA), National Environmental Policy Act (NEPA), and Executive Order 12866, among others. For example, National Standard 8 (MSA Section 301[a][8]) explicitly requires that, to the extent practicable, fishery management actions minimize economic impacts on fishing communities. To satisfy these mandates and inform policymakers and the public of the likely regional economic impacts associated with fishery management policies, economists need appropriate economic models and data to be used for implementing the models.

While there exist many regional economic models that can be used for regional economic impact analysis for fisheries (Seung and Waters 2006), much of the data required for regional economic analysis of fisheries are either unavailable or unreliable. IMPLAN (IMpact analysis for PLANning) is widely used by economists for implementing various regional economic models. However, for several reasons, it is not advisable to use unrevised IMPLAN data for analyzing U.S. fishery industries in general and Alaska fishery industries in particular. First, IMPLAN applies national-level production functions to regional industries, including fisheries. While this assumption may not be problematic for many regional industries, use of average production relationships may not accurately depict regional harvesting and processing technologies.

Therefore, to correctly specify industry production functions, it seems necessary to obtain primary data on harvesting and processing sector expenditures through detailed surveys or other methods. Second, the employment and earnings of many crew members in the commercial fishing sector are not included in the IMPLAN data because IMPLAN is based on state unemployment insurance program data which excludes "uncovered" employees such as self-employed and casual or part-time workers. Therefore, IMPLAN understates employment in the commercial fishing sectors. Processing sector data is also problematic because of the nature of the industry. Geographical separation between processing plants and company headquarters often leads to confusion as to the actual location of reported employment. Finally, fishery sector data in IMPLAN are highly aggregated. Models using aggregate data cannot estimate the potential impacts of fishery management actions on individual harvesting and processing sectors. To estimate these types of impacts, IMPLAN commercial fishery-related sectors must be disaggregated into subsectors by vessel and processor type. This requires data on employment, labor income, revenues and expenditures (intermediate inputs) by vessels and processors. An additional problem with IMPLAN data in small rural economies like Alaska fishing communities is that data are often inaccurate because of the nature of rural enterprises and populations. Much of rural Alaska operates on a cash or exchange basis, thus much economic activity is not accounted for in conventional data sources. Community surveys are to be used to correct this anomaly in rural Alaska fishing communities (Holland *et al*. 1997).

In sum, while regional economic models for analysis of fisheries do exist, reliable data on fisheries-related economic sectors necessary to implement the models is lacking. The absence and/or deficiencies of these data have severely limited development of viable regional economic models for fisheries. Currently, two data collection projects are underway in the Southwest and Gulf Coast regions of Alaska.

In the Southwest project, we will collect data on employment, labor income, and costs for fishery industries. For information on employment and labor income, we will use mailout surveys to the fleet. For estimating information on costs, we will use two different methods. First, for much of the operating and ownership costs for vessels, we will use a "cost-engineering" approach in which boat builders and suppliers will be contacted with average vessel specifications, and asked to provide information on costs that these boats will incur. Second, interview and telephone calls will be made to suppliers of inputs to vessels. The schedule for the project is as follows: (1) develop mailout survey questions for three different classes of vessels, (2) develop procedures for sampling (unequal probability sampling and determining sample size), (3) mail out the surveys, (4) conduct interviews and telephone calls to boat builders/ dealers, suppliers of inputs, and processing plants (headquarters), (5) examine the statistical validity of the survey results, (6) revise IMPLAN data with the primary data estimated as above and balancing social accounting matrix (SAM), (7) develop regional economic models such as input-output (IO) model and computable general equilibrium model (CGE). Similar methods will be employed for Gulf Coast region project.

It should be emphasized that a good deal of effort has gone into developing an appropriate sampling methodology for the ongoing regional economic data collection projects. Since the majority of gross revenue within each harvesting sector comes from a few number of boats, a simple random sampling (SRS) of boats would only include a small portion of the total ex-vessel values, and therefore, would be misleading. Therefore, an unequal probability sampling (UPS) method without replacement will be used. The objective of implementing the sampling task is to estimate the employment and labor income information for each of three disaggregated harvesting sectors using the ex-vessel revenue information provided by CFEC earnings data. Since each sector will be used as a separate economic sector in the IMPLAN model, we face three separate problems for three different sectors in sampling. So for each sector, we will implement a UPS without replacement. In the literature, many methods exist for conducting UPS without replacement. One critical weakness with most of these methods is that the variance estimation is very difficult because the structure of the 2nd order inclusion probabilities is complicated. One method that overcomes this problem is Poisson sampling. However, one problem with Poisson sampling is that the sample size is a random variable, which increases the variability of the estimates produced. An alternative method that is similar to Poisson sampling but overcomes its weaknesses is Pareto sampling (which yields a fixed sample size). In this project, there are two tasks that we need to accomplish to estimate the population parameters using the UPS. First, the optimal sample size needs to be determined. Second, once the optimal sample size is determined, the population parameters and confidence intervals need to be estimated. For the first task, we will use the Poisson *variance* (not Poisson sampling). For the second task, we will use a Pareto sampling method. In determining the optimal sample size, we will use information on an auxiliary variable (ex-vessel revenue). To estimate the population parameters, we will use actual response sample information on the variables of interest (employment and labor income). With inputs from experts in UPS sampling, a document detailing these sampling procedures has been completed and an Excel program has been developed to show these procedures using an example data (2002 ex-vessel value data for small boat sector).

When these two projects regional data collection projects are completed, another data collection project for the Southeast region will be conducted. The regional economic models developed with the data obtained via these projects as well as other available data are expected to provide policy-makers with useful information on the effects of fishery management policies on fishery-dependent communities. The mailout survey questions in the small boat survey developed for Southwest region is presented following the reference below.

References

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Small Boat Version

2005

Southwest Alaska Fisheries Economic Activity Survey

Sponsored by

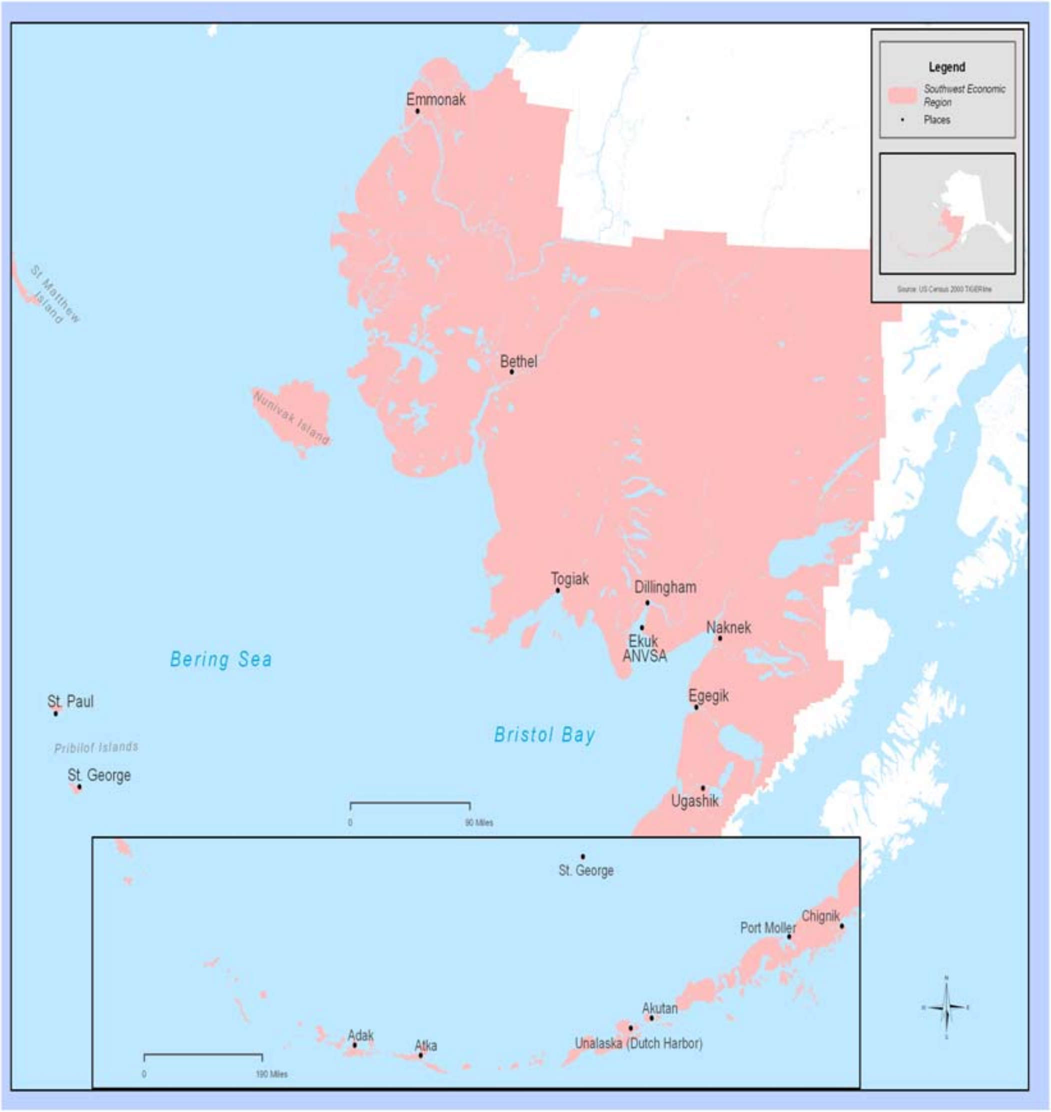
University of Alaska, Fairbanks (UAF)

and

National Marine Fisheries Service (NMFS)

OMB Control # XXXXXX
Expiration Date MM/DD/YY

Map of Southwest Alaska



CONFIDENTIALITY: Per Section 402(b) of the Magnuson-Stevens Act (16 U.S.C. 1801, et seq.), all individual surveys will be held by only a limited number of researchers at UAF who are concerned with entering or working with the data. When the data are entered in an electronic format, only these researchers will have password-protected access to the data. When the surveys are not being entered, they are kept in a locked metal cabinet. The individual surveys will be destroyed upon completion of the study. Your name (including boat identification) and address will only be used for mailing and survey administration purposes. Only summary results will be reported to the public. NMFS and other agencies will receive only aggregate results in summary form (as an economic model database).

Your Vessel Information

Please tell us if the following information on record about your vessel is accurate. If the information in Column 2 is correct, please place a check mark in the Corrections column (Column 3). If the information in column 2 is incorrect or there is no information, please provide the correct information in Column 3 (Corrections column). Please indicate "N/A" in Column 3 if the item does not apply to your vessel.

Column 1 Item	**Column 2** Information on Record	**Column 3** Corrections
Owner's Name	Phish Erman	
Owner's Address	Rt. 1, Box 368, Stewart, MN 55385	
Vessel Name	Lutefisk	
USCG Vessel ID	3333666	
State/Vessel ID	AK/FV33336	
Vessel Home port	Dillingham, AK	
Length (feet)	32	
Fuel capacity	600 gal.	
Engine Horsepower	300	
Fuel type	diesel	
Net Tonnage	15 tons	
Gross Tonnage	35 tons	
Refrigeration system?	yes	
Freezing (processing) system?	no	

Skipper and Crew Payment and Employment Information

The following questions are about your crew and skipper(s) employment and payments to them in 2005.

1) **On average, in 2005, how many crew and skipper jobs (positions) did this boat have while it was fishing, or having maintenance or repairs performed upon it?**

____

2) **How many owners did this boat have in 2005?** ____________________

3) **In the following table, for the species listed in Column 1, please indicate the total number of crew members (Column 2), skippers (Column 3), and owners serving as skippers (Column 4), employed by this boat in 2005. If you didn't land one or more of the species, place N/A in columns 2, 3, and 4. If a crew member (or skipper) fished for more than one species, please count them as employed for each species for which they fished.**

Column 1 Species This Vessel Landed in 2005	**Column 2** Number of Crew Members employed	**Column 3** Number of Skippers employed	**Column 4** Number of Owners that served as skippers
Salmon (all)			
Herring			
Halibut and Black Cod (sablefish)			
Crab (all)			
Groundfish (all)			
Other species (all)			

The following question asks for information specific to crew members, skippers, and owners who are from Southwest Alaska. Please see the map of Southwest Alaska on Page 1 for assistance.

4) **For each of the species listed in Column 1, please indicate the number of crew members you employed who were Southwest residents (Column 2), skippers you employed who were Southwest residents (Column 3), and the number of owners that served as skippers who were Southwest residents (Column 4). If you didn't land one or more of the species place N/A in columns 2, 3, and 4. If a crew member (or skipper) fished for more than one species, please count them as employed for each species for which they fished.**

Column 1 Species This Vessel Landed in 2005	**Column 2** Number of Southwest Resident Crew Members	**Column 3** Number of Southwest Resident Skippers	**Column 4** Number of Southwest Resident Owners that served as skippers
Salmon (all)			
Herring			
Halibut and Black Cod (sablefish)			
Crab (all)			
Groundfish (all)			
Other species (all)			

5) In the following table, for each species listed in Column 1, please record the number of days you paid P&I (crew liability insurance) on your vessel's crew during 2005 in Column 2. If you didn't fish for one or more of the species, indicate N/A in Column 2.

Column 1 Species This Vessel Landed during 2005	**Column 2** Number of days you paid P & I on your vessel's crew
Salmon (all)	
Herring	
Halibut and Black Cod (Sablefish)	
Crab (all)	
Groundfish (all)	
Other species (all)	

The following question is about your payments to crew and skipper(s) for the <u>2005 fishing year</u>. If you have ready access to your delivery settlement sheets, this may assist you in accurately estimating the payments to the crew and skipper(s).

6) **Please record the payment made to crew (Column 2) and skipper (Column 3) in the following table by species (Column 1). Please use actual dollars ($) paid to your crew and skipper(s) by species. To assist you to recall, Column 2 contains the reported ex-vessel value of each species you delivered in 2005.**

Column 1 Species This Vessel Landed in 2005	**Column 2** Actual Ex-vessel Value (by Species) for Your Boat ($)	**Column 3** Total Crew Payments ($)	**Column 4** Total Skippers' Payments ($)
Salmon (all)	$175,000		
Herring	$52,000		
Halibut and Black Cod (Sablefish)			
Crab (all)			
Groundfish (all)			
Other species (all)			

Comments

Please use this space to provide us with any comments that you feel would assist us to report the economic contribution of fishers like you to the economy of Southwest Alaska.

Contact Information

Please fill in this section only if you want us to contact you to discuss your answers.

Your Name : ___________________________________

Phone Number : (_ _ _) _ _ _ - _ _ _ _ Extension (if applicable): x ___________

E-mail : _____________________________

Please return the survey in the enclosed self-addressed stamped envelope.

THANK YOU FOR PARTICIPATING IN THE SURVEY!

Please direct any questions to Hans Geier at the University of Alaska, Fairbanks by phone (907) 474-7727 or by e-mail at ffhtg@uaf

Estimating Interregional Economic Effects of Vessels in Both Alaska and West Coast Fisheries

Edward Waters and Chang Seung*
**For further information, contact Chang.Seung@NOAA.gov*

Many of the vessels operating in Alaska fisheries are owned and crewed by residents of Washington and Oregon. Some of these vessels also participate in West Coast fisheries during the year. While much of the income earned by these vessels leaves Alaska, expenditures made elsewhere will generate positive economic impacts for that region, and may also have spillover effects. Hushak (1987) demonstrated that assuming all commodities and services are locally supplied will significantly overestimate regional impacts. Understanding the location of expenditures made by these vessels, both in Alaska and elsewhere, will enhance our understanding of the overall economic impacts of Alaska fisheries.

Standard regional economic models focus on a single region. These models generally fail to capture economic impacts transmitted outside that region, and also do not account for spillover effects in the study region resulting from events occurring outside. An inter-regional or multi-regional model can more fully measure the impacts of a region's fisheries, including those impacts occurring in regions that supply commodities or factors of production to industries in the study region, or that demand the goods and services produced there. An inter-regional model would be especially useful in the case of Alaska, where most intermediate goods are imported and much of the factor income leaks out of the region to nonresident vessel owners and crew members (Seung and Waters 2006[a]). This type of model could also be used to track the impact of expenditures by vessel owners and crew members who are also active in other regions' fisheries. However developing an inter-regional model involves the daunting task of estimating inter-regional flows of commodity inputs and factor services. Acquiring this information has traditionally been very challenging due to an absence of interregional trade flow statistics. Consequently, to date, only one study (Butcher et al. 1981) employed an interregional or multiregional model to estimate economic impacts of fisheries.

This project will estimate the distribution and magnitude of intra-regional and inter-regional economic impacts generated by vessels participating in both Alaska fisheries and in fisheries off the U.S. West Coast. Recently, Alaska Department of Labor and Workforce Development (DOLWD) has created useable data for estimating nonresident labor use by Alaska industries, including seafood processing and some commercial fishing. Data on the ownership of vessels used in Alaska and West Coast fisheries also exists, and annual catch by these vessels is available from PacFIN and NORPAC data systems. Information on the cost structures of vessels participating in the two fisheries will be gathered from the literature and key industry informants. Results of a cost and earnings survey of West Coast groundfish trawlers that is currently being administered by NWFSC may be available to assist this project. This project will develop a multi-regional social accounting matrix (SAM) model of Alaska and West Coast fisheries using these data combined with IMPLAN regional models constructed for Alaska and the U.S West Coast (i.e., Washington and possibly Oregon). IMPLAN Version 3.0 (beta version) will include an inter-regional trade modeling capability that will facilitate the estimation of commodity trade flows between the two regions. The investigators in this project recently developed a single-region Alaska SAM model to examine the economic impact of Alaska fisheries (Seung and Waters 2006[b]). This project will build on that effort to develop an updated interregional SAM model.

The implementation of this project will include the following steps:

1. Gather data on the residence of owners and crews of vessels operating in Alaska and U.S. West Coast fisheries from NOAA permits databases and other sources.
2. Gather annual catch data by these vessels from PacFIN and NORPAC data systems.
3. Gather information on vessel cost structures and the locus of input purchases by vessels participating in the two fisheries. Major sources of data will include relevant literature and interviews with key industry informants. Results of a cost and earnings survey of West Coast trawlers currently being administered by NWFSC may be available to assist this task.
4. Generate regional economic models of Alaska and the U.S. West Coast (Washington and Oregon) economies using IMPLAN. The models will incorporate the latest representative economic data available for both regions.
5. Estimate the value of commodities, services, labor and capital flowing between Alaska and the West Coast using IMPLAN and the models developed in Step 4. The focus will be on those factors, commodities, and services of particular importance to commercial fisheries-related economic activity.
6. Develop a multi-regional social accounting matrix (SAM) model of Alaska and West Coast economies using fisheries data, trade estimates and IMPLAN regional models developed in steps 1–5.
7. Use the multi-regional SAM model to estimate economic impacts of commercial fishing and related activities on Alaska and the U.S. West Coast.

Understanding the location and magnitude of effects generated by these vessels, both in Alaska and elsewhere, will enhance our understanding of the overall economic impacts of Alaska fisheries. After this project is completed, the investigators will conduct (possibly jointly with a NWFSC economist) a potential follow-on project. In the follow-on project, a more comprehensive data gathering program will be implemented to resolve economic data issues identified in steps 1–3 above. These data will be used to validate the interregional SAM model and would be available for the development of an advanced model such as an interregional computable general equilibrium (CGE) model.

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Two Phases of an Integrated Economic-Ecosystem Modeling Project Completed

Chang Seung*
**For further information, contact Chang.Seung@NOAA.gov*

Commercially valuable fish species are dependent on many other species and organisms dispersed throughout their habitat. Therefore, when formulating renewable fishery resource policies, it is important to understand the ecological relationships between these species. It is also important to understand how these fishery resource policies affect human activity and the economy, and how human activity affects these species in a marine ecosystem. The objective of this project is to develop an integrated ecological/economic model for Alaska fisheries that can track both ecological relationships and human activities. The ecosystem model to be developed will be combined with a computable general equilibrium (CGE) model. Such an integrated ecosystem approach will provide more useful information to policy-makers than stand-alone regional economic or ecological models for fisheries, and better satisfy the National Standard 8. The resulting integrated model from this research will serve as a decision-making tool for fishery management actions.

In the first phase of the project the contractors, Dr. David Finnoff and Dr. John Tschirhart at the University of Wyoming, developed a report/research plan that described the elements of the model. Subsequent to the completion of this report, ecosystem modelers and economists at AFSC held a workshop with the contractors at the AFSC in February, 2006.

In the one day workshop, the contractors made a presentation on the work they had done, based on their report on the first phase of the integrated modeling project. In the subsequent small group meetings, AFSC scientists with diverse research foci had discussions with the contractors, providing useful comments on the ecosystem and economics components of the model.

In the second phase of the project since the workshop was held, the contractors have been working on improving the model using the comments from the AFSC scientists.

Specifically, a thirteen species ecology component of the General Equilibrium Ecosystem Model (GEEM) has been rewritten and we will now be able to add more species or species groups to the model. We have also completed developing a vector autoregression of the 13 species ecosystem which is a linear reduced form of GEEM that will be useful for future work that addresses optimum multi-species harvesting issues. In addition, the contractors have added juvenile Pollock to the 13 species model referenced above. That is, they have broken the pollock into adult and juvenile groups; this part of the work has taken quite a bit of time since it represents the first attempt at adding an age-structured population to GEEM. In making this addition the contractors drew heavily from a 2002 NOAA Technical Memorandum by Aydin, Lapko, Radchenko and Livingston ("A Comparison of the Eastern Bering and Western Bering Sea Shelf and Slope Ecosystems Through the Use of Mass-Balance Food Web Models) and a 1999 UBC Fish Center Report by Trites, Livingston, Vasconcellos, MacKinson, Springer and Pauly ("Ecosystem change and the decline of marine mammals in the EBS: testing the ecosystem shift and commercial whaling hypotheses) to find the parameters for juvenile populations. However, the more difficult part was developing the dynamic adjustment equations for the adult and juvenile populations because, again, this is novel in GEEM. The system is now running and they are in the process of testing it with varying harvests of adults by the fishery.

For the economic component of the analysis, the contractors and AFSC have worked primarily to parameterize the fishery component of the Computable General Equilibrium (CGE) model. In particular, the contractors have attempted to estimate Constant Elasticity of Substitution (CES) production functions for the pollock and flatfish Bering Sea fisheries. Unfortunately, this has been problematic. Across numerous specifications the observed data just does not fit the assumed CES production technology. While estimates of the CES parameters have been derived and can be employed in the next stage of the model development, this has prompted some effort (ongoing) put into empirically deriving the appropriate specification for the fisheries production technology.

A second aspect that we have worked to include into the economic component of the analysis is the importance of marine mammals to Alaska residents. While this component of model development and research is ongoing, the most fruitful method appears to be one developed by V. K. Smith and J. Carbone; in their method the influence of non-market goods on households, and in turn market behavior, is represented in the CGE framework through non-separable contributions of the non-market goods to household preferences. The method reflects any changes in non-market services as essentially altering the trade-offs between marketed goods and leisure, where leisure is as given in the usual labor-leisure tradeoff. The welfare consequences of these changes therefore depend critically on the degree of substitution or complementarity between the non-market and market goods. It is expected that major progress will be made in this summer.

Promoting key economic and social scientific concepts to fisheries managers

Alan Haynie*

**For further information, contact Alan.Haynie@NOAA.gov*

NOAA Fisheries has recognized that the agency will benefit from increasing the role that social scientists play in fisheries management. The number of economists and social scientists in NOAA Fisheries has increased significantly over the last decade, but in many cases economists and other social scientists have not adequately conveyed their insights to fisheries managers with NOAA Fisheries, the fisheries council management community, or the larger academic fisheries science and policy communities.

Alan Haynie conducted a survey of NOAA Fisheries economists and other social scientists about their opinions on priority topics for fisheries management. Alan presented this research at the San Francisco NMFS Social Scientists Meeting and at the International Symposium on Society and Resource Management (ISSRM) in Vancouver in June. Since Alan's initial survey, Alan has been working with headquarters economists Mark Holliday, Kristy Wallmo, and Erik Helm on a new initiative to promote economic awareness throughout NMFS.

Stakeholder Concerns and Spinner Dolphin Management

Jennifer Sepez*

**For further information, contact Jennifer.Sepez@NOAA.gov*

Dr. Jennifer Sepez completed a NOAA rotational assignment at the Pacific Islands Regional Office. The region is concerned about the effects of "swim-with-wild-dolphins" tourism activity that has increased in recent years. NMFS is considering whether to propose regulations to protect wild spinner dolphins in the main Hawaiian Islands from "take," as defined in the Marine Mammal Protection Act (MMPA) and its implementing regulations, or from actions that otherwise adversely affect the dolphins (see http://www.regulations.gov). NMFS encourages members of the public to view and enjoy spinner dolphins in the main Hawaiian Islands in ways that are consistent with the provisions of the MMPA, and supports responsible wildlife viewing as articulated in agency guidelines (http://www.nmfs.noaa.gov/prot_res/MMWatch/hawaii.htm).

Viewing wild marine mammals in Hawaii is a popular recreational activity for both tourists and residents alike. In the past, most recreational viewing focused on humpback whales *(Megaptera novaeangliae)* during the winter months when the whales migrate from their feeding grounds off the coast of Alaska to Hawaii's warm and protected waters to breed and calve. However, in recent years, recreational activities have increasingly focused on viewing small cetaceans, with a particular emphasis on spinner dolphins, which are routinely found close to shore in shallow coves and bays and other areas throughout the main Hawaiian Islands. These dolphins feed offshore at night, and return near shore during the day to rest and socialize. NMFS is concerned that some near shore human activities cause unauthorized taking of dolphins, diminish the value to the dolphins of habitat routinely used by them for resting, and cause detrimental individual-and population-level impacts.

Dr. Sepez interviewed stakeholders in the main locations where spinner dolphin tourism takes place. She met with a broad array of individuals with an interest in the issue, from residents who engage in swimming with dolphins on a regular basis, to opponents of the activity, to other ocean users who may encounter dolphins. She is currently drafting a report on her findings which will include a description of the types of interactions between humans and spinner dolphins at various locations, and a preliminary analysis of the impacts of different policy choices articulated by NOAA in the Advanced Notice of Proposed Rulemaking published in the Federal Register on December 12, 2005 (http://www.gpoaccess.gov/fr/).

Estimating Economic Base Relationship for Alaska Fisheries within Panel Co-integration Framework

Chang Seung*

**For further information, contact Chang.Seung@NOAA.gov*

Virtually all regional economic impact models developed to date far for analysis of U.S. fisheries are static models. For example, frequently used input-output (IO) models that have been implemented for calculating regional economic impacts of fisheries are static models. However, the regional economic impacts of fishery management actions calculated based on a single period, static model can be misleading since most of fishery management policies have permanent effects over time and the impacts occur over a number of periods. With static models, it is impossible to address the timing of the impacts, which needs to be considered in formulating fishery management policies. In addition, IO models always predict positive (negative) impacts with positive (negative) shocks to seafood industries. The IO model does not allow adjustment by other supporting industries to long-run equilibrium of a fishery-dependent regional economy. An alternative model that avoids these weaknesses is a dynamic economic base model, which is often implemented with a vector autoregressive error correction (VECM) model. The VECM model provides the time and magnitudes of regional economic impacts in response to shocks to seafood industries as well as the long-run relationships between basic industries (including seafood industry) and non-basic (supporting) industries (which cannot be done in a static, IO framework). Using monthly employment data at regional level from 1990 to 2000, Dr. Chang Seung developed VECM models for two fishery-dependent regions in Alaska – the Southwest and Gulf Coast regions. In the model, the dynamic impacts of the seafood industry on the economies of the two regions are investigated. A very recent development in VECM modeling – “panel co-integration” – made it possible to apply this model with panel (a cross-sectional time series) data. Therefore, using panel employment data obtained via a project by Alaska Department of Labor and Workforce Development Dr. Seung is planning to develop a panel co-integration model of Alaska fisheries.

North Pacific and West Coast Fisheries Community Profiles

Jennifer Sepez*
*For further information, contact Jennifer.Sepez@NOAA.gov

Community Profiles for West Coast and North Pacific Fisheries – Washington, Oregon, California, and other U.S. States by Norman, Sepez, Lazrus, Milne, Package, Russell, Grant, Petersen, Primo, Styles, Tilt, and Vaccaro has been released for public review in draft form. The individual profiles of 125 communities, along with introductory and methodological information, are currently available on the Northwest Fisheries Science Center's website at http://www.nwfsc.noaa.gov/research/divisions/sd/communityprofiles/index.cfm. The project is a joint effort between the Alaska Fisheries Science Center and Northwest Fisheries Science Center (NWFSC), with additional support from the Southwest Fisheries Science Center. The profiles are currently being reviewed by community representatives and volunteers affiliated with the Port Liaison Project (PLP). The PLP projected, administered by Oregon Sea Grant and funded by the NWFSC, is designed to connect members of the commercial fishing industry with fisheries researchers. Other members of the public who are knowledgeable about these communities are also invited to read the profiles and send in suggested revisions during this review period.

This is the follow up document to NOAA Technical Memorandum NMFS-AFSC-160, *Community Profiles for North Pacific Fisheries – Alaska*, which describes 136 communities located in the State of Alaska with involvement in North Pacific fisheries. AFSC community profiles for North Pacific Fishing Communities located in Alaska are available online at http://www.afsc.noaa.gov/REFM/Socioeconomics/Projects/CPU.htm. Because a large number of communities located on the West Coast participate in North Pacific fisheries; consequently it was more efficient to jointly profile these communities along with the other communities involved in fishing along the West Coast.

One hundred and twenty-five predominately West Coast communities were selected for profiling, from over 1500 communities in the contiguous United States and Hawaii which had some involvement in either commercial fishing in the North Pacific or along the West Coast, or some involvement in both regions. The 125 selected communities primarily include U.S. Census Places from: Washington (40 communities), Oregon (31 communities), California (52 communities), New Jersey (1 community), and Virginia (1 community). All of the profiled communities except for one (Valleyford, CA), had some involvement in North Pacific fisheries, either commercial, recreational, or both. Two communities, Seaford, Virginia, and Pleasantville, New Jersey, were selected for profiling solely because of their involvement in North Pacific fisheries.

The narrative profiles follow an outline nearly identical to the preceding Alaska profiles and include sections titled *People and Place* and *Infrastructure,* but distinguish between *Involvement in West Coast Fisheries* and *Involvement in North Pacific Fisheries. Involvement in West Coast Fisheries* details community activities in West Coast commercial fishing (landings delivered to community, processing, vessels, and permit holdings), sportfishing (sportfishing operators, license vendors and revenue, and landings), and subsistence fishing. *Involvement in North Pacific Fisheries* details community activities in North Pacific commercial fishing (landings delivered by community residents, crew member licenses, and permit holdings), and sportfishing (businesses and licenses).

Together with the Alaska profiles, this document provides a consolidated source for baseline social and fisheries information for the communities most involved in North Pacific fisheries. Consideration and analysis of fishing communities is mandated under National Standard 8 of the Magnuson-Stevens Fishery Conservation and Management Act. The draft profiles will be finalized and published later this year.

Fishing Communities Project Evaluates Scale and Methods

Jennifer Sepez*

**For further information, contact Jennifer.Sepez@NOAA.gov*

Under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and other legal mandates, NOAA Fisheries has been conducting basic social science research on fishing communities. The research must cover very large geographic scales and address a broad array of analytical issues. These conditions are in tension with the traditional ethnographic methods of anthropology and the MSA's focus on the community as a unit of analysis. This dilemma forces NOAA social scientists to examine the scales at which they work, and the methods that are appropriate for different geographic scales.

AFSC social scientist Dr. Jennifer Sepez published an article in the applied anthropology journal *Human Organization* on these issues. The article was written with co-authors Karma Norman, who is a social scientist at the Northwest Fisheries Science Center, Amanda Poole, a graduate student in Environmental Anthropology at the University of Washington who has served as a research assistant at the AFSC for several different projects, and Bryan Tilt, Assistant Professor of Anthropology at Oregon State University, who worked with Sepez and Norman on North Pacific and West Coast community profiles.

The article describes how social scientists at the Alaska Fisheries Science Center and Northwest Fisheries Science Center navigated these conflicting imperatives by adopting large-scale community profiling using social and fishing indicators informed by ethnographic site visits, and by advocating a "nested-scale" analytical framework that imbricates the community level analytical unit with macro-level considerations related to regional and global forces and micro-level dynamics related to intra-community heterogeneity.

The article appears as Sepez, J. K Norman, A. Poole and B. Tilt. 2006. Fish Scales: Scale and Method in Social Science Research for North Pacific and West Coast Fishing Communities. *Human Organization* 65(3)280-293.

Gulf of Alaska Halibut IFQ and Small Remote Fishing Communities

Dan Lew and Jennifer Sepez*
**For further information, contact Jennifer.Sepez@NOAA.gov*

Individual fishing quota programs, like other dedicated access privilege programs, are often criticized for their distributional consequences. In the Gulf of Alaska halibut fishery, many regulatory precautions were taken to preserve the character of the fishery. However, there is concern that fishing quota holdings are being reduced in small, remote Alaska fishing communities (SRFCs). Jennifer Sepez and Dan Lew have been working with University of Washington Ph.D. student Courtney Carothers to analyze quota share transactions from 1994 to 1999 to assess whether halibut fishing quota holdings are migrating away from SRFCs.

In this study, a community is a SRFC if it meets criteria based on population size, proximity to the coast, historical participation in Alaska fisheries, and designation as a rural area, which is a proxy for remoteness. Several size-based SRFC definitions are developed to account for sensitivity to population size threshold assumptions. The data show that quota share did leave the smallest SRFC communities over the five-year period, as evidenced by the net quota share change in these communities during that time. In more populated SRFC communities, the trend is generally reversed; that is, more quota share entered these communities than left. These results suggest the size of a SRFC community may influence whether its residents will sell or buy halibut IFQ and hence whether we see quota share leaving or entering the community in aggregate.

To more formally investigate the role of SRFC residency in decisions to buy or sell halibut quota share, the probability that an individual is a buyer or seller is modeled as a function of characteristics of the individual and analyzed using logit techniques. In this way, the influence of individual characteristics, such as age and the community's population, on buying and selling behavior can be separated from effects due to residency specifically in SRFCs. The logit results indicate that the marginal effect due to SRFC residency influences the decision to buy or sell more than one's age (other individual and transaction-specific effects were precluded from the model due to data limitations). The size of SRFC communities matters as well. Additional analysis is planned to explore the extent to which specific characteristics of communities contribute to buying and selling behavior more generally and to investigate the reasons underlying the observed buying and selling trends in SRFCs.

Through a Cod's Eye:
Exploring the Social Context of the BSAI Pacific cod Fishery

Emilie Springer*
**For further information, contact emilie1@u.washington.edu*

Overview

As fisheries management in the North Pacific shifts towards quota-based management systems (typically labeled "rationalization") it is essential to consider how fishermen and their communities will be impacted. To understand such impacts one must have a baseline understanding of the affected parties. Unfortunately there is a paucity of data on fishermen operating in the BSAI. Gathering personal information from fishermen to more thoroughly understand their social and economic environment is therefore an important and timely undertaking.

The Bering Sea (BSAI) groundfish industry is a complex social environment—different types of vessels converge from communities across the west coast and Alaska with diverse expectations, intentions and needs. The crew and captains of these vessels create a particular "occupational community" or "virtual community" that network with each other in various ways.

This project strives to interpret the behavior and characteristics of commercial fishermen beyond the basic statistical information that is available from federal and state sources such as NMFS, the North Pacific Fisheries Management Council (NPFMC) or the Alaska Commercial Fisheries Entry Commission (CFEC). The ultimate goal is to develop a better understanding of fishermen in the Bering Sea by focusing on individuals who are involved in the Pacific cod industry.

I chose the Pacific cod industry as a focal group because it is a fishery pursued by all of the gear categories represented in the Bering Sea: trawl, fixed gear (hook-and-line and pot) and jig. These vessel categories are further distinguished by their processing status and are identified as either a "catcher-vessel" or a "catcher-processor."

This report briefly outlines some of the key objectives of the project, the methods used to conduct the interviews, basic characteristics of the response categories, key findings and preliminary analysis. This is a work-in-progress and a more detailed conclusion will be available upon submission of my thesis at the University of Washington's School of Marine Affairs.

Objectives

There are six specific research objectives for this project:

1) Understand the general management context of the Bering Sea Groundfish industry as whole, with particular emphasis on the Pacific cod industry.

2) Describe how participants/vessels in the Pacific cod fishery are more broadly

connected to other BSAI groundfish, BSAI crab, halibut and other state water fisheries.
3) Understand and be able to generalize typical social patterns (also referred to as "employment trajectories" in the thesis) of individuals who participate in the fishery.

4) Understand decision making strategies and hierarchy regarding basic logistics of fishing (when, where, with what crew, etc.).

5) Understand the extended social, cultural and professional networks of individuals who will be impacted by regulatory changes in the BSAI Pacific cod industry.

6) Document the best ways to contact and interview fishermen and their representatives.

Methods

Prior to initiating industry interviews, I reviewed method-based texts to gain proficiency in the process and utility of qualitative interview techniques. These texts included: Spradley 1979, Cole and Knowles 2001, Rubins 2005, Weiss 1994, Seidman 1998, Yin 2003 and Dewalt 2002. I also reviewed the standard National Oceanographic and Atmospheric Administration's Guidelines for Social Impact Assessments (SIA).

Several of these texts discuss the venture of human-based research with the philosophy that understanding and reporting on human behavior requires a careful ethical code. Though one of my research goals is to work towards the creation of an "industry profile"—a compilation of typical characteristics—I will not minimize the individuality of any of the people interviewed for this study.

Data Organization

Interviews

This project attempts to gain insight regarding Bering Sea Aleutian Island groundfish fisherman by using a flexible, qualitative approach. Though interview responses are variable and anecdotal, it is possible to construe some standardized comparisons. Interviews generally incorporated questions from the following categories:

- Employment history
- Education
- Number of years fishing
- Fisheries in which they participate
- Typical yearly schedule
- Typical day on boat
- Typical characteristics of crew
- Draw/lure of commercial fishing
- Impressions of the Bering Sea
- Changes in the industry
- Percent of income from Pacific cod
- Interactions with other gear types

I conducted 9 interviews with individuals representing the trawl catcher-vessel fleet, 11 interviews with individuals representing the pot catcher-vessel fleet and 7 interviews with individuals representing the hook-and-line fleet. I was unable to conduct interviews with fishermen in the jig fleet[*].

In addition to these 27 formal interviews, I engaged in dozens of less formal conversations with industry representatives, fishery managers, academics and fishermen from other industries to supplement the interpretations of the responses I received from Bering Sea Aleutian Islands Pacific cod fishermen. Beyond the basic categories identified above, spontaneous sub-categories emerged depending on the conversational direction of the particular interview.

Profiles

Interviews were organized by gear category. Individual commentary and occupational descriptions were extracted from the interview database to generate a representative "profile." The profiles compare and connect major remarks from the interview subjects and present information in a format that utilizes interview comments as a prototype for the larger community.

Conclusions and Recommendations

This portion of the report is currently in progress. However, preliminary findings suggest:

1) <u>Some generalizations can be applied to various fleets, and fishers' foci differ</u>

In general, the fishermen exhibited similar personality characteristics, employment paths, and descriptions of their maritime lifestyles. However, there were definite distinctions between responses in each gear-category. Some differences were subtle and others were more obvious. One notable example is that interviewees responded to questions with varying degrees of formality. Not surprisingly, those who were most professional represented vessels that belong to large businesses or corporations—those who were more casual represented vessels owned by a family or small partnership. These variations determined that information be extracted in different ways.

The range of opinions regarding the political status of BSAI commercial fisheries was diverse. Issues that were important or significant to one fleet were not necessarily relevant to the others. Most notably, interviewees who represented the pot catcher-vessels were almost certain to discuss the issue of crab rationalization while the others might not mention it.

2) <u>Networking is vital to access appropriate interviewees</u>

To gain background information for the project, I attended several North Pacific Fisheries Management Council meetings, trade shows and industry-sponsored events such as the Alaska Crab Coalition meeting. By observing interactions between participants at these

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[*] There are few participants in this gear sector and they are largely based outside of Seattle. It was not feasible to include this gear sector in the research project because participants were not available for interviews based on the technique of sampling by referral.

meetings I realized that it is critical to be able to work with individuals who are already insiders to a particular social setting in order to gain access to information and future interviewees. Almost all of my interviewees came via the recommendation of a fishermen or representative with whom I had already worked. There must be consistency and trust in communication in order to facilitate an improved flow of information.

The Economics and Social Sciences Research group at AFSC funded this study in order to improve our understanding of how policies impact different types of people involved in the fishing industry. Though information can be deduced from data analysis, interaction with people who are directly involved in the industry provides critical insight to contemporary fishery issues.

3) Industry Knowledge of the Environment

In addition to learning about the fishermen and their employment motivations, it was very clear that any subsequent research project that relies on industry interviews could also focus on biological and environmental awareness that fishermen can describe. Fishermen can testify to changes observed over several decades.

4) More systematic research of fishermen is necessary

My research was insightful but not of sufficient scale to be thoroughly conclusive. I was not able to achieve comprehensive generalizations to several of my interview questions. My suggestions for future research aimed at improving our understanding of the BSAI groundfish industry include:

a. Timing should be better aligned with the industry schedule

The timing available to conduct interviews was January-May, 2006. This is a busy time of year for many BSAI fishermen and there was a shortage of available fishermen with whom to meet. If further research is initiated, interviews should be scheduled for mid-November through early-December.

b. More research should be designed for the Alaska-resident fleet

I preferred to conduct interviews in person and therefore the fishermen represented in this project are primarily based out of Seattle. The only Alaskans interviewed for this project were from the pot fleet.

c. More research should be conducted on catcher-processor vessels and questions should be reviewed to ensure suitability for crew members

My interview questions were most appropriate for fishermen in the catcher-vessel fleet. These vessels have smaller crews of 4-6 people with opportunities for the development of lasting and interactive relationships and occupational guidance between the skipper and crew members. Formal occupational hierarchy on the larger vessels likely creates a scale of social separation between the captain and a crew-member on the processing line. Research access to the crew members on large catcher-processor ships would require a different tactic than the one used for this study.

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Projects Funded in 2006 to be Conducted in 2007

Data Collection:

Fuel Consumption Pilot Survey for Alaska Groundfish Fisheries

One of the largest components of a fisher's costs of operating is the cost of fuel. As such, it is a critical element in the analyst's took kit when attempting to estimate the economic impacts of any management action (such as marine protected areas) that will affect where fishers may fish. Unfortunately, economists at the AFSC do not have reliable estimates from which to gauge the amount of fuel burned by vessels of a given gear type, length, tonnage, and horsepower. The other primary cost of fishing is the payment made to crew, which is typically some percentage of revenue (for which we have good data). If we could account for the cost of fuel for vessels, along with our current estimates of crew share payments, we will be able to account for a large portion of operating costs. This will not only facilitate analysis of impacts from having to fish in different location, but also allow us to calculate quasi-rents from the trip, and how such rents have been impacted by the recent increases in fuel costs. It is well known that the prices of fish products have increased in the recent past, in part attributable to increased fuel costs, and it would be interesting to estimate the percent of those cost increases that has been passed on to the final consumer. Simply put, data on fuel consumption per day or per nautical mile will be a major workhorse for analysts tasked with estimating the impact of all kinds of policies, and also be very valuable in applied empirical models.

Vessel Monitoring System Data Collection and Compilation

The National Marine Fisheries Service has long recognized the importance of spatially explicit data to improve fisheries management. Although data from the Observer Program, fish tickets, and logbooks allow AFSC researchers to conduct research on the various fishing fleets active in Alaskan fisheries, the Vessel Monitoring System (VMS) allows NMFS to have real-time knowledge of the precise location of trawling vessels in the Bering Sea. Researchers at the AFSC and at the Alaska Region have employed VMS data to examine some aspects of fleet behavior, but due to the format of the VMS data, this information has been underutilized in spatial research. This is unfortunate, as the underlying spatial detail in VMS records is exactly the type of information that could be used by scientists trying to better understand and explain the fishing behavior of Alaskan fleets. VMS data truly present researchers with the best spatial data available in the world, a resource that should be fully utilized to improve management and methods of spatial fisheries research; this research aims to do just that.

Raw VMS data contain several basic pieces of information (e.g., vessel identification, location, and a time stamp) along with calculated fields that provide additional information such as the speed of a vessel. However, no information is currently provided in VMS data about whether a vessel is actively fishing, traveling to fishing grounds, in port, or waiting out a storm. By analyzing VMS data and determining whether vessels are fishing, traveling, or in port will substantially increase its usefulness in modeling fishers' behavior. Furthermore, linking it to existing Observer records will allow us to organize the VMS data on a trip-by-trip basis (the format most amenable to spatial behavioral analysis). The VMS data will also be integrated into a GIS framework in order to get a graphical depiction of the distances traveled while fishing, and to and from port. An examination of these data may also provide information about fleet search behavior. Further, this project will allow us new insight into how observed and unobserved fishing trips may differ (in terms of fishing location choice and harvesting strategies).

Fishing Target Accuracy Data Collection Pilot Project

The National Marine Fisheries Service uses the definition of a “targeted fishery” to develop management strategies and to define the vessels active in different fisheries. The target of a particular fishing trip is defined by the species that comprises the largest portion of retained catch, rather than what the skipper of the vessel *intended* to catch.

We recognize that vessel operators choose to accept certain amounts of bycatch at different times because the costs of avoidance are high. What we do not know, however, is to what degree skippers actually have control over what species they catch in a given haul or trip, particularly in the multi-species flatfish fishery. There may be significant policy implications if we observe that vessel operators in some fisheries have little ability to make choices over their target species when attempting to avoid bycatch of prohibited species.

In general, the question of what fishermen expect to catch when choosing different fishing locations is an area that has received considerable attention from fisheries economists. However, there has been little systematic data collected to compare realized catch with intended catch, which is what this project proposes to do. We have expressed a desire to have the Federal Observer Program collect this data on a regular basis, and due to some difficulty in convincing them to do so, we have proposed this pilot study. We hope that by verifying that target species and realized catch frequently differ, the Observer Program will collect this information in the future. The data collected in this project will also be useful in decisions and analyses regarding bycatch regulations and fisheries management.

Research:

Spatial Economic Performance: Regulation-Induced Changes in Fishing Location and Practices in the Alaskan Pollock Fleet

Current research at the AFSC has focused on evaluating the impacts on economic performance of the implementation of the American Fisheries Act (AFA) on the Bering Sea and Aleutian Islands (BSAI) pollock fishery. This research has resulted in an article on harvesting productivity and an ongoing study on processing productivity (including product choice and quality) in this fishery. Our analyses have identified important changes in the BSAI fishery structure since the AFA that may involve not only direct impacts of the Act, but also of concurrent regulations such as prohibitions on bottom trawling and fishing location. A combination of such regulatory factors has affected fishing productivity and revenues through adaptations in fishing strategies and practices, including fishing speed and thus the quality of the catch and choice of final products. Specifically, the AFA likely affected *how* fishers fish and the area closures *where* they fish, both of which affect the productivity and revenue of the fishery.

The proposed research will focus on disentangling the effects of regulatory changes on economic performance of the BSAI fishery, with particular attention to the impacts of fishing area closures for the protection of Steller sea lion habitat. These commercial fishing restrictions in the Steller sea lion Conservation Area (SCA) are designed to increase Steller sea lion populations by protecting the fish on which they prey. However, they also may have had effects on fishery productivity through restricted location choices, greater travel distances, and increased density of fishing in the remaining areas. This research will measure such impacts using parametric models of optimal catch or revenues that can directly represent, both within the estimation model and the stochastic structure, the impacts of regulatory factors on productivity and economic returns. The research will thus result in productivity measures that embody both direct regulatory impacts and indirect externalities from other boats' fishing choices.

Measures of Technical Efficiency and Their Impact on Spatial Regulatory Measures

The production function framework used to characterized production processes in non-fishery industries technologies fails to incorporate many of the spatial characteristics of fishing vessels that use inputs to create fish outputs: their production functions are highly mobile. This level of mobility implies that their production functions are not only defined by the technology they possess and the inputs they utilize but also by the location in which they employ them. Therefore, previous research conducted on the level of technical efficiency possessed by vessels within a fishing fleet ignores one of the most important inputs of production: where they chose to fish. The purpose of this research is to estimate the spatial technical efficiency of trawl vessels operating within the Bering Sea and Aleutian Islands within the regions potentially closed under proposed EFH alternatives and to determine whether or not the proposed closures will have a deleterious effect on their production processes.

Recreational Fishing Demographics in Alaska

The two most important saltwater recreational fisheries in Alaska are halibut and salmon. Of these, the halibut fishery is managed by the North Pacific Fishery Management Council, which has been debating instituting a controversial Guideline Harvest Level and limited allocation for the sector. Available information about the recreational fishermen who will be affected is quite limited. This project will analyze data which has been collected by NMFS, but which remains unprocessed, to create a demographic description of the participants in Alaska's saltwater recreational fisheries. Recreational license information for Alaska has previously been analyzed by AFSC for data on community of residence, and place of license purchase. But the value of this database is very limited because demographic information is not requested on the license application. In 2004 AFSC economists conducted a nationwide mail survey of people who had purchased recreational fishing licenses in Alaska the previous year. In collaboration with the AFSC non-economic social scientist, six demographic questions were included in this survey: age, gender, race/ethnicity, education, household size, and income. This data is a unique window onto participants in Alaska's recreational fisheries just at the time when Council is considering policies which will affect this otherwise undescribed group.

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AFSC Economics and Social Sciences Research Program
Publication List for Full-Time Staff (names in bold), 2002-2006

Branch, T., R. Hilborn, **A.C. Haynie**, G. Fay, L. Flynn, J. Griffiths, K. Marshall, J.K. Randall, J.M. Scheuerell, E.J. Ward, and M. Young. 2006. "Fleet dynamics and Fishermen Behavior: Lessons for Fisheries Managers." *Canadian Journal of Fisheries & Aquatic Sciences"* Vol 63(7):1647-1668.

We review fleet dynamics and fishermen behavior from an economic and sociological basis in developing fisheries, in mature fisheries near full exploitation, and in senescent fisheries that are overexploited and overcapitalized. In all cases, fishing fleets behave rationally within the imposed regulatory structures. Successful, generalist fishermen who take risks often pioneer developing fisheries. At this stage, regulations and subsidies tend to encourage excessive entry and investments, creating the potential for serial depletion. In mature fisheries, regulations often restrict season length, vessel and gear types, fishing areas, and fleet size, causing or exacerbating the race for fish and excessive investment, and are typically unsuccessful except when combined with dedicated access privileges (e.g., territorial rights, individual quotas). In senescent fisheries, vessel buyback programs must account for the fishing power of individuals and their vessels. Subsidies should be avoided as they prolong the transition towards alternative employment. Fisheries managers need to create individual incentives that align fleet dynamics and fishermen behavior with the intended societal goals. These incentives can be created both through management systems like dedicated access privileges and through market forces.

Carothers, C. and **Sepez, J**. "Commercial Fishing Crew Demographics and Trends in the North Pacific: 1993-2003." Pp. 37-40 in *Managing Fisheries Empowering Communities Conference Proceedings*, Alaska Sea Grant, Anchorage.

This report examines demographic change in Bering Sea and Aleutian Island (BSAI) fishing communities since 1920. We undertook this research in an attempt to begin introducing human population dynamics as an indicator for regional ecosystem analyses. We focus here on human inhabitants of the Bering Sea coast, using total population by community and by Census area as the primary indicator, with some analysis of other population characteristics such as ethnicity. This approach is concordant with research on arctic communities that uses crude population growth or loss as a general measure to determine community viability, as this indicator is easy to understand, locally meaningful, and points to the capacity of people in these places to "dwell and prosper for some period, finding sources of income and meaningful lives" (Aarsaether et.al. 2004). An understanding of recent and historic demographic data in the region is a preliminary step to developing models that will attempt to predict demographic effects of changes in fish populations, fisheries management, industry conditions and markets, and climate characteristics. This research project examined birth rates, migration, indigeneity, boom-bust economic cycles, and seasonality as factors in understanding population trends in the region. This report discusses community selection methodology and challenges, describes and analyzes the causes of demographic trends in BSAI fishing communities since 1920, points to the impacts of population decline or growth on local communities, and finally, suggests opportunities for including demographic indicators in future research on fisheries science and policy.

Dalton, M. and S. Ralston. 2004. "The California Rockfish Conservation Area and Groundfish Trawlers at Moss Landing Harbor." *Marine Resource Economics* Vol. 18: 67-83.

This article uses a bioeconomic model and data for groundfish trawlers at Moss Landing Harbor in Central California to analyze effects of spatial closures that were implemented recently by West Coast fishery managers to reduce bycatch of overfished groundfish stocks. The model has a dynamic linear rational expectations structure, and estimates of its parameters exhibit spatial variation in microeconomic and ecological factors that affect decisions about where and when to fish. Test results show that variation in marginal costs of crowding externalities and biological rates of stock productivity are the most significant factors to consider in the spatial management of groundfish trawlers at Moss Landing.

Dalton, M., B. C. O'Neill, A. Prskawetz, L. Jiang, J. Pitkin. 2006. "Population Aging and Future Carbon Emissions in the United States." *Energy Economics* (in press).

Changes in the age composition of U.S. households over the next several decades could affect energy use and carbon dioxide (CO2) emissions, the most important greenhouse gas. This article incorporates population age structure into an energy-economic growth model with multiple dynasties of heterogeneous households. The model is used to estimate and compare effects of population aging and technical change on baseline paths of U.S. energy use, and CO2 emissions. Results show that population aging reduces long-term emissions, by almost 40% in a low population scenario, and effects of aging on emissions can be as large, or larger than, effects of technical change in some cases. These results are derived under standard assumptions and functional forms that are used in economic growth models. The model also assumes a closed economy, substitution elasticities that are fixed, and identical across age groups, and patterns of labor supply that vary by age group, but are fixed over time.

Felthoven, Ronald G. 2004. "Methods for Estimating Fishing Capacity with Routinely Collected Data: A Comparison." *Review of International Fisheries Law and Policy*, Vol. 1(2): 125-137.

In the past three years, the National Marine Fisheries Service (NMFS) has assembled both an internal task force and an external expert panel to suggest methods for computing fishing capacity in U.S. fisheries. The primary difficulty in choosing a suggested methodology has been the lack of economic data required for many of the capacity models developed in the economic literature. In most U.S. fisheries, the available data are limited to catch records, vessel numbers and characteristics, and some indicators of fishing effort, necessitating the use of "primal" models, and measures of "technical" fishing capacity. This paper describes two of the suggested frontier methods for measuring capacity: data envelopment analysis (DEA) and the stochastic production frontier (SPF). We discuss how to implement these models, and various notions of "capacity" that can be computed, depending on the assumptions made regarding potential increases in effort.

Felthoven, Ronald G. and C.J. Morrison Paul. 2004. "Multi-Output, Non-Frontier Primal Measures of Capacity and Capacity Utilization." *American Journal of Agricultural Economics,* Vol. 86(3): 615-629.

This paper offers and implements an econometric approach for generating primal capacity output and utilization measures for fisheries. In situations where regulatory, environmental, and resource conditions affect catch levels but are not independently identified in the data, frontier-based capacity models may interpret such impacts as production inefficiency. However, if such inefficiencies are unlikely to be eliminated, the implied potential output increases may be unrealistic. We develop a multi-output, multi-input stochastic transformation function framework that permits various assumptions about how output composition may change when operating at full capacity. We apply our model to catcher-processor vessels in the Alaskan pollock fishery.

Felthoven, Ronald G., Terry Hiatt, and Joseph M. Terry. 2004. "Measuring Fishing Capacity and Utilization with Commonly Available Data: An Application to Alaskan Fisheries." *Marine Fisheries Review* Vol. 64(4): 29-39.

Due to a lack of data on vessel costs, earnings, and input use, many of the capacity assessment models developed in the economics literature cannot be applied in U.S. fisheries. This incongruity between available data and model requirements underscores the need for developing applicable methodologies. This paper presents a means of assessing fishing capacity and utilization (for both vessels and fish stocks) with commonly available data, while avoiding some of the shortcomings associated with competing "frontier" approaches (such as data envelopment analysis).

Felthoven, Ronald G. and C.J. Morrison Paul. 2004. "Directions for Productivity Measurement in Fisheries." *Marine Policy*, Vol. 28: 161-169.

Fisheries policy is often aimed at sustaining and improving economic performance, but the use of traditional productivity measurement to assess performance over time has been quite limited. In this paper we review the currently sparse literature on productivity in fisheries, and suggest ways to better account for many of the relevant issues unique to the industry. Specifically, we discuss the need to incorporate bycatch levels, to better account for environmental and stock fluctuations, and to relax some of the restrictive economic assumptions that have been imposed in the research to date. A methodological framework that may be used to incorporate these factors is proposed.

Felthoven, Ronald G. 2002. "Effects of the American Fisheries Act on Capacity, Utilization and Technical Efficiency." *Marine Resource Economics*, Vol. 17(3): 181-205.

The American Fisheries Act (AFA) of 1998 significantly altered the Bering Sea and Aleutian Islands pollock fishery by allowing the formation of harvesting and processing cooperatives and defining exclusive fishing rights. This paper uses data envelopment analysis and stochastic production frontier models to examine effects of the AFA on the fishing capacity, technical harvesting efficiency (TE), and capacity utilization (CU) of pollock catcher-processors. Results from multi-input, multi-output models indicate that fishing capacity fell by more than 30% and that harvesting TE and CU measures increased relative to past years. This work provides examples of how existing data, which is currently devoid of operator costs and provides only general indicators of earnings, may be used to analyze changes in elements of fleet and vessel performance in response to management actions.

Garber-Yonts, B.E.,. J. Kerkvliet, R. Johnson. 2004. "Public Values for Biodiversity Conservation Policies in the Oregon Coast Range." *Forest Science* Vol. 50(5): 589-602.

This study uses a choice experiment framework to estimate Oregonians' willingness to pay (WTP) for changes in levels of biodiversity protection under different conservation programs in the Oregon Coast

Range. We present biodiversity policy as an amalgam of four different conservation programs: salmon and aquatic habitat conservation, forest age-class management, endangered species protection, and large-scale conservation reserves. The results indicate substantial support for biodiversity protection, but significant differences in WTP across programs. Oregonians indicate the highest WTP for increasing the amount of forest devoted to achieving old-growth characteristics. On average, respondents indicate an annual household WTP of $380 to increase old-growth forests from 5% to 35% of the age-class distribution. Conversely, WTP for increasing conservation reserves peaks at $45 annually to double the current level to 20% of the landscape, whereas WTP is negative for any increase over 32%. We also find resistance to any change in conservation policy, which substantially offsets WTP for increases in all four conservation programs.

Garber-Yonts, B.E. 2004. "The Economics of Amenities and Migration in the Pacific Northwest: Review of Selected Literature with Implications for National Forest Management." U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. General Technical Report PNW-GTR-617. 48 p.

This paper reviews literature on the influence of nonmarket amenity resources on population migration. Literature reviewed includes migration and demographic studies; urban and regional economics studies of amenities in labor markets, retirement migration, and firm location decisions; nonmarket valuation studies using hedonic price analysis of amenity resource values; land use change studies; and studies of the economic development influence of forest preservation. A synthesis of the literature finds that the influence of amenities is consistently shown to be a positive factor contributing to population growth in urban and rural areas characterized by proximity to public forest lands. Beyond this broad finding, however, little research has been conducted at an appropriate scale to be directly useful in forest management and planning decisions. Areas for further research are identified.

Garber-Yonts, B.E.. 2005. "Conceptualizing and Measuring Demand for Recreation on National Forests: a Review and Synthesis." U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. General Technical Report PNW-GTR-645.40.

This analysis examines the problem of measuring demand for recreation on national forests and other public lands. Current measures of recreation demand in Forest Service resource assessments and planning emphasize population-level participation rates and activity-based economic values for visitor days. Alternative measures and definitions of recreation demand are presented, including formal economic demand and multi-attribute preferences. Recreation assessments from national-level Renewable Resources Planning Act Assessments to site-level demand studies are reviewed to identify methods used for demand analysis at different spatial scales. A finding throughout the multiple scales of analysis, with the exception of site-level studies, is that demand measures are not integrated with supply measures. Supply analyses, in the context of resource assessments, have taken the form of mapped spatial inventories of recreation resources on the national forests, based on the classification of recreational settings according to the opportunities they produce (e.g., the Recreation Opportunity Spectrum). As such, integration of demand analysis with these measures of supply requires measuring the demand for recreational settings. To support management and planning decisions, recreation demand analysis must also permit projection of changes in visitation at multiple scales as changes in management and policy alter recreational settings, and as the demographics and behavior of the user base changes through time. Although this is currently being done through many formal economic studies of site demand, methods are needed that scale up to higher levels of spatial aggregation.

Several areas for research, development and application of improved methods for demand analysis are identified, and improved methods for spatially explicit models of recreation visitation and demand are identified as a priority area for research.

Harris, T., **C. Seung**, Tim Darden, and William Riggs. 2002. "Rangeland Fires in Northern Nevada: An Application of Computable General Equilibrium Modeling." *Western Economics Forum*, Vol. 1(2):3-10.

A dynamic computable general equilibrium model of a five county Northern Nevada economy is used to estimate the business losses and recovery efforts of a 1.6 million acre rangeland fire. In comparison to input-output or social accounting models, the dynamic computable general equilibrium model incorporates the roles of markets and prices in the estimation of this natural catastrophe. Results indicate that fire suppression and rehabilitation expenditures were not enough to offset the losses in public land grazing activities.

Johnson, K.N., P. Bettinger, J. Kline, T. A. Spies, M. Lennette, G. Lettman, **B. Garber-Yonts**, and T. Larsen. 2006. "Simulating Forest Structure, Timber Production, and Socio-Economic Effects in a Multi-Owner Province." *Ecological Applications* (in press).

Protecting biodiversity has become a major goal in managing coastal forests in the Pacific Northwest—an area in which human activities have had a significant influence on landscape change. A complex pattern of public and private forest ownership, combined with new regulations for each owner group, raises questions about how well and how efficiently these policies achieve their biodiversity goals. To develop a deeper understanding of the aggregate effect of forest policies, we simulated forest structures, timber production, and socio-economic conditions over time for the mixture of private and public lands in the 2.5-million-ha Coast Range Physiographic Province of Oregon. To make these projections, we recognized both vegetative complexity at the stand level and spatial complexity at the landscape level. We focused on the two major factors influencing landscape change in the forests of the Coast Range: 1) land use, especially development for houses and cities, and 2) forest management, especially clearcutting. Our simulations of current policy suggest major changes in land use on the margins of the Coast Range, a divergence in forest structure among the different owners, an increase in old-growth forests, and a continuing loss of the structural elements associated with diverse young forests. Our simulations also suggest that current harvest levels can be approximately maintained, with the harvest coming almost entirely from private lands. A policy alternative that increased requirements for retention of live trees for wildlife at final harvest on private lands would be relatively costly (5-7% reduction in timber production) to landowners. Another alternative that precluded thinning of plantations on federal land would significantly reduce the area of very large diameter (>75 cm dbh) conifer forests at 100 years.

Lew, Daniel K. and Douglas M. Larson. 2005. "Accounting for Stochastic Shadow Values of Time in Discrete-Choice Recreation Demand Models." *Journal of Environmental Economics and Management,* 50(2): 341-361.

In this paper, a discrete-choice recreation demand model that explicitly accounts for a stochastic shadow value of time function is proposed. Using data from a survey of San Diego beach users, the stochastic shadow value of time, labor supply, and beach choice are jointly estimated. Results from this joint estimation approach are compared with the familiar two-step approach that estimates labor supply first and uses predicted values of time in the recreational site choice model. The approaches produce markedly different welfare measures, with the two-step model, which does not account for unobserved variability of time values, predicting significantly higher values. A Monte Carlo simulation illustrates how ignoring the stochastic nature of shadow value of time in discrete-choice recreation demand models can bias model parameters, and hence, welfare estimates.

Kline J.D., R.J. Alig, **B. Garber-Yonts**. 2004. "Forestland Social Values and Open Space Preservation." *Journal of Forestry* 102(8):39-45.

Concerns have grown about the loss of forestland to development, leading to both public and private efforts to preserve forestland as open space. These lands comprise social values-ecological, scenic, recreation, and resource protection values-not typically reflected in market prices for land. When these values are present, it is up to public and private agencies to provide them in sufficient quantity. We discuss nonmarket social values in the context of forestland market values, to explain the economic rationale for public and private efforts to protect forestland as open space.

Larson, Douglas M. and **Daniel K. Lew**. 2005. "Measuring the Utility of Ancillary Travel: Results from a Study of Recreation Demand." *Transportation Research Part A*, 39(2-3): 237-255.

The issues involved in determining economic values of travel as a component of away-from-home trips are discussed. Four distinct concepts are relevant and useful depending on circumstances: marginal and total values of travel, and gross versus net values. A utility-theoretic inverse demand systems approach is implemented to estimate the separate demands for recreation trips and time onsite at the destination, and implemented using data on pink salmon fishing in Alaska. The distance function underlying the demand system is used to determine the net values of travel ancillary to fishing. Some 64% of fishermen had positive net values of travel, and the value of travel per hour traveled averaged $1.64/hour with a median of $3.18/hour.

Harris, Thomas, **C. Seung**, T. Darden, and W. Riggs. 2002. "Rangeland Fires in Northern Nevada: An Application of Computable General Equilibrium Modeling." *Western Economics Forum*, Vol. 1(2):3-10.

A dynamic computable general equilibrium model of a five county Northern Nevada economy is used to estimate the business losses and recovery efforts of a 1.6 million acre rangeland fire. In comparison to input-output or social accounting models, the dynamic computable general equilibrium model incorporates the roles of markets and prices in the estimation of this natural catastrophe. Results indicate that fire suppression and rehabilitation expenditures were not enough to offset the losses in public land grazing activities.

Lazrus, H. and **Sepez, J**., 2005. "The NOAA Fisheries Alaska Native Traditional Knowledge Database," *Practicing Anthropology* 27(1):33-37.

Applications of the Alaska Native Traditional Environmental Knowledge Database were critically examined by Lazrus and Sepez based on interviews with intended users at the AFSC and elsewhere.

Comprised of information from pre-existing sources in the literature, the database was a partial response to public comments about the lack of TEK in the Draft Groundfish Programmatic Supplemental Environmental Impact Statement (PSEIS). Lazrus and Sepez review ways in which authors of the revised PSEIS found the database helpful and the challenges they faced using the information. Lazrus and Sepez discuss several issues surrounding how TEK is compiled and cited in agency documents. Because it is passed from one generation to another, TEK can lend a great deal of place-specific temporal depth to scientific investigations that may only have data for a short period of time. Such temporal depth lends historical perspective to environmental phenomena and can facilitate the construction of baselines or indicate rates of change. It can also point to issues that may not have been considered by the agency. However, TEK offers very localized information that does not always correspond to the geographic scope of regional agency interests. Additionally, the Alaska Native Traditional Environmental Knowledge Database does not offer users an easy way to assess the authority of the information source, so it may be difficult to judge the validity of a claim. The article discusses the ways in which TEK and scientific investigation have different paradigms that entail different ways of observing and drawing conclusions about how the world works. This disparity may at times complicate applying information from both paradigms to a single issue. On the other hand, this may also lead to a more multidimensional examination of an issue and a more robust analysis. Of course, ethical issues arise when expert information is taken from a community without addressing issues of compensation and co-management of resources. Lazrus and Sepez also discuss the problem of treating TEK as a series of facts or observations that can be extracted from cultural context. Without the context in which they are developed and understood, fragments of information may be misinterpreted or misapplied. Despite the challenges, NOAA scientists were generally very interested in understanding and incorporating TEK in agency efforts to analyze and manage North Pacific marine resources.

Lew, Daniel K. and Douglas M. Larson. 2005. "Valuing Recreation and Amenities at San Diego County Beaches." *Coastal Management,* 33(1): 71-86.

Policymakers and analysts concerned with coastal issues often need economic value information to evaluate policies that affect beach recreation. This paper presents economic values associated with beach recreation in San Diego County generated from a recreation demand model that explains a beach user's choice of which beach to visit. These include estimates of the economic values of a beach day, beach closures, and beach amenities.

Package, C. and Sepez, J. 2004. "Fishing Communities of the North Pacific: Social Science Research at the Alaska Fisheries Science Center." *AFSC Quarterly Report* April-May-June 2004, available online at http://www.afsc.noaa.gov/Quarterly/amj2004/amj04featurelead.htm

NOAA Fisheries is involved in a nationwide effort to profile fishing communities for the purpose of expanding baseline knowledge of people who may be affected by changes in fishery regulations. In 2003 a team of graduate students at the Alaska Fisheries Science Center (AFSC) completed draft short-form profiles for 130 communities located in the state of Alaska. These profiles have been compiled in the upcoming publication Fishing Communities of the North Pacific, Volume I: Alaska. Longer profiles based on in-depth research also are being developed at the AFSC for a more select group of Alaska fishing communities. In mid-2004, the AFSC team joined with a team from the Northwest Fisheries Science Center to begin developing short-form profiles for West Coast communities, many of which are very involved in Alaska fisheries.

Sepez, J. 2003. "Makah." In *Dictionary of American History, 3rd Edition.* Charles Scribner's Sons: New York.

This dictionary article briefly describes the history of the Makah Indian Tribe of northwest Washington State, including population history, early contact with European explorers, cultural and subsistence patterns, the excavation of the Ozette archaeological site, and the modern resumption of subsistence whaling.

Sepez, J. 2002. "Treaty Rights and the Right to Culture: Native American Subsistence Issues in US Law." *Cultural Dynamics* 14(2): 143-159.

The interplay of treaty rights with the right to culture has produced a variety of results for Native American subsistence hunting and fishing rights in the United States. Where allocation and conservation measures fail to account for cultural considerations, conflict ensues. This paper discusses three examples: waterfowl hunting in Alaska, Northwest salmon fishing, and Inuit and Makah whaling. Each demonstrates that treaty rights are a more powerful force than cultural rights in the law, but that both play important roles in actual policy outcomes. A more detailed examination of whaling indicates how the insertion of needs-based criteria into a framework of cultural rights shifts the benefit of presumption away from indigenous groups. The cultural revival issues and conflicting paradigms involved in Makah whaling policy debates indicate how notions of tradition, authenticity, and self-determination complicate the process of producing resource policies that recognize cultural diversity.

Sepez, J. 2005. "Introduction to Traditional Environmental Knowledge in Federal Natural Resource Management Agencies," *Practicing Anthropology* 27(1):2-5.

This introduction summarizes the articles and issues in the special theme issue on traditional environmental knowledge in Federal natural resource management agencies (see issue abstract).

Sepez, J. 2006. Communities Research at the Alaska Fisheries Science Center. Pp. 31-36 in *Managing Fisheries Empowering Communities Conference Proceedings*, Alaska Sea Grant, Anchorage.

This paper describes the Alaska Fisheries Science Center's large-scale approach to conducting social science research on fishing communities. It discusses details of compiling large amounts of pre-existing quantitative data on involvement in fisheries by community, using indicators to assess the relative importance of participation of communities in fisheries. Data has been compiled for fishing communities in Alaska, Washington, Oregon, California, and other US States that participate in North Pacific Fisheries. The paper also describes using key data to select communities for narrative profiling, 136 in Alaska, 129 in other states. It gives the outline of the narrative profiles and describes the process followed for obtaining community feedback. The paper ends with a discussion of the benefits and drawbacks of using such a large-scale approach to study fishing communities, concluding that despite acknowledged limitations, the method is very useful. It provides a consolidated source of information to policy makers, analysts, and community members, attends to a wide range of communities, including many that have never before been explicitly mentioned in fisheries impact analysis, creates a uniform approach to fisheries participation assessment that allows for comparisons between fishing communities and eventually (when other NMFS regions complete their profiles) will allow for comparisons of fisheries participation between regions.

Sepez, J. A., B. Tilt, C. Package, H. Lazarus, and I. Vaccaro. Community Profiles for North Pacific Fisheries - Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-160, 552 p.

This document profiles 136 fishing communities in Alaska with basic information on social and economic characteristics. Various federal statutes, including the Magnuson-Stevens Fishery Conservation and Management Act and the National Environmental Policy Act, among others, require agencies to examine the social and economic impacts of policies and regulations. These profiles can serve as a consolidated source of baseline information for assessing community impacts in Alaska. The profiles are given in a narrative format that includes three sections: People and Place, Infrastructure, and Involvement in North Pacific Fisheries. People and Place includes information on location, demographics (including age and gender structure of the population, racial and ethnic make up), education, housing, and local history. Community Infrastructure covers current economic activity, governance (including city classification, taxation, Native organizations, and proximity to fisheries management and immigration offices) and facilities (transportation options and connectivity, water, waste, electricity, schools, police, and public accommodations). Involvement in North Pacific Fisheries details community activities in commercial fishing (processing, permit holdings, and aid receipts), recreational fishing, and subsistence fishing. To define communities, we relied on Census place-level geographies where possible, grouping communities only when constrained by fisheries data, yielding 128 individual profiles. Regional characteristics and issues are briefly described in regional introductions. The communities were selected by a process which assessed involvement in commercial fisheries using quantitative data from the year 2000, in order to coordinate with 2000 Census data. The quantitative indicators looked at communities that have commercial fisheries landings (indicators: landings, number of processors, number of vessels delivering to a community), communities that are the registered homeports of vessels participating in the fisheries, and communities that are home to documented participants in the fisheries (indicators: crew license holders, state and federal permit holders, and vessel owners). Where appropriate, the indicators were assessed as a ratio to the community's population. Selection of a community was triggered by its surpassing a certain threshold in any one of the indicator categories, or in an aggregated category made up of the individual indicators. The Alaska communities selected and profiled in this document are: Adak, Akhiok, Akiachak, Akutan, Aleknagik, Alitak Bay, Anchor Point, Anchorage/Chugiak/Eagle River/Girdwood, Angoon, Atka, Bethel, Chefornak, Chignik (Bay), Chignik Lagoon, Chignik Lake, Clam Gulch, Clark's Point, Cordova, Craig, Dillingham, Edna Bay, Eek, Egegik, Ekuk, Ekwok, Elfin Cove, Elim, Emmonak, Excursion Inlet, Fairbanks, False Pass, Fritz Creek, Galena, Goodnews Bay, Gustavus, Haines, Halibut Cove, Hobart Bay, Homer, Hoonah, Hooper Bay, Hydaburg, Igiugig, Iliamna, Ivanof Bay, Juneau/Douglas/Auke Bay, Kake, Karluk, Kasilof, Kenai, Ketchikan/Ward Cove, King Cove, King Salmon, Kipnuk, Klawock, Kodiak, Kokhanok, Koliganek, Kongiganak, Kotlik, Kwillingok, Larsen Bay, Levelock, Manokotak, Marshall, Mekoryuk, Metlakatla, Meyers Chuck, Naknek, Napakiak, Nelson Lagoon, New Stuyahok, Newhalen, Newtok, Nightmute, Nikiski, Nikolaevsk, Ninilchik, Nome, Old Harbor, Ouzinkie, Palmer, Pedro Bay, Pelican, Perryville, Petersburg, Pilot Point, Pilot Station, Platinum, Point Baker, Port Alexander, Port Alsworth, Port Graham, Port Heiden, Port Lions, Port Moller, Port Protection, Portage Creek, Prudhoe Bay, Quinhagak, Saint George, Saint Mary's, Saint Paul, Sand Point, Scammon Bay, Seldovia, Seward, Shaktoolik, Sitka, Skwentna, Soldotna, South Naknek, Sterling, Tenakee Springs, Thorne Bay, Togiak, Toksook Bay, Tuntutuliak, Tununak, Twin Hills, Ugashik, Unalakleet, Unalaska/Dutch Harbor, Valdez, Wasilla, Whale Pass, Whittier, Willow, Wrangell, and Yakutat.

Sepez, J. and Lazrus, H. (eds.). 2005. “Traditional Environmental Knowledge in Federal Natural Resource Management Agencies.” *Practicing Anthropology* 27(1):1-48.

"Traditional Environmental Knowledge (TEK) in Federal Natural Resource Management Agencies" is the theme of this special issue of the journal Practicing Anthropology. The issue features articles from NOAA/NMFS contributors, as well as articles by (or about) other federal agencies, including the Bureau of Land Management, Environmental Protection Agency (EPA), National Park Service, and the U.S. Fish and Wildlife Service. The issue includes two important articles by NMFS authors. Lazrus and Sepez critically examine the application of the Alaska Native Traditional Environmental Knowledge Database developed at the Alaska Fisheries Science Center. They conclude that agency scientists are interested in using traditional environmental knowledge in their work, but that both practical and theoretical issues present serious challenges to meaningful incorporation (see article abstract). The issue also includes an article by Jennifer Isé and Susan Abbott-Jamieson of NMFS describing the Local Fisheries Knowledge Pilot Project http://www.st.nmfs.noaa.gov/lfkproject/, which takes place in two lobstering communities in Maine, and may be expanding to Alaska in the coming years. The project involves high school students in collecting cultural, environmental, and historical knowledge from local fishing families. Other articles in the issue discuss understanding Huna Tlingit traditional harvest management techniques for gull eggs in Glacier Bay National Park, incorporating Swinomish cultural values into wetland valuations, integrating TEK into subsistence fisheries management in Alaska, considering traditional tribal lifeways in EPA decision making, conserving wild medicinal plants that have commercial value, and including TEK in planning processes for the National Petroleum Reserve. The compilation concludes with a cautionary commentary from Preston Hardison of the Indigenous Biodiversity Information Network about international protocols, government-to-government relationships, rules of disclosure for tribal proprietary information, and the spiritual contexts of knowledge production and knowledge sharing. The issue is an important source of information on TEK program possibilities and lessons learned for federal resource scientists and managers interested in incorporating traditional environmental knowledge into their work.

Sepez, J., K. Norman, A. Poole, and B. Tilt. 2005. “Fish Scales: Scale and Method in Social Science Research for North Pacific and West Coast Fishing Communities.” *Human Organization*, Vol 65(3):280-293.

Driven by the requirements of the Magnuson-Stevens Fishery Conservation and Management Act and the demand among stakeholders for social science to inform fisheries policy, the need for NMFS to conduct social science research is widely accepted. But how such research should be carried out is not at all well established. This article describes the development of a research program at NMFS--led by anthropologists--designed to understand the interaction between fisheries and communities in the North Pacific and West Coast regions. Specific conceptual and methodological challenges are discussed, including the vast number of communities involved in fishing in these regions, limited government resources, competing definitions of what constitutes a community, and the need for indicators which are comparable across communities and regions. The research program described here takes a multi-method, multi-scale approach, combining social indicators research with ethnographic fieldwork and Rapid Assessment Procedures (RAP). We argue that such an approach is necessary to understand the social and economic aspects of fishery management. As fishery managers and policy makers increasingly recognize that humans play an important role in natural resource issues, the experiences of this research program will influence the course of social science research at NMFS in the years to come.

Seung, Chang and Edward Waters. 2005. "A Review of Regional Economic Models for Alaska fisheries." *Alaska Fisheries Science Center Processed Rep. 2005-01.*

There are many regional economic models in the literature, and a limited number have been used to investigate the impacts of fishery management policies on communities. However, there is no formal study in the literature that provides a thorough, comparative evaluation of the regional economic models that have been, or can be, used for regional impact analysis for fisheries. In Part I, we describe the Alaska seafood industry, discuss the importance of the industry to the state economy, and indicate the importance of regional economic analysis for the Alaska seafood industry. Next a theoretical overview of regional economic models is provided. Specifically, we discuss major features of each type of regional economic model – economic base model (EB), input-output model (IO), social accounting matrix model (SAM), supplied-determined model, and computable general equilibrium model (CGE). Finally, a comparative discussion of these models is also provided. While Part I focuses on a theoretical review of regional economic models, Part II discusses applications of those regional economic models to fisheries. These include input-output (IO) models, which have been used in many previous studies of regional economic impacts for fisheries, the Fisheries Economic Assessment Model (FEAM), which has been one of the major analytical tools used to examine the impacts of fisheries on the West Coast and in Alaska, and the first regional computable general equilibrium (CGE) model used for fisheries in a U.S. region. In addition, some issues related to specifying such models for Alaska fisheries, data needs and availability for modeling regional economic impacts for Alaska fisheries, and perspectives on regional economic modeling for Alaska fisheries are discussed.

Seung, Chang and Edward Waters. 2006. "A Review of Regional Economic Models for Fisheries Management in the U.S." *Marine Resource Economics*, Vol. 21(1):101-124.

In 1986 Andrews and Rossi reviewed input-output (IO) studies of U.S. fisheries. Since then many more fisheries studies have appeared using IO and other types of regional economic models, such as Fishery Economic Assessment Models, Social Accounting Matrices, and Computable General Equilibrium models. However no updated summary of these studies or models has appeared since 1986. This paper attempts to fill this gap by briefly reviewing the types of regional economic models that have been applied to fisheries; reviewing studies using these models that have been conducted for U.S. fisheries; and identifying data and modeling issues associated with regional economic analysis of fisheries in the U.S. The authors conclude that although economic impact analysis of fisheries policy is required under federal law, development of more representative regional economic models for this purpose is not likely to be forthcoming without increased information obtained through some type of comprehensive data collection program.

Seung, Chang and Edward Waters. 2006. "The Role of the Alaska Seafood Industry: A Social Accounting Matrix (SAM) Model Approach to Economic Base Analysis." *The Annals of Regional Science,* Vol 40(2): 335-360.

A social accounting matrix (SAM) model for Alaska is constructed to investigate the role of the state's seafood processing industry. The SAM model enables incorporation of the unique features of Alaska economy such as (i) the existence of a large nontraditional economic base, (ii) a large leakage of labor income, and (iii) a very large share of intermediate inputs imported from outside the state. The role of an industry in an economy with these features can not be examined correctly within an input-output framework, which is the method most often used for examining the importance of an industry to a region. Taking an export base view of the economy, we found seafood processing to be an important industry, generating 4.5% of the state's total employment. While an important driver of the state's economy, the industry has the smallest SAM multiplier mainly due to a large leakage of labor earnings and a large share of imported intermediate inputs. We also found that non-traditional economic base components such as (i) federal transfers to state and local governments, and (ii) federal transfers, permanent fund dividend (PFD) payments, and other extra-regional income received by households generate about 26 % of the state's total employment and earnings.

Spies, T.A., K.N. Johnson, K.M. Burnett, J.L. Ohmann, B.C. Mccomb, G.H. Reeves, P. Bettinger, J.D. Kline, **B. Garber-Yonts.** 2006. "Cumulative Ecological and Socio-Economic Effects of Forest Policies in Coastal Oregon." *Ecological Applications* (in press).

Forest biodiversity policies in multi-ownership landscapes are typically developed in an uncoordinated fashion with little consideration of their interactions or possible unintended cumulative effects. We conducted an assessment of some of the ecological and socio-economic effects of recently-enacted forest management policies in the 2.5-million-ha Coast Range Physiographic Province of Oregon. This mountainous area of conifer and hardwood forests includes a mosaic of landowners with a wide range of goals, from wilderness protection to high-yield timber production. We projected forest changes over 100 years in response to logging and development using models that integrate land use change and forest stand and landscape processes. We then assessed responses to those management activities using GIS models of stand structure and composition, landscape structure, habitat models for focal terrestrial and aquatic species, timber production, employment, and willingness to pay for biodiversity protection. Many of the potential outcomes of recently enacted policies are consistent with intended goals. For example, we project the area of structurally diverse older conifer forest and habitat for late successional wildlife species to strongly increase. Other outcomes might not be consistent with current policies-- for example, hardwoods and vegetation diversity strongly decline within and across owners. Some elements of biodiversity, including streams with high potential habitat for coho salmon (*Oncorhynchus kisutch*) and sites of potential oak woodland, occur predominately outside federal lands and thus were not affected by the strongest biodiversity policies. Except for federal lands, biodiversity policies were not generally characterized in sufficient detail to provide clear benchmarks against which to measure the progress or success. We conclude that land management institutions and policies are not well configured to deal effectively with ecological issues that span broad spatial and temporal scales and that alternative policies could be constructed that more effectively provide for a mix of forest values from this region.

Vaccaro, I. and **Sepez, J**. 2003. "Understanding Fishing Communities: Three Faces of North Pacific Fisheries," pp. 220-221 in Witherall, D. (Ed.) *Managing Our Nation's Fisheries: Past, Present, and Future.* Proceedings of a Conference on Fisheries Management in the United States Held in Washington, DC.

Understanding and managing the impacts of fisheries means understanding fishing, and fishing communities, as much as understanding fish. Fishing communities are human settlements with a substantial level of dependence on or engagement in extraction of living marine resources. In the North Pacific, these communities are shaped by the interaction of productive and consumptive practices, resource availability, markets, and regulatory policies. The protection of these communities and their way of life depends on a careful appraisal of multi-faceted relationships with marine resources. At the Alaska Fisheries Science Center, this means developing techniques for social analyses that recognize how fishing is articulated around three different types of activities: commercial, subsistence, and recreational. Public policy and science have often considered fisheries management to be almost exclusively concerned with commercial fishing. This perspective is understandable if we consider that commercial fishing accounts for 95% of the catch in Alaska, while subsistence accounts for just 4% and recreational 1%. The implications of this distribution for concerns such as biomass, ecological dynamics, and production of wealth are unambiguous. However, in the terrain of the social landscape, the much smaller catch percentages of subsistence and recreational fishing do not necessarily translate into insignificant social impacts. For example, in some communities, 100% of local households are participating in subsistence fishing, while only a small portion of residents are connected to the commercial fishing industry. In fact, leakage of wealth produced by the commercial fishing industry – through both imported labor forces and externalized corporate functions – is a significant factor attenuating the local impact of the commercial sector. Our analysis of the fishing communities of Alaska, their social context and the productive implications of marine natural resources, indicates that an approach which prioritizes commercial fishing to the exclusion of these other sectors is insufficient, and potentially misleading as to the social dynamics of both the complementary and conflicting interests which make up human communities. Subsistence and recreational fishing are fundamental parts of the social structure, and also the economy of many Alaskan communities, often supplying different segments of the population than commercial fisheries. At the Alaska Fisheries Science Center, anthropologists in the Economics and Social Sciences Research Program are involved in compiling profiles of North Pacific Fishing Communities. For communities located in Alaska, we have endeavored to describe and analyze the triadic relationship between commercial, subsistence and recreational fishing sectors. This is accomplished by characterizing the participation by community members in each type of fishery, and where possible, indicating the kinds of interrelationships that make the triad a dynamic and evolving social framework: competition for fisheries allocation; economic diversification of rural communities; joint production efficiencies; seasonal complementarities and conflicts; ethnicity and immigration issues; and local responses to the forces of globalization. Fisheries management or public policy impact assessment that does not take into account this multiple and complex nature of the relation between fishing communities and marine resources may create substantial unintended impacts on the very same communities they are intending to protect.

Working or Submitted Papers:

Dalton, M. 2006. Simulated Maximum Likelihood Estimation and Analysis of Covariance in a Panel Tobit Model: Some Monte Carlo Results. NOAA/Sea Grant working paper.

Dynamic economic models are often estimated and tested using pooled time series data (e.g. Sargent, 1978; Rosenman, 1987; Dalton, 2001). However, if individual effects are significant, then the use of pooled data can produce biased estimates and potentially incorrect test results.
Therefore, when panel data are available, an analysis of covariance is generally recommended to verify whether individual effects are present (Hsiao, 1986). In practice, a complication often encountered with panel data is missing, or zero, values. In many cases, a reasonable assumption is that a positive value for an individual is recorded only if some threshold event occurs, for example when an individual's valuation of a good or service is above an observed price. When this type of censoring occurs, the Tobit model is a standard tool for estimation and testing that gives unbiased results for static models under typical assumptions. Until recently, estimation and testing of dynamic Tobit models under more general conditions has not been feasible because of computational constraints. This paper presents a simple dynamic Tobit model and likelihood simulator for use with panel data, and reports Monte Carlo results of estimation and testing. The panel Tobit model presented in this paper is an extension of the dynamic Tobit model in Lee (1999), for use with panel data, as in Lee (1998). Work in this paper is confined to first-order autocorrelation to facilitate an analysis of covariance that tests for heterogeneity among individuals in a panel. The likelihood simulator used in this paper could be extended to other covariance structures (e.g. ARCH, GARCH) in a straightforward way. However, the preferred interpretation for the model in this paper is a single equation from a reduced-form vector autoregression (VAR), disaggregated to incorporate effects of individual heterogeneity as in a panel VAR (e.g. Holtz-Eakin, Newey and Rosen, 1988; Hsiao, Pesaran and Tahmiscioglu, 2001), and designed to accommodate panels with censored endogenous variables. The ultimate goal, which is beyond the scope of this paper, is to use dynamic Tobit models in panel VARs to test the cross-equation parameter restrictions implied by the rational expectations hypothesis. Monte Carlo simulations in this paper are used to evaluate maximum likelihood estimates, and perform an analysis of covariance that compares panel Tobit models with, and without, individual effects. Results show estimates of the dynamic parameters in the panel Tobit model are generally unbiased, but other parameters exhibit bias, up to 10\% in some cases. The bias-correction procedures described by Lee (1998) could be used to improve estimates in this paper, but these procedures would not affect results from the analysis of covariance. Tests of the analysis of covariance evaluate probabilities for two types of errors. The first type rejects the pooled model when the panel consists of identical individuals. The second type fails to reject the pooled model when the panel consists of heterogeneous individuals. Monte Carlo results indicate the first type of error does not occur in small panels, but 5\% significance levels are approached in larger and longer panels, with at least sixty individuals and eighty or more time-periods. The model performs well in detecting some types of heterogeneity within about twenty periods, even in small panels. However, the autocorrelation coefficient and variance parameter for the stochastic error process require large, and long, panels to detect individual heterogeneity.

Dalton, M. 2006. Simulated Maximum Likelihood Estimation and Analysis of Covariance in a Panel Tobit Model of California's Groundfish Trawl Fishery, 1981-2001. NOAA/Sea Grant working paper.

Spatial management is currently an important issue in fisheries, and a central question for managers is how fishing effort will respond to marine reserves and other types of closures. This paper develops a panel Tobit model to analyze the influence of spatial and dynamic factors on decisions about where

and when to fish. The model includes autocorrelation. A simulated maximum likelihood approach is used to compute parameter estimates and conduct hypothesis tests, including an analysis of covariance to detect sources of individual heterogeneity.
The model is used with ten panels of data, representing fleets from ports in California's groundfish trawl fishery. Results show that ex-vessel prices are the most important explanatory variable in the model, and affect the spatial distribution of fishing effort. Regulatory variables, in the form of limits on landings for some species, are also important in most cases, and these reveal both spatial and temporal effects of past regulations. Dynamic factors such as autocorrelation, or effects of past fishing effort in a particular area on current effort, are also significant at several ports, but spatial interactions in effort are important in only two cases. Results from the analysis of covariance show that using pooled time series data to analyze effects of spatial management is acceptable practice in some cases.

Dalton, M. 2006. Monte Carlo Simulations of a Linear Rational Expectations Model with Static and Stock Externalities and Dynamically Interrelated Variables. NOAA working paper.

Information about future conditions can influence economic behavior. Lucas (1976) showed that a fundamental conflict exists in models used for policy analysis that do not explicitly consider the microeconomic aspects of how decisions are made when information about future conditions is available. He contended that a major revision of prevailing econometric practice was needed to resolve this conflict with microeconomic theory. Lucas' critique gave way to a new class of econometric models, based on a hypothesis of rational expectations. Typically, externalities associated with common property resources justify limited entry or other regulations, and thus, are a fundamental component of resource management, but effects of these externalities with rational expectations are complicated. Therefore, the level of technical sophistication required to estimate and test rational expectations models has probably been an impediment to their use in natural resource management. This paper presents a linear model of resource use, under rational expectations, with multiple dynamic variables, and considers two types of externalities among resource users. Simulated data from the model are used to compute maximum likelihood estimates, and for conducting tests of rational expectations and other hypotheses. The model in this paper is based on solving the dynamic optimization problem of a single firm that operates in an industry with many identical firms, and quadratic adjustment costs. To enhance the interpretation of renewable resources, the model in this paper includes a static congestion externality among labor variables, and a dynamic externality that operates through productivity of the resource stocks. Because of these externalities, symmetric industry equilibrium with optimizing behavior by individual firms is generally not efficient. The first goal of the paper is to evaluate maximum likelihood estimates and Sargent's (1978) test of rational expectations in the model without dynamically interrelated variables. Performance of the maximum likelihood estimates is evaluated by comparing point estimates from the maximum likelihood procedure with successively longer time series in Monte Carlo simulations. Estimation results from the Monte Carlo simulations show the limits appear to be unbiased in most cases. Exceptions are limited to a set of parameters that form a nonlinear relationship across equations, which are identified only if each takes a nonzero value. The relationship among these parameters is the most complex in the model, and involves a three-way interaction among exogenous variables, capital, and labor: i) effects of exogenous variables on capital stocks, ii) effects of labor on capital stocks, and iii) direct and indirect influence of these effects on productivity and labor through stock externalities. These interactions highlight the subtle nature of some relationships implied by rational expectations, and demonstrates why a careful numerical approach is needed. However, the stock and congestion externalities are specialized features of the model in this paper, and point estimates for other parameters typically found in linear rational expectations models are accurate to within 10% after one hundred time periods, and some after twenty.

The second goal of the paper is to evaluate maximum likelihood estimates and significance tests for dynamically interrelated variables. These results are based on a restricted version of the model, with only parameters related to dynamic adjustment costs allowed to vary, because severe convergence problems were encountered in less restricted versions of the model with dynamically interrelated variables.

Dalton, M. 2006. Effects of Spatial Management on Fishing Effort in California's Groundfish Trawl Fishery: Results from a Rational Expectations Model with Dynamically Interrelated Variables. NOAA working paper.

This paper develops a microeconomic model of groundfish trawlers that is both dynamic and spatial, which is based on a rational expectations competitive equilibrium. Advantages of a rational expectations model for the work in this paper include an explicit representation of information sets held by individuals at each point in time. In addition, this model has an operational, and thus testable, mechanism for translating information sets held by individuals into predictions about the future that can affect aggregate outcomes. Uncertainty is a fundamental part of many fisheries that can affect decisions about fishing effort. In addition, open access is sometimes used to justify an assumption in fisheries models that current decisions do not depend on expectations about future conditions, thus profit maximization for individuals is a static decision. While the assumption of open access is plausible in many fisheries, groundfish trawlers on the West Coast are part of a limited entry program, and ignoring information about future conditions for regulations, stock abundance, or climate would not be optimal. In addition, Rosenman (1986) showed that a type of open access equilibrium can occur with behavior that is forward looking, and the dynamic policy implications for fishery managers in this case are different from those of a static model. Therefore, assumptions about dynamic behavior should be tested. Practical experience supports this type of testing: Fishermen on the West Coast are known to modify behavior based on expectations of future conditions. Therefore, forward looking behavior is a plausible response to uncertainty about future regulations, price changes, climate fluctuations, or other events. The model in this paper is identical to the spatial model of fishing effort and dynamic adjustment costs under rational expectations described in Dalton and Ralston (2004), except that adjustment costs in this paper include a term for dynamically interrelated variables, which is the underlying mechanism for shifts in fishing effort that are analyzed in the paper.

Dalton, M. C. Pomeroy, M. Galligan. 2006. Measuring Impacts on Fishing Communities: A Framework for Integrated Socioeconomic Assessment. NOAA working paper.

An impact assessment with scientific review is typically required before U.S. fishery managers are able to implement new programs or regulations. These assessments may be the primary, or even sole, source of information that managers have about the economic effects of a proposed policy, and thus, are an important part of any policy-making process in which economic tradeoffs are a consideration. Ideally, accurate data and an economic model would be available to analyze tradeoffs among policy alternatives, but in practice, the models usually are not. Instead, fishery analysts often use a simplified approach based on total requirements, or other, multipliers derived from a system of regional economic accounts. Under rigid assumptions, the use of multipliers to analyze economic tradeoffs may be justified, but even so, the multipliers are valid only if the underlying data from the regional accounts are consistent with producers’ current expenditures. This paper investigates whether data derived from the regional accounts for a particular county, which has two major ports, diverse fisheries, and a sufficiently large number of fish processors, are realistic, and if not, show how these data can be improved. This paper describes a methodology for two tests that are applicable to commercial fishing industries represented in IMPLAN data for coastal counties with at least one fishing port in Alaska, or along the West Coast of the United States. The first test uses data for ex-vessel revenues and processors' fish purchases that are readily available for each West Coast port from the Pacific Coast Fisheries Information Network (PacFIN), and AKFIN data are available for Alaska. Data for the second test involve expenditure levels on inputs for fishing operations and processors, which are harder to acquire, and must be collected in the field from fishery participants. For the second test, we developed a set of research protocols, and conducted two waves of interviews and surveys in Monterey County, California. Results of both tests imply increases in total requirements multipliers computed from the adjusted SAMs. Total requirements multipliers for raw, and processed, fish did not change much with the adjustments to ex-vessel revenues, and processors' fish purchases, but the cross-multipliers for processed fish in the raw fish industry increase drastically in the 2003 SAM. The reason is that purchases of raw fish in PacFIN at Monterey ports by fish processors located in Monterey County are about 40 times larger than the corresponding IMPLAN value. Results of the second test include both adjustments to PacFIN, and expenditure shares for raw fish and processed fish that are sample means from the surveys. In this case, the multiplier for raw fish increases modestly, by 10% or 20%, and the multiplier for processed fish decreases, by 100% in 1998, but only 5% in 2003. The cross-multipliers increase dramatically after adjusting to the survey data.

Etnier, M. and **Sepez, J**. 2005. Ecological, Political, and Cultural Explanations for Changing Patterns of Sea Mammal Exploitation among the Makah. *In review.*

The Makah Indians from the outer coast of Washington are renowned for their strong maritime orientation, and have maintained high levels of continuity in resource use over 500 years. However, marine mammal use has declined considerably. Today, the Makah consume less than 30% of the same taxa as their ancestors at Ozette. Comparison between the Ozette archaeofaunas and the modern ecological communities on the coast of Washington indicate major changes in this ecosystem within the past 200-300 years. In the past, northern fur seals (Callorhinus ursinus) appear to have been the dominant pinniped species, with a breeding population perhaps as close as 200 km from Ozette. Among cetaceans, gray whales (Eschrichtius robustus) and humpback whales (Megaptera novaeangliae) were equally abundant. Today, the dominant pinniped species is California sea lion (Zalophus californianus), while cetaceans are dominated by a single species, the gray whale. Thus, most of the differences in Makah consumptive use of marine mammals can be explained by examination of the modern ecological environment. However, the article discusses some case in which political and cultural motivations provide better explanations.

Felthoven, Ronald G. and Daniel Holland. 2005. "Performance Measures for Fishery Rationalization Programs: Data and Other Considerations." Submitted to *Marine Policy.*

The North Pacific Fishery Management Council (NPFMC) has developed a plan to "rationalize" the Bering Sea and Aleutian Islands (BSAI) crab fisheries. A mandatory data collection program has been implemented to assess the effects on both the harvesting and processing sectors. Monitoring the performance of the rationalization program will allow an assessment of whether rationalization is achieving its objectives and may aid the design of future rationalization programs in other fisheries. This paper discusses various measures that may be used to monitor the impacts of rationalization programs on plant and vessel performance, identifies the data required to adequately construct the measures, and discusses some hurdles that must be overcome to properly interpret and use such data.

The concepts discussed are applicable in fisheries other than BSAI crab, and may serve as a useful guide to those tasked with collecting and assessing the data needed to analyze the effects of rationalization.

Felthoven, Ronald G. and C.J. Morrison Paul. 2005. "Measuring Productivity Change and its Components for Fisheries: The Case of the Alaskan Pollock Fishery, 1994-2003." Submitted to the *Journal of Environmental Economics and Management*.

Economic and biological performance has been an important focal point in fisheries economics, while traditional productivity measurement has played an ancillary role. In the past two decades, however, it has been increasingly recognized that modeling and measuring fisheries' production relationships is central to understanding, and ultimately correcting, imbalances from market failures and biological constraints. In this paper we use a transformation function production model to estimate productivity and its components for the Bering Sea and Aleutian Islands pollock fishery. We explicitly recognize the roles of externalities present in pollock harvesting by incorporating data on environmental conditions, bycatch, and biomass stock, and capture regulatory impacts through fixed effects and quality indicators. Our approach also relaxes assumptions regarding constant returns to scale, marginal cost pricing, Hicks-neutrality, and homothetic separability that are maintained in the limited literature on fisheries productivity. We find that the productive contributions of environmental conditions, bycatch, and discretionary production processes are statistically significant; that restrictive assumptions common in previous fisheries productivity studies are not supported by our data; and that regulatory changes have had both direct and indirect impacts on catch patterns.

Felthoven, Ronald G., W. Horrace and K. Schnier. 2006. "Estimating Heterogeneous Primal Capacity and Capacity Utilization Measures in a Multi-Species Fishery." Working paper.

We use a stochastic production frontier model to investigate the presence of heterogeneous production and its impact on fleet capacity and capacity utilization in a multi-species fishery. Furthermore, we propose a new fleet capacity estimate that incorporates complete information on the stochastic differences between each vessel-specific technical efficiency distribution. Results indicate that ignoring heterogeneity in production technologies within a multi-species fishery, as well as the complete distribution of a vessel's technical efficiency score, may yield erroneous fleet-wide production profiles and estimates of capacity.

Haynie, A. and D. Layton. 2006. "The Effects of the Steller Sea Lion Conservation Areas on the Pollock Fishery." Working paper.

This paper presents the development of a new type of discrete/continuous model for analyzing spatial fishing behavior. Traditionally, the fisher location choice literature has predicted location choice in a two-stage process, where in the first stage the average revenue is calculated, and in the second stage average revenue is used as a predictor of location choice. In the expected profit model (EPM), we endogenously estimate expected catch simultaneously with location choice. In the expected profit model (EPM), we endogenously estimate expected catch simultaneously with location choice. We overcome the standard inability to scale the logit model and are to monetize the discrete choice model. We conduct a series of Monte Carlo experiments to test the efficacy of the EPM. We then estimate a series of EPM models for the Bering Sea pollock fishery. We incorporate a variety of vessel characteristics and functional forms in our model estimates, and implement a frequentist model averaging procedure for forming final predictions. We estimate the per-trip welfare impact of the emergency closure of the Steller sea lion conservation area, which substantially restricted the grounds of the pollock fishery.

Sepez, J. 2005. If Middens Could Talk: Comparing Ancient, Historic and Contemporary Makah Subsistence Foraging Patterns. *In review.*

The paper combines archaeological data with data from early ethnography and contemporary harvest surveys to examine consistency and change in Makah Tribe subsistence hunting and fishing practices between 1500 and today. The data indicate a significant shift in contribution of different resource groups to the animal protein diet between 1500 and today, with harvest of marine mammals dropping tremendously (from 92% to less than 1%), and the contemporary diet consisting primarily of fish (50%), shellfish (11%), land mammals (15%), and store-bought meats (24%). However, a high diversity of species used by tribal members prior to Euroamerican colonization are still in use today, from halibut and salmon to harbor seals and sea urchins. Several species no longer used, such as wolves and fur seals, can be explained by ecological factors, such as post-colonial extirpation. Other resources no longer used, such as many small birds and small shellfish, represent a general contraction of the subsistence diet breadth following the introduction of commercial foods. As predicted by optimal foraging theory, the resources most likely to be eliminated from the diet are those that rank low in terms of post-encounter caloric return. Tribal members made use of nearly all available resources in ancient times; additions to the tribe's subsistence base in modern times were due primarily to the introduction of exotic species such as the Pacific oyster, and local population growth of other species, such as the California sea lion. Road building and habitat changes in the forests increased access to land-based resources, such as deer and elk. Land-based resources in general (terrestrial mammals and commercial meats) increased from less than 1% of consumed animal protein prior to 1500 to close to 40% today. However, with over 60% of animal protein still stemming from marine resources, Makah tribal members remain oriented, both nutritionally and culturally, toward the ocean environment.

Seung, Chang. 2006. "Estimating Dynamic Impacts of Seafood Industry in Alaska." Submitted to *Regional Studies.*

To date, regional economic impact analyses for fisheries have neglected use of time-series models. This study, for the first time in the literature of regional economic impacts of fisheries, address this weakness by employing a vector autoregressive error correction model (VECM). Based on economic base concept, this study develops a VECM to investigate multivariate relationships between basic sectors (including seafood sector) and nonbasic sectors for each of two fishery-dependent regions in Alaska. While structural models such as input-output model and computable general equilibrium model facilitate more detailed intersectoral long-run relationships in a regional economy, the present study shows that the VECMs have the advantage of properly attributing the impact of shocks, estimating directly the long-run relationships, and of identifying the process of adjustment by nonbasic sectors to the long-run equilibrium. Results show, first, that a nonbasic sector may increase or decrease in response to a shock to a basic sector – a result that would be obscured within in a linear economic impact model such as an input-output model, which always predicts positive impacts. Second, the impacts of seafood processing employment are relatively small in the two study regions, where a significant number of seafood processing workers are nonresidents and a large portion of intermediate inputs used in seafood processing are imported from the rest of the United States.

A Discrete Choice Expected Profit Model for Analyzing Spatial Fishing Behavior

By Alan Haynie[3] and David Layton[4]

Abstract

This paper presents the development of a new type of discrete/continuous model for analyzing spatial fishing behavior. Traditionally, the fisher location choice literature has predicted location choice in a two-stage process, where in the first stage the average revenue is calculated, and in the second stage average revenue is used as a predictor of location choice. In the expected profit model (EPM), we endogenously estimate expected catch simultaneously with location choice. In the expected profit model (EPM), we endogenously estimate expected catch simultaneously with location choice. We overcome the standard inability to scale the logit model and are to monetize the discrete choice model. We conduct a series of Monte Carlo experiments to test the efficacy of the EPM. We then estimate a series of EPM models for the Bering Sea pollock fishery. We incorporate a variety of vessel characteristics and functional forms in our model estimates, and implement a frequentist model averaging procedure for forming final predictions. We estimate the per-trip welfare impact of the emergency closure of the Steller sea lion conservation area, which substantially restricted the grounds of the pollock fishery.

Keywords: discrete choice models, fisheries, location choice, econometrics, marine protected areas, cost estimation, discrete-continuous models, random utility model

1. Introduction

Marine protected areas (MPAs) have expanded rapidly across the globe over the last decade as a means to preserve marine habitat. MPAs are often seen as a means to help vulnerable or depleted fish stocks recover, but in some cases have been created to provide habitat and prey for threatened or endangered marine mammals. The Steller Sea Lion Conservation Area (SCA) is an MPA of this type—the SCA was created to increase available fish prey for Steller sea lions rather than human consumption. The most significant fishery affected by the closure is the Bering Sea pollock fishery, the largest food-fish fishery in the world, representing approximately one-third of the fish caught in the United States (1.5 million tons in 2003). The *ex-vessel* value of pollock was $203 million in 2003, which is more than

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[3] Alan Haynie, NOAA Fisheries, Alaska Fisheries Science Center, Alan.Haynie@noaa.gov

[4] David Layton, University of Washington, Evans School of Public Affairs, dflayton@u.washington.edu

salmon or halibut but less than American lobster or Gulf shrimp.

Biologically MPAs have been shown in many cases to facilitate stock recovery (e.g. Halpern 2002, McClanahan 2000), although in some cases and for various reasons MPAs have failed to increase stocks (e.g. Crowder 2000). A variety of physical conditions determine what makes a good MPA. The SCA was defined only by Steller sea lion critical habitat and not by other factors that encourage biological or economic productivity. Steller sea lions return to haulouts and rookeries on land but swim out to sea at times to forage for prey. Despite the biological health of the pollock fish stock, local and temporal depletion was identified as a possible cause of the Stellers' decline, and fishing was limited in the SCA beginning in 1999.[5]

What is the economic impact of such a closure of fishing grounds? The literature of fisher location choice has focused on making predictions about fisher behavior and trying to understand what factors determine how fishers choose where to fish. This is an interesting area of exploration for economists because we observe repeated choices and a high volume of information about the actors. In the recreational context where many choice models have been developed, one does not observe utility, but with commercial fisheries one actually observes revenues. Our approach utilizes this additional information to directly estimate how fishers trade off expected revenues with travel costs. Our model, which we call the expected profit model (EPM), simultaneously estimates parameters of expected catch and location choice. When we observe profit maximizing actors simultaneously choosing locations with different expected revenues across space (and corresponding distances from port), we can estimate expected profits when we know an important element of costs – distance to fishing locations – but not costs themselves.[6] We can therefore predict the cost of the closure by comparing the expected profits with and without the closed area in the fishers' choice set.

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[5] There may be reserve effects of such closures (i.e. fish stocks may increase in the reserve). Since the emergency closure of the SCA was a short-term closure and no research has been conducted that assesses the reserve effect of the area, the reserve effect can not be considered here.

[6] This is the best cost data available for the majority of fisheries in the United States.

This methodological advance is one of several innovations made in this paper. The paper introduces a new method, the EPM, which provides *ex-ante* predictions and welfare analysis to a regulatory body like a fisheries council. An additional area of innovation is the use of frequentist model averaging of welfare estimates. In addition to making model averaged predictions and welfare estimates, we simulate model averaged confidence intervals.

The policy problem where we apply the EPM is one that is representative of the type of conflict that arises with spatial restriction of a fishery to achieve other conservation objectives. The decline of the western stock of Steller sea lions (SSL) has been long-term trend and there has been a large overlap of the decline of the SSL population and the growth of the groundfish fishery. Between the late 1950's and 1990, the Steller population declined by approximately 80 percent as illustrated in Figure 1 for the later decades.

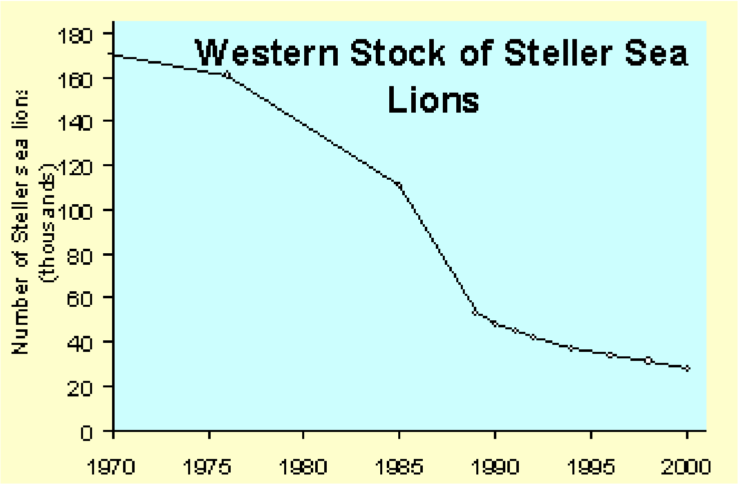
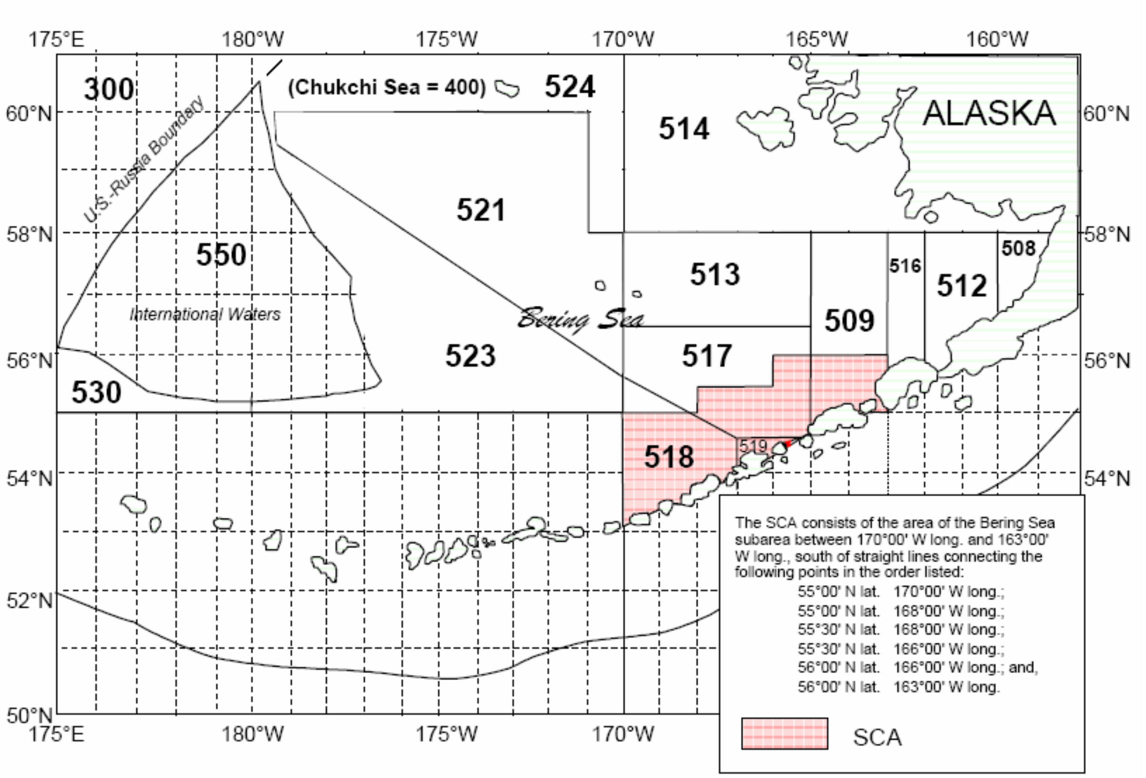


Figure 1: Decline of Steller sea lions (Source: NMFS)

Between the 1950's and 1990's annual groundfish catch increased from 27,000 tons to about 2.1 million tons (Fritz and Ferrero 1998). After the listing of the Steller sea lion as threatened in 1990, the first spatial closures were created: 3-nautical mile no-entry zones were created around sea lion rookeries. Since this time there have been numerous revisions of excluded areas, including the creation of 10 and 20-nautical mile protected areas around Steller sea lion rookeries and haulouts. These did not significantly limit the pollock fishing grounds until 1999, when the area around Cape Sarichef on Unimak Island was closed which was an area where 24 percent of the trips from 1995-1998 had taken place. In 1998, Steller sea lion Critical Habitat was identified, an area that would later be named the Steller Sea Lion Conservation Area (SCA). Biological studies of SSL prey have indicated that pollock are an important element of SSL diet, so NMFS took measures to ensure that pollock were available as prey. The SCA is shown in Figure 2. In August of 2000, the SCA was closed by judicial mandate to all trawling for the remainder of the season.



The SCA consists of the area of the Bering Sea subarea between 170°00' W long. and 163°00' W long., south of straight lines connecting the following points in the order listed:

55°00' N lat.	170°00' W long.;
55°00' N lat.	168°00' W long.;
55°30' N lat.	168°00' W long.;
55°30' N lat.	166°00' W long.;
56°00' N lat.	166°00' W long.; and,
56°00' N lat.	163°00' W long.

Figure 2: Steller Sea Lion Conservation Area (SCA)

When an important part of a fishery is closed to fishing by an MPA, in the short-term the costs of fishing will inevitably increase. In the long-term costs will increase unless the reserve effects of the MPA outweigh the increased travel or search costs of fishing outside of the MPA.

The remainder of this paper is organized as follows. Section 2 describes the EPM and other aspects of our modeling approach. Section 3 describes the data and Section 4 offers empirical results. Section 5 offers further discussion and concludes.

2. The expected profit model: joint estimation of catch and location choice

Our approach to this problem builds upon the literature that assesses how commercial fishermen choose where to fish. The literature in this area is typically traced to the work of Bockstael and Opaluch (1982) and Eales and Wilen (1986). Bockstael and Opaluch (1982) utilize a discrete choice model to assess the factors that cause fishers to switch targeted fisheries. Eales and Wilen (1986) are the first to develop a two-stage model where in the first stage the expected catch of an area is estimated using the average catch from that area from the previous day, and in the second stage, location choice is modeled as a function of expected revenue in each area. This literature has employed variations of logit models (conditional logit, nested logit, etc.) to model how fishers choose where to fish. The more recent work in this literature has included much more complex covariates (e.g. Dupont (1993); Holland and Sutinen (1999, 2000); Campbell and Hand (1999); Curtis and Hicks (2000); Mistiaen and Strand (2000); Smith (2000, 2001); Smith and Wilen (2003); Hicks et al (2004)).

Numerous interesting issues have been addressed in this literature, including research by Curtis and Hicks (2000) that places a value on the closure of a large area in the Pacific Ocean for turtle protection. Curtis and Hicks (2000) utilize an option price method based on the assumption of a logarithmic utility function (following Bockstael and Opaluch 1982). Combining these methods with vessel cost survey data, they are able to make *ex-post* welfare estimates of sea turtle closures.

While our work builds directly upon this literature, it also differs fundamentally. Our primary goal is to make *ex-ante* welfare and location choice predictions rather than to explain location choice *ex-post*. As in the literature described above, a key element of our model is explaining how fishers choose to fish.

One recent work does make *ex-ante* predictions with the incorporation of cost-survey data. Hicks et al. (2004) consider the economic impact on the surfclam and ocean quahog fisheries of a number of proposed essential fish habitat closures on the Atlantic Coast. Utilizing available cost and vessel value data they also follow the Bockstael and Opaluch (1982) procedure and utilize a logarithmic utility function which includes zonal variance, initial wealth (a function of vessel and gear value) and the expected profit per zone as a function of costs and average revenues per zone.

The standard econometric models in this field are multinomial and conditional (often nested) logit models following McFadden (1974) and Luce (1977) where the fisher chooses a location to maximize utility where utility is a function of fisher and area characteristics, subject to Type I Extreme Value random error (subscripted by individual *i* and zone *j*):

$$U_{ij} = \beta x_{ij} + \varepsilon_{ij} \qquad \varepsilon_{ij} \sim TYPE\ I\ EV\left(0, \sigma_{\varepsilon}\right) \tag{1}$$

The probability of selecting a particular zone is a function of characteristics of the zone and the decision maker:

$$P(j = k) = \frac{\exp \beta' x_{ik}}{\sum_{j=1}^{J} \exp \beta' x_{ij}} \tag{2}$$

The area chosen (*k*) comes from a discrete number of available zones (j=1…J). Typically, following Eales and Wilen (1986), one important independent variable in this model is the expected catch (or revenue) for a zone, sometimes taken in a moving average form so that it represents recent catch. For example, Holland and Sutinen (1999, 2000) use average revenue for landings over the last 10 days this year as well as a variable for landings the 20 days before and after the landing date the previous year.

The expected catch is calculated as an average in the first stage, and then entered into the logit, above (or into a nested version).[7]

A direct approach to the problem is to utilize a logit similar to the model described in (1) and (2), but with area-specific constants. This enables us to estimate the relative value of closing (or opening) one zone relative to another, but without estimating expected revenue. We utilize this model as a benchmark for the expected profit model, described below.

Nesting has often been employed in modeling location choice because fishers' may make what appears to be a two-stage decision in which they first choose one general direction, and then sub-areas (e.g. Campbell and Hand (1999) model longitude and then latitude) or choose a location-fishery combination (e.g. Holland and Sutinen (1999, 2000)). Smith (2001) and Smith and Wilen (2003) use the nested logit to model the decision of whether to fish in the first stage, and where to fish in the second. We assume that fishers are going to fish, and therefore do not model the decision whether or not to go fishing; given that this is a seasonal model and given the binding constraint of a TAC, this appears a reasonable assumption.[8] We do not see the independence of irrelevant alternatives (IIA) issue being a significant problem with the choice that we are modeling. As discussed below, we include models with a random parameter on mileage, which accounts for heterogeneity in how vessels trade off mileage.

2.1 The Expected Profit Model (EPM)

Our initial assumption is that fishers choose a fishing location to maximize expected variable profits from the trip, where variable profits are defined as revenues minus travel costs. [9] A fisher's expected

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[7] Given our predictive goals, however, some tools that are available to the researchers above are not available to us (e.g. using yesterday's catch to predict today's location choice).

[8] Schnier (2005) makes a similar assumption for Bering Sea fisheries.

[9] We recognize that we are actually estimating only 'variable profits,' but this is what is needed for the nature of the problem, as we discuss below.

profits are formulated as follows (with P representing price[10], Y catch, and C costs, and α the expected catch for the zone):

$$E(\pi_{ij}) = E(PY_{ij} - C_{ij}) = E(PY_{ij}) - E(C_{ij}) \tag{3}$$

$E(Y_{ij}) = E(Y_j) = \alpha_j$.

$C_{ij} = X_{ij}\beta$

We model the fisher's expected profit as function of expected catch, prices, cost coefficients to be estimated (a function of mileage and boat characteristics), and an additive error (similar in spirit to work by Chicchetti and Dubin (1994) in another context):

$$E(\pi_{ij}) = P\alpha_j + X_{ij}\beta + \varepsilon_{ij} \tag{4}$$

$$\varepsilon_{ij} \sim TYPE\,I\,EV(0, \sigma_\varepsilon)$$

$Y_{ij} = \alpha_j + \eta_{ij}$

$\eta_{ij} \sim Normal(0, \sigma_j)$

Thus the model has two error terms and two types of variances that can be estimated.[11] Because of the nature of the joint estimation and the fact that we observe the catch (and revenue) from a trip as well as the choice of a zone, we are able to identify the scale parameters, which we describe as *sigmacatch* (σ_j) and *sigmachoice* (σ_ε).[12]

As in a standard random utility model (RUM), we assume that for individual i and zone j:

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[10] Price may easily be made to vary by individual or zone. Price variation by zone could account for expected deterioration with distance or product quality in general.

[11] One could obviously consider alternative distributions for both error terms.

[12] *Sigmacatch* can be restricted so that it is equal for all zones, but here we estimate a separate *sigmacatch* for each zone.

$$E\left(\pi_{ij}\right) > E\left(\pi_{ik}\right) \;\forall\; k \neq j \Rightarrow$$

$$P\alpha_j + X_{ij}\beta + \varepsilon_{ij} > P\alpha_k + X_{ik}\beta + \varepsilon_{ik} \;\forall\; k \neq j$$

The model is estimated using full-information maximum likelihood (FIML). The approach taken in the EPM is to develop a discrete/continuous model in which zone-specific expected catch is simultaneously estimated with coefficients on other variables (e.g. mileage, boat characteristics, etc.). For example, for a trip to zone 1 (out of *J* zones), we maximize the logarithm of the following expression:

$$\ell_1 = \underbrace{\frac{1}{\sigma_1\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{Y_{i1} - \alpha_1}{\sigma_1}\right)^2\right]}_{continuous} \times \underbrace{\frac{e^{\left(\frac{P\,\alpha_1 + X_{i1}\,\beta}{\sigma_\varepsilon}\right)}}{\sum_{j=1}^{J} e^{\left(\frac{P\,\alpha_j + X_{ij}\,\beta}{\sigma_\varepsilon}\right)}}}_{discrete} \tag{5}$$

The first set of terms marked by the label 'continuous' in (5) is the continuous normal choice portion. The second term portion is the discrete logit component. In the continuous portion, *Y* is the actual catch, α_1 is the endogenously estimated average catch for zone 1[13], and σ_1 (*sigmacatch*) *is* the standard error for zone 1. In the discrete portion, *X* is a matrix consisting of the miles from the centroid of the chosen and alternative areas to the landing port of each trip and vessel characteristics (interacted with miles to the centroid of each area), σ_ε is the choice error (*sigmachoice*), and *P* is the

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[13] α_1 can also be $\overline{\alpha}_1$, a function of vessel characteristics.

yearly average annual ex-vessel pollock price.[14]

Because all of the parameters are identified, including scale, we are able to directly calculate the welfare impact of closing a zone without knowing the cost per mile in advance (welfare calculations are described below). What we estimate might be called 'variable profits' or 'net revenues,' in that fixed costs are unknown and what is estimated is the expected difference in revenues and travel costs for each zone. Given the nature of the problem – evaluating the costs of an area closure to fishers who are choosing among alternative zones – variable profits are what are required under the simplifying assumption that the number of trips does not change.

We assume that *sigmacatch* and *sigmachoice* are independent. One can certainly envision situations in which this would not be the case. We compare the results of the EPM models to a suite of logit models with zone-specific constants to provide one measure of the validity of our assumption of independence, though we think that it's not very important to the practical functioning of the model, given the context. We return to this topic in the discussion at the end of the paper.

Monte Carlo experiments have shown that the EPM is consistent and more efficient than the two-stage model. A description of our methodology for these Monte Carlo tests and qualitative results of our Monte Carlo experiments are presented in Appendix 2.

Two papers present the first estimable discrete-continuous economic models in the literature. Duncan (1980) develops a discrete/continuous model in the context of a single-plant firm making a discrete choice of where to locate, followed by the continuous choice of what vector of inputs and outputs to choose to maximize profits. Hanemann (1984) considers the consumer choice problem of what goods to buy (discrete choice) and how much of the chosen goods to purchase (continuous choice). The EPM most closely follows the formulation of Duncan (1980).

Several papers in the recreational fisheries literature have simultaneously estimated a model to

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[14] Prices typically do not vary within the season, except for roe bonuses that are prevalent in the winter season. However prices vary among different vessels/processors, but due to a lack of confidence in the observed data for actual landings, we use the average annual price.

calculate expected catch. Morey and Waldman (1998) use a catch rate model where the individual catch rates for different recreational visitors are used in the joint estimation of expected catch and recreational site demand. Morey and Waldman (1998) demonstrate analytically how the standard approach of equating average and expected catch is biased downwards and therefore undervalues the importance of expected catch on the value of a site (although the standard estimator is asymptotically unbiased). Morey and Waldman (1998) also note that the standard estimator fails to take advantage of all available information, and therefore is not efficient.

Train et al. (2000) argue that under a wider range of typical circumstances, the Morey and Waldman (1998) estimator is also biased in ways that the standard estimator is not. Specifically, where there are unobserved variables that are uncorrelated with catch, these variables will bias the Morey and Waldman estimator but not the standard model. Train et al. (2000) suggest that the judicious use of dummy variables for zones with limited catch data will avoid this problem. Morey and Waldman (2000) respond to Train et al. (2000) and take issue with the notion that the standard estimator is more appropriate under a wider range of circumstances. Morey and Waldman (2000) note that there are many cases where there are limited data available for several sites and the creation of dummies may exclude many of the low-use sites are often the subject of damage assessments.

Another recreational fisheries model with a related joint estimation procedure is Englin et al. (1997), who jointly model recreational angling site demand and a production function for the number of fish caught. The two equations are connected because estimated demand influences fishing demand.

Thus the EPM integrates two lines of research: the joint estimation of a discrete/continuous model and the literature on location choice. Having laid the groundwork for the model's development, we now proceed to describe the models that we actually estimate.

2.2 Frequentist Model Averaging

When conducting applied welfare analysis as in this paper, model selection may have a large policy impact. Typically when creating an econometric model to explain a problem, the researcher conceives of a group of models that he/she believes are likely to best explain the phenomenon that he/she is attempting to describe. The researcher runs several of these models and compares the goodness of fit among the models. Depending on the context, the researcher may or may not have strong theoretical assumptions about the nature of the "true" model. When the researcher provides results in published papers, he/she may present several candidate models or may only report the "best" model. Readers of these papers often have little knowledge of the range of models that were considered.

An alternative to this standard model selection and reporting process which has been developed in the Bayesian context is model averaging. The essence of model averaging is that if two models have a similar fit, why choose just one? If two models fit the same, each one can be weighted 50% in generating behavioral predictions or welfare estimates from the models. In the frequentist framework in which we are operating, there is not the clear theoretical underpinning that exists in the Bayesian environment, but nonetheless it offers attractive transparency (see for example Koop and Tole (2004)).

Buckland et al. (1997) develop an attractive frequentist model averaging (FMA) framework that we most closely follow. In order to conduct FMA, we need to choose a selection criterion to weight models. AIC (Akaike 1973), AICc (Hurvich and Tsai 1989, 1995), and BIC (Schwarz 1978) are three commonly used selection criteria that are attractive and used by Buckland et al. (1997).[15] Here we present results only for the BIC, primarily due to the results of the comparative analysis of Hjort and Claeskens (2003) showing the relative weakness of the AIC and predictive comparisons by Raftery and Zheng (2003) which demonstrates the predictive superiority of BIC relative to the AIC. [16] Compared to the AIC and AICc, the BIC rewards models with fewer parameters. There is an implied

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[15] Layton and Lee (2005) follow Buckland et al. (1997) directly and present results from the AIC, AICc, and BIC.

[16] Hjort and Claeskens (2003) find that the FIC (focused information criteria) performs better than AIC, but they do not compare the results to the BIC. They propose a method slightly different than Buckland et al. (1997), but their method gains its advantages in a special case, as identified by Raftery and Zheng (2003). We agree with Raftery and Zheng (2003) of the need for additional work comparing the BIC and FIC and would suggest additional Monte Carlo work to test the performance of the indicators in a more general setting.

philosophical difference between the AIC and the BIC – the AIC implies that there is a higher order "true" model, while the BIC rewards parsimony and suggests that there is a low-order "true" model.[17] The BIC is defined as follows:

$$BIC = -2\ell + p\ln\left(n\right) \tag{6}$$

where ℓ is the log likelihood, p is the number of parameters in the model, and n is the sample size. When using this criterion to select a model, one picks the model with the smallest criterion value. [18] Importantly, this approach can be applied to both nested and non-nested model selection.

After calculating the BIC for all appropriate models, we have to weight the models according to this criterion. As in Buckland et al. (1997), we weight the parameter estimates using the model selection criteria, here the BIC. Weights, w_m, are created over M models, 1 to M as:

$$w_m = \frac{\exp\left(\frac{-BIC_m}{2}\right)}{\sum_{i=1}^{M}\exp\left(\frac{-BIC_i}{2}\right)} \tag{7}$$

This produces weights for each model that sum to 1 across all models. Buckland et al. (1997) design this weight to mimic the Bayes Factor, although it is also quite similar to a logit in appearance.

Following Buckland et al. (1997) and Layton and Lee (2005), we use the selection criterion (here the BIC) to weight parameter estimates. Here we form a weighted estimate of model averaged expected welfare change, *EW* as:

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[17] For further discussion see Buckland et al. (1997), Layton and Lee (2005) and Kass and Raftery (1995).

[18] Some researchers divide the criteria by 2, or multiply by -1 and reverse the selection procedure.

$$EW_{Mavg} = \sum_{1}^{M} w_i \, EW_i \tag{8}$$

Where EW_i is the expected welfare change for model i. We apply the Krinsky and Robb (1986) method to simulate a confidence interval for each EW_i. We retain all of the generated EW_i samples and then draw $w_i R$ draws from each model i's simulated distribution, where R is the overall number of draws desired to simulate a confidence intervals for the model averaged estimate of EW, EW_{Mavg}. Thus each model contributes the weight w_i to the EW_{Mavg} distribution. We use this new distribution to create the confidence intervals for EW_{Mavg}. We use a similar procedure to generate BIC-weighted choice predictions.

2.3 EPM models to estimate

Because of our interest in using frequentist model averaging (FMA), we estimate a large number of models as part of this analysis. The "basic" EPM includes an *alpha* parameter for each zone included in the model (in our case 22 zones), *sigmacatch* parameters on the variance of each zone, a *sigmachoice* parameter which scales the choice model, plus a parameter on mileage. More complex models include linear, quadratic, and interacted terms of boat characteristics.[19] The boat characteristics available for all active vessels are: vessel tonnage, length, horsepower, and age. We estimate three different classes of EPM models. The first type of model considers vessel heterogeneity (via boat characteristics) only in the choice portion of the likelihood function. The second type of model considers vessel heterogeneity only in the catch portion of the likelihood, while the third type of model considers vessel heterogeneity in both the catch and choice portions of the likelihood. Select models of each type are displayed in Table 1.

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[19] Boat characteristics do not vary by zone choice, so to be estimable they must be interacted with a characteristic that does; therefore, all boat characteristics are interacted with miles from the port where the trip originated to the zone.

Table 1: Select EPM model variations

Model	Catch terms	Choice terms	RP
A	HP x Age	miles, HP, age, length, HPxAge, HPxLength, Age x Length	
B	HP x Age	miles, tons, HP, age, len, tons x HP, tons x age, HPxAge	
C	HP	miles, HP, age, length, HPxAge, HPxLength, Age x Length	
D	HP x Age	miles	
E		miles	
F		miles	X
G		miles, HP, age, length, HPxAge, HPxLength, Age x Length	

Initially we ran a suite of models that included Models E, F, and G in Table 1. Table 2 displays this suite of models.

Table 2: Models with vessel characteristics in choice component of EPM

Model	Independent variabbles
1	miles
2	miles, miles^2
3	miles, tons, HP, age, length
3.1	miles, HP, age, length
3.2	miles, tons, age, length
3.3	miles, tons, HP, length
3.4	miles, tons, HP, age
4	miles, miles^2, tons, tons^2, HP, HP^2, age, age^2, length, length^2
4.1	miles, miles^2, tons, tons^2, HP, HP^2, age, age^2, length, length^3
4.1	miles, miles^2, tons, tons^2, HP, HP^2, age, age^2, length, length^4
4.3	miles, miles^2, tons, tons^2, HP, HP^2, age, age^2, length, length^5
4.4	miles, miles^2, tons, tons^2, HP, HP^2, age, age^2, length, length^6
5	miles, tons, HP, age, length, tons × HP, tons × age, tons × length, HP × age, HP × length, age × length
5.1	miles, HP, age, length, HP × age, HP × length, age × length
5.2	miles, tons, age, length, tons × age, tons × length, age × length
5.3	miles, tons, HP, length, tons × HP, tons × length, HP × length
5.4	miles, tons, HP, age, tons × HP, tons × age, HP × age

Our motivation for selecting these models was that we should design a suite of models to capture a variety of the possible effects of the data. The most basic models (model 1 and 2 in Table 2) do not in any manner account for vessel heterogeneity, but include a linear or linear and quadratic terms on mileage. The other models in this class of models are as follows. Model 3 includes a linear term for mileage and each boat characteristic, while models 3.1-3.4 include three of the four boat characteristics. Model 4 includes a linear and quadratic term for all of these terms, while models 4.1-4.4 include linear and quadratic terms for three of 4 boat characteristics. Model 5 includes the linear terms from Model 3 as well as terms which interact all of the included boat characteristics. Models 5.1-

5.4 exclude one of the boat characteristics for each model. Model 2.1 is a version of these models.

For all of the above models, we model miles both as a fixed parameter and as a random parameter, following McFadden and Train (2000) and Train (2003). Including the mixed logit models, a total of 34 EPM models are estimated. For each form of the EPM in Table 2, we construct one model with a fixed parameter on miles, and one parameter which varies according to a log-normal distribution.[20] Mixed logit probabilities are the integrals over a distribution of standard logit probabilities such that the probabilities are generated by the following integral:

$$P_{ij} = \int L_{ij}(\beta) f(\beta \mid \theta) d\beta \tag{9}$$

where $f(\beta)$ is distributed log-normal with parameters θ.[21] Using a mixed logit gives greater flexibility to our cost parameter by allowing for heterogeneity of vessel costs, though as shown in the results and discussed below, the best fitting model by far remains one with a fixed coefficient.[22]

The second general class of models includes vessel characteristics as a factor that influences catch, but not choice. Including vessel characteristics in the catch continuous portion of the likelihood will make α_i also a function of differing vessel attributes, which is almost certain to be the case. The number of potential models to be included in the model averaging process goes up greatly with this change in functional form, however, so we selected a reasonable cross section of models for inclusion.[23]

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[20] Model F in Table 1 is an RP version of Model E in the same table.

[21] We choose the log-normal distribution because it is reasonable to assume that mileage is undesirable and would have the same (negative) sign for all actors.

[22] We generate random draws according to a Halton draw framework, augmented with random variables (see Sándor and Train (2004) and Bhat (2003) for current discussions of the strengths of different types of random draw schemes). Using Halton draws instead of pseudo-randomly generated numbers produces greater precision of estimation of the random coefficients and a significant reduction in estimation time.

[23] Due to the difficult of estimating these complicated models and the lack of superior performance with the random parameters models, above, we have not placed a random parameter on mileage in these models.

To logically complement the “choice only” models above, we run a model with each of the vessel characteristics included individually, as well as models which interact two and three of the four vessel characteristics. In all cases, the included vessel characteristics are interacted with area specific constants. This formulation allows us too include vessel characteristics in both the catch and choice components of the likelihood, because the vessel characteristics are interacted with mileage in the choice term.

Table 3: "Catch only" models

Name	Catch terms
catch1	Tons
catch2	HP
catch3	Len
catch4	Age
catch5	Tons*HP
catch6	Tons*len
catch7	Tons*age
catch8	HP*len
catch9	HP*age
catch10	Len*age
catch11	Tons*HP*len
catch12	Tons*HP*age
catch13	Tons*len*age
catch14	HP*len*age

The third general group of EPM models includes vessel characteristics in both the catch and choice portion of the likelihood. Feasibly, all of the different catch and choice models from Table 2 and Table 3 could be interacted, but this offers an unfeasibly large number of models. Initially, we ran each of the best choice-only models with horsepower (HP) in the choice component, then with vessel length (len). We then used the best “catch only” models, “catch9,” and interacted this with the five best “choice only” models.

Table 4: Model with vessel characteristics in both choice and catch portions of likelihood

Model	BC in Catch	Independent variables in choice
both1	HP	miles, tons, HP, age, length, tons x HP, tons x age, tons x len, HPxAge, HPxLength, Age x Length
both 2	HP	miles, HP, age, length, HPxAge, HPxLength, Age x Length
both3	HP	miles, tons, age, length, tons x age, tons x len, Age x Length
both4	HP	miles, tons, HP, length, tons x HP, tons x len, HPx Len
both5	HP	miles, tons, HP, age, tons x HP, tons x age, HPxAge
both6	len	miles, tons, HP, age, length, tons x HP, tons x age, tons x len, HPxAge, HPxLength, Age x Length
both7	len	miles, HP, age, length, HPxAge, HPxLength, Age x Length
both8	len	miles, tons, age, length, tons x age, tons x len, Age x Length
both9	len	miles, tons, HP, length, tons x HP, tons x len, HPx Len
both10	len	miles, tons, HP, age, tons x HP, tons x age, HPxAge
both11	HP*age	miles, tons, HP, age, length, tons x HP, tons x age, tons x len, HPxAge, HPxLength, Age x Length
both12	HP*age	miles, HP, age, length, HPxAge, HPxLength, Age x Length
both13	HP*age	miles, tons, age, length, tons x age, tons x len, Age x Length
both14	HP*age	miles, tons, HP, length, tons x HP, tons x len, HPx Len
both15	HP*age	miles, tons, HP, age, tons x HP, tons x age, HPxAge

In addition to the three groups of EPM models, we run suite of conditional logit models with zone-specific constants.[24] We refer to this type of model as a "zonal logit." The zonal logit is simple but in some sense elegant in regard to evaluating area closures. For the zonal logit that we examine here, we estimate zone-specific constants (with an appropriate normalization) and a parameter on the miles required to travel to the chosen zone, as well as parameters on boat characteristics (interacted with miles). While this is a quite basic model, it provides a simple means to turn zones "on" and "off" with area closures. As discussed above, it also provides us with benchmark to assess the error correlation in our model.

We also compare the EPM to a two-stage expected catch model common in the literature. The two-stage model that we use is a conditional logit, but we replace the zone-specific constants with a parameter on average catch for the zone, which we calculate prior to estimating the choice model. We then estimate parameters on average catch and mileage. We expected that the gains from the EPM over such a model would be in efficiency[25] but at the seasonal level, the two-stage model gives non-

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[24] Each of the Type 1 models has a conditional logit analog, and the results of a number of these models are presented next to the corresponding EPM in the Appendix.

[25] See, for example, Greene 1997, p. 923.

economic results (i.e. a negative coefficient on expected revenue) and does not give accurate predictions. As highlighted in the discussion between Morey and Waldman (1998, 2000) and Train et al. (2000), there are on-going questions about the bias involved in the two-stage model. Our experience here with the two-stage model is that it does appear to be biased, though we are uncertain of the source of the bias. This may be due to intra-seasonal variation. The results from these models are not reported.

2.4 Welfare estimation framework

One of the important features of the EPM is that it allows us to explicitly calculate welfare changes that come with area closures. A measure of the welfare loss from closing a group of zones can be formulated by determining the profits that will equate the expected benefits before and after the change. Using the random utility structure (RUM):

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad (10)$$

The welfare loss from the closure can be computed as the amount of money that must be given to equate profits before and after the policy change. This is found by the relation:

$$E\left(MAX\left(U_{ij}, j = 1 : m_1\right)\right) - E\left(Max\left(U_{ij}, j = 1 : M\right)\right) = W, \qquad (11)$$

where m_1 is the subset of M zones that are open before and after the closure. With the EPM, we can find the welfare loss directly, following the standard “log sum” formula by incorporating the EPM parameters into the standard formula, which results in (12) (see, for example, Hanemann (1999) based upon Ben Akiva (1972), McFadden (1973), and Domencich and McFadden (1975)). With an estimated scale parameter for the choice specific errors (*sigmachoice* or σ_ε)so that in $U_{ij} = V_{ij} + \varepsilon_{ij}$, where

$V_{ij} = P\alpha_j + X_{ij}\beta$ and ε_{ij} is distributed Type I Extreme Value with scale = σ_ε, the expected value of the maximum can be shown to be:

$$E\left(Max\left(U_{ij}, j=1:M\right)\right) = \sigma_\varepsilon \ln\left(\sum_{j=1}^{j=M} \exp^{V_{ij}/\sigma_\varepsilon}\right) - \sigma_\varepsilon \times 0.57721, \qquad (12)$$

and similarly for $E\left(MAX\left(U_{ij}, j=1:m_1\right)\right)$.[26]

In this manner we are able to calculate the expected profit of fishing in any zone and the losses associated with closures.[27] We then find the median, 2.5%, 5%, 95% and 97.5% draws, which are interpreted as the welfare confidence intervals.[28]

3. Description of data

There are three sectors of the Bering Sea pollock fishery: catcher boats (also called the inshore processing sector), catcher-processors (also referred to as CP's or factory trawlers), and motherships. Catcher boats make up the largest sector of the fishery (50% of total catch), and the SCA has been closed to catcher processors for a longer period of time[29], so the emergency SCA closure primarily affected the inshore sector, which is the focus of this paper. Fishing trips are typically 2-3 days long,

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[26] Note the second term in (12) drops out in (11) because it is common to both terms.

[27] The identical method could also be used to estimate the benefit of re-opening a closed area for which there is historical catch data.

[28] We simulate confidence intervals for these welfare estimates using the method of Krinsky and Robb (1986). First, we assume a multivariate normal distribution and take 1000 random draws from the variance-covariance matrix of the EPM. For each draw from the variance-covariance matrix, we calculate the welfare impact for each observation in the data set. We calculate the change in expected profits, W, as in (13). In using frequentist model averaging, we use this method to draw from the saved results from individual models proportional to the FMA weights. This may not be ideal in that it does not account for covariance among the models, but in averaging welfare levels from different models, the covariance does not enter our calculations. We leave this task to address in future work.

[29] The SCA largely overlaps with the CVOA or 'Catcher vessel operational area,' which was created to allocate the near-shore portion of the fishery to the inshore pollock fishery.

but occasionally can be several days longer.

The catch quantity and location data that we utilize comes from the North Pacific Groundfish Observer Program. Since 1989, NOAA has placed observers on all trawling vessels over 60 feet in length that fish in the Bering Sea. For vessels 125 feet and longer, observers are on-board 100 percent of days at sea. For vessels from 60-124 feet, observers are on-board for 30 percent of days at sea.[30] Catcher boat trips for the summer seasons from the 1995-1998 (2265 records) are the basis of this estimation, with the predictions compared to actual 1999-2002 data.[31] Processor-reported fish tickets are used to assign hauls recorded by the observer program to trips taken by each vessel and to assign a landing date to each trip. Price data displayed in Table 5 are taken from the North Pacific Fisheries Management Council/NMFS Economic SAFE documents (Hiatt et al. 2002, Hiatt and Terry 2000).

Table 5: Average annual ex-vessel Bering Sea pollock prices (2000$)

Year	$/lb	$/mt
1995	0.106	234.57
1996	0.088	194.97
1997	0.107	235.68
1998	0.073	159.97
1999	0.098	216.25
2000	0.118	260.15
2001	0.106	234.67
2002	0.111	245.68

With non-linear models, scaling the data is a critical part of the empirical exercise. In running this model, data are rescaled so that catch, price, and mileage data are of a similar magnitude. Specifically, per-ton price data are divided by 100, catch data (in tons) is divided by 1000, and one-way mileage data are divided by 100. Boat characteristic information is taken from federal and state vessel registration documentation and for scaling purposes is normalized so that the mean is one for

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[30] There are no observer observations for the several vessels smaller than 60 feet, which make up less than 1 percent of total catch. The impacts on these vessels are not included in our welfare estimates.

[31] All of these data are protected by confidentiality agreements so no data can be presented which reveals any information about particular vessels or processors. Because there is one port with less than 3 processors, this prevents us from summarizing information by port.

each boat characteristic.

Data are recorded by the NOAA Observer Program in three different scales/resolutions: NMFS area, ADF&G 'STAT6' statistical areas, and the latitude and longitude (in minutes) where a haul starts and ends. The vast majority of trips take place to just a few of the NMFS areas, so we have used the STAT6 areas, which have a finer resolution than the NMFS areas, as the scale of the discrete choice used in this model. These areas are shown below in Figure 3. This scale (roughly 40 miles (64 km) east-west by 35 miles north-south) allows us to distinguish meaningfully among choice opportunities within the discrete choice framework.

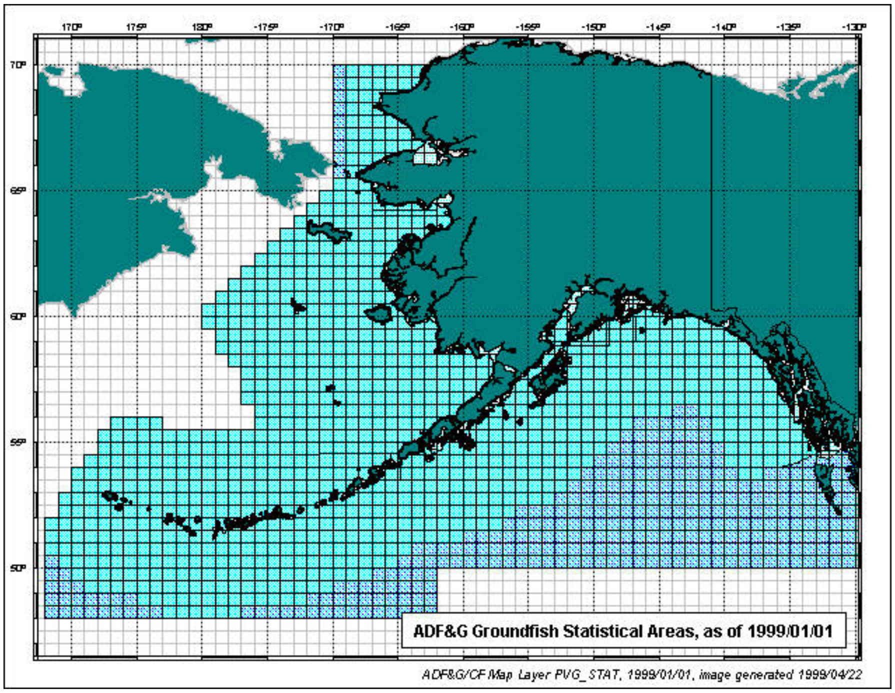

Figure 3: ADF&G Statistical Areas (STAT6 Areas)

For each trip, the centroid of all hauls of the trip is calculated. Using ArcGIS, the STAT6 area of the centroid is determined. The one-way distance from the landing port to the centroid of the STAT6 area is then used as the distance of the trip. For 1995-1998, we considered the 2265 trips that were taken to the 22 zones where more than 2 trips occurred—two additional zones received one or two trips during this period. Between 1991 and 1994, several trips were also taken to five additional zones. Table 6 displays how during the in-sample period most of the trips (99.9 percent) were accounted for, but during 2000 more than 20 percent of trips were taken outside the original choice set. These trips were taken to the seven zones where trips had been taken from 1991 and 1998 but were not in the model. However this is not a major source of error in the model during the closure period; the primary source of error in prediction during the closure period was an unexpectedly large number of trips to one zone where minimal fishing had occurred in the past. We will return to this issue in the empirical results and the conclusion.[32]

Table 6: Number of trips in and out of the model's estimation areas

	95-98	1999	2000C	2000D	2001-2002
Trips in 22 included zones	2265	541	115	468	1626
Total trips	2268	577	157	583	1638
% of trips in included zones	99.9%	94%	73%	80%	99.3%

In the 1999 summer season, the average SCA total allowable catch (TAC) was 56% of the total TAC.[33] In 2000, the C Season[34] (June 10-August 20) SCA TAC was 13.5% of the total TAC, and the D season (August 20-November 4) TAC was set at 22.5% of the seasonal TAC.[35] On August 9, 2000, prior to the end of the C season, however, the SCA was closed by judicial mandate to all trawling for the remainder of the season, so there was no fishing inside the SCA in 2000 D Season.

Table 7 illustrates how SCA restrictions impacted the fishery (in terms of trips, not catch).[36] In 1999 and 2000 the SCA was partially or totally closed. In 2001 and 2002, the SCA was completely open to catcher vessels during the summer season and given the choice, fishers chose to fish in the

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[32] An important challenge of an *ex-ante* policy prediction such as we undertake is to consider what information was really available *ex-ante*. There is a "Lucas Critique" to be made that there really was no way to foresee the concentration of the fishery in 2000 in one previously rarely-fished zone.

[33] During 1999, one area which represented approximately a quarter of trips from 1995-98 was also closed.

[34] The sub-season names have varied over the years – currently the 'A' season is the winter season and the 'B' season is the summer/fall season.

[35] 65 FR 3892, January 25, 2000 actually set the fishery to close on November 1 but the season was extended until November 4.

[36] The total allowable catch (TAC) for the summer 2000 season was met.

SCA on 98 percent of the trips in those two years.[37]

Table 7: Summer season catcher boat trips in and out of the SCA, by year

SCA	1995	1996	1997	1998	1999	2000	2001	2002
Outside	1	3	0	60	253	654	30	0
Inside	583	543	539	539	324	86	761	847
% Inside	99.8	99.5	100.0	90.0	56.2	11.6	96.2	100.0

4. Empirical results

The estimation results of seven EPM models are shown in Table 8.[38] The alpha coefficients may appear similar to one another in each model, but there is approximately a 20 percent difference among zones. The first two models shown are ones with significant BIC weight – Model A and Model B. Both models have HP interacted with Age in the catch portion of the likelihood; Model A has all interactions of vessel characteristics (excluding tons) and Model B has all vessel characteristics (excluding length). Models C is the best joint model without prescreening of the catch-side vessel characteristics and Model D is the best "catch only" model. The simplest "choice only" model, Model E, with only miles included as a covariate, is shown for comparison purposes, and model F displays the random parameters version of this model. Model G is the best of the Type 1 "choice only" models. The log-likelihood, the BIC, the number of model parameters, and the BIC weights are shown at the bottom of the table for each model. Despite the complexity of these models, the vast majority of parameters are significant.

Because miles are interacted with boat characteristics, one cannot directly interpret the mileage coefficients for the models with positive weight. In the type 1 model, however, the coefficient on miles can be interpreted as a cost per-mile. The coefficient of 0.015 when rescaled is \$15.27 per mile (round trip). With all of the models we can estimate the model with and without costs and then follow

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[37] Note that the number of trips in these years increased, as did the TAC for the inshore sector, which increased by approximately 50 percent from 1999 to 2002.

[38] The results of representative models are included in Appendix 1.

the Krinsky-Robb (1986) method to determine the median welfare impact. The results are comparable to the results above.[39] Our measure of mileage – the linear distance to the centroid of all hauls of a trip -- is a proxy for the actual trade-off that is made between closer areas with lower potential catch rates and more distant areas with higher catch rates. One should note that this issue of costs is a function not of inconsistency of the EPM, as the same results occur in the zonal logit. This is an area that requires further research.

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[39] Results will be displayed in subsequent drafts.

Table 8: Select EPM Models

	A			B			C			D			E			F			G		
	Est.	SE	Est./SE	Est.	SE	Est./SE	Est.	SE	Est./SE	Est.	SE	Est./SE	Est.	SE	Est./SE	Est.	SE	Est./SE	Est.	SE	Est./SE
alpha1	0.045	0.006	8.0	0.045	0.006	7.4	0.052	0.006	9.4	0.046	0.0054	8.4	0.187	0.0115	16.3	0.179	0.008	23.1	0.191	0.004	42.6
alpha2	0.051	0.005	10.3	0.051	0.005	10.1	0.057	0.005	11.8	0.050	0.0049	10.3	0.211	0.0040	52.9	0.209	0.004	55.1	0.211	0.003	66.7
alpha3	0.046	0.005	8.8	0.046	0.006	8.2	0.053	0.005	10.2	0.046	0.0053	8.6	0.194	0.0098	19.7	0.186	0.007	26.0	0.195	0.004	48.8
alpha4	0.042	0.006	7.2	0.043	0.006	6.9	0.049	0.005	9.6	0.040	0.0087	4.6	0.194	0.0093	20.8	0.186	0.007	25.3	0.195	0.005	43.2
alpha5	0.042	0.007	6.1	0.042	0.007	5.7	0.049	0.006	8.6	0.040	0.0091	4.3	0.186	0.0137	13.6	0.174	0.010	17.1	0.187	0.006	30.6
alpha6	0.046	0.005	9.5	0.046	0.005	9.2	0.052	0.005	10.7	0.047	0.0047	10.1	0.214	0.0036	60.0	0.213	0.004	60.1	0.214	0.003	68.1
alpha7	0.038	0.008	4.8	0.038	0.009	4.3	0.044	0.006	7.1	0.041	0.0085	4.8	0.179	0.0146	12.3	0.168	0.009	17.8	0.184	0.006	31.7
alpha8	0.051	0.005	10.5	0.051	0.005	10.4	0.057	0.005	11.8	0.050	0.0049	10.2	0.221	0.0042	52.5	0.223	0.004	57.2	0.220	0.003	69.0
alpha9	0.051	0.005	10.3	0.051	0.005	10.2	0.057	0.005	11.8	0.050	0.0048	10.3	0.210	0.0042	50.1	0.208	0.004	54.7	0.210	0.003	65.9
alpha10	0.043	0.005	7.8	0.043	0.006	7.6	0.049	0.005	10.0	0.042	0.0070	6.1	0.199	0.0071	28.2	0.194	0.006	34.4	0.201	0.004	51.8
alpha11	0.042	0.006	6.8	0.042	0.007	6.4	0.049	0.005	9.2	0.041	0.0080	5.1	0.190	0.0112	17.0	0.181	0.008	21.8	0.191	0.005	39.1
alpha12	0.035	0.010	3.4	0.034	0.011	3.0	0.041	0.007	6.2	0.039	0.0103	3.8	0.171	0.0180	9.5	0.149	0.016	9.3	0.170	0.008	22.7
alpha13	0.036	0.008	4.3	0.035	0.009	4.1	0.042	0.005	8.5	0.040	0.0085	4.7	0.198	0.0072	27.5	0.191	0.005	35.5	0.199	0.004	54.7
alpha14	0.030	0.011	2.7	0.030	0.012	2.5	0.037	0.005	7.0	0.036	0.0117	3.1	0.185	0.0120	15.4	0.171	0.010	17.1	0.184	0.005	37.6
alpha15	0.043	0.005	8.0	0.043	0.006	7.6	0.049	0.005	10.0	0.045	0.0055	8.1	0.199	0.0071	27.8	0.194	0.005	38.4	0.201	0.004	55.6
alpha16	0.036	0.008	4.6	0.036	0.008	4.3	0.043	0.005	8.3	0.039	0.0097	4.0	0.188	0.0113	16.6	0.180	0.008	23.3	0.191	0.004	43.6
alpha17	0.046	0.006	7.6	0.046	0.007	6.8	0.051	0.006	8.5	0.045	0.0058	7.7	0.187	0.0120	15.6	0.178	0.009	20.6	0.190	0.005	40.3
alpha18	0.041	0.006	6.4	0.041	0.007	6.1	0.047	0.005	9.2	0.040	0.0090	4.4	0.192	0.0102	18.9	0.184	0.008	24.1	0.194	0.004	46.0
alpha19	0.040	0.007	5.5	0.040	0.008	5.2	0.047	0.005	8.5	0.037	0.0110	3.4	0.188	0.0127	14.8	0.176	0.010	17.8	0.188	0.005	35.4
alpha20	0.034	0.009	3.7	0.034	0.010	3.4	0.041	0.006	7.2	0.038	0.0108	3.5	0.181	0.0141	12.9	0.171	0.009	18.1	0.185	0.005	34.7
alpha21	0.038	0.007	5.3	0.038	0.008	5.0	0.044	0.005	8.8	0.040	0.0089	4.5	0.191	0.0104	18.3	0.183	0.007	25.6	0.194	0.004	44.0
alpha22	0.040	0.007	5.6	0.040	0.007	5.3	0.046	0.005	8.4	0.040	0.0087	4.6	0.187	0.0117	16.1	0.178	0.009	21.0	0.190	0.005	35.9
epsilon1	0.168	0.008	20.0	0.168	0.009	18.4	0.160	0.007	24.5	0.171	0.0091	18.8									
epsilon2	0.173	0.006	29.3	0.172	0.006	28.3	0.166	0.004	37.0	0.175	0.0057	30.8									
epsilon3	0.169	0.008	21.0	0.169	0.008	19.9	0.161	0.005	32.1	0.173	0.0074	23.5									
epsilon4	0.172	0.007	26.3	0.172	0.007	24.7	0.165	0.005	34.0	0.180	0.0043	41.7									
epsilon5	0.167	0.010	17.6	0.167	0.010	16.4	0.160	0.005	29.1	0.178	0.0057	31.3									
epsilon6	0.183	0.005	39.5	0.183	0.005	38.6	0.176	0.004	39.8	0.181	0.0042	42.8									
epsilon7	0.174	0.007	24.2	0.174	0.008	20.8	0.167	0.007	24.4	0.175	0.0068	25.9									
epsilon8	0.180	0.004	41.7	0.180	0.004	41.1	0.173	0.004	39.4	0.179	0.0041	43.6									
epsilon9	0.173	0.006	31.0	0.173	0.006	30.4	0.166	0.004	37.3	0.176	0.0055	31.9									
epsilon10	0.176	0.005	35.5	0.176	0.005	34.2	0.169	0.005	37.4	0.180	0.0042	43.2									
epsilon11	0.171	0.007	23.1	0.171	0.008	21.8	0.163	0.005	32.9	0.177	0.0051	34.8									
epsilon12	0.176	0.008	21.1	0.176	0.010	17.6	0.168	0.008	22.4	0.175	0.0070	25.0									
epsilon13	0.185	0.005	34.3	0.186	0.006	33.0	0.178	0.004	39.8	0.182	0.0047	38.8									
epsilon14	0.186	0.006	31.9	0.186	0.006	30.6	0.178	0.005	37.7	0.182	0.0047	38.6									
epsilon15	0.178	0.005	39.5	0.178	0.005	38.3	0.171	0.004	38.1	0.178	0.0044	40.1									
epsilon16	0.180	0.005	39.2	0.180	0.005	37.5	0.172	0.005	37.7	0.180	0.0043	41.9									
epsilon17	0.167	0.010	17.0	0.167	0.011	15.6	0.160	0.007	24.4	0.172	0.0084	20.5									
epsilon18	0.174	0.006	28.3	0.173	0.007	26.6	0.166	0.005	35.1	0.180	0.0043	41.7									
epsilon19	0.171	0.007	22.9	0.171	0.008	21.3	0.163	0.005	31.9	0.181	0.0046	38.9									
epsilon20	0.180	0.005	35.6	0.180	0.005	32.7	0.172	0.005	34.2	0.180	0.0046	38.9									
epsilon21	0.179	0.005	39.2	0.179	0.005	37.6	0.172	0.004	38.4	0.180	0.0043	42.3									
epsilon22	0.174	0.006	28.6	0.174	0.007	26.4	0.167	0.005	34.8	0.178	0.0049	36.7									
miles (mu for RP)	-0.119	0.076	-1.6	-0.030	0.031	-1.0	-0.118	0.039	-3.0	-0.003	0.0027	-1.1	-0.015	0.0063	-2.4	-4.099	0.057	-72.3	-0.233	0.019	-12.2
s (for RP only)																0.880	0.188	4.7			
tons*miles				-0.038	0.043	-0.9															
HP*miles	0.102	0.062	1.6	0.108	0.063	1.7	0.132	0.028	4.7										0.295	0.000	1938
length*miles	0.107	0.071	1.5				0.104	0.040	2.6										0.232	0.020	11.7
age*miles	0.100	0.084	1.2	0.023	0.029	0.8	0.091	0.060	1.5										0.133	0.029	4.6
tons*HP*miles				0.001	0.003	0.2															
tons*len*miles																					
tons*age*miles				0.031	0.040	0.8															
HP*len*miles	-0.016	0.011	-1.4				-0.017	0.007	-2.5										-0.038	0.010	-3.9
HP*age*miles	-0.069	0.046	-1.5	-0.097	0.058	-1.7	-0.098	0.024	-4.1										-0.263	0.015	-17.8
len*age*miles	-0.103	0.086	-1.2				-0.092	0.060	-1.5										-0.136	0.029	-4.7
sigmachoice	0.007	0.004	1.9	0.007	0.004	1.9	0.007	0.000	18.1	0.005	0.0045	1.1	0.015	0.0057	2.6	0.020	0.004	5.4	0.013	0.002	8.4
sigma1	0.115	0.024	4.9	0.115	0.024	4.8	0.118	0.025	4.7	0.114	0.0307	3.7	0.142	0.0202	7.0	0.142	0.029	4.8	0.143	0.031	4.7
sigma2	0.088	0.005	19.0	0.088	0.005	18.9	0.089	0.005	19.3	0.088	0.0041	21.7	0.118	0.0062	19.1	0.117	0.006	18.4	0.118	0.007	18.1
sigma3	0.098	0.018	5.4	0.098	0.018	5.5	0.099	0.020	5.0	0.099	0.0230	4.3	0.129	0.0199	6.5	0.126	0.024	5.3	0.130	0.025	5.3
sigma4	0.095	0.018	5.2	0.095	0.018	5.4	0.094	0.018	5.2	0.094	0.0223	4.2	0.158	0.0214	7.4	0.162	0.030	5.5	0.158	0.036	4.4
sigma5	0.139	0.051	2.7	0.139	0.053	2.6	-0.136	0.038	-3.5	-0.133	0.0580	-2.3	0.147	0.0589	2.5	0.156	0.043	3.6	-0.146	0.049	-3.0
sigma6	-0.156	0.005	-32.8	-0.156	0.005	-32.8	-0.159	0.005	-33.6	0.156	0.0049	32.2	0.209	0.0062	33.7	0.209	0.006	32.5	-0.209	0.007	-30.1
sigma7	0.134	0.039	3.5	0.134	0.045	3.0	0.130	0.049	2.7	-0.134	0.0409	-3.3	-0.128	0.0282	-4.5	-0.128	0.040	-3.2	0.128	0.045	2.9
sigma8	0.109	0.002	45.4	0.109	0.002	45.2	0.111	0.002	45.1	0.109	0.0018	59.2	0.146	0.0034	42.6	0.146	0.003	45.5	0.146	0.002	59.0
sigma9	0.081	0.004	19.3	0.081	0.004	19.2	0.080	0.004	19.1	0.081	0.0044	18.3	0.105	0.0058	18.1	0.105	0.006	17.3	0.106	0.004	24.1
sigma10	0.080	0.010	8.3	0.080	0.010	8.4	-0.082	0.010	-7.8	0.081	0.0140	5.8	0.136	0.0152	9.0	0.137	0.017	8.3	-0.136	0.018	-7.6
sigma11	0.114	0.028	4.1	0.114	0.028	4.1	0.114	0.027	4.3	0.111	0.0341	3.2	0.124	0.0297	4.2	0.130	0.032	4.1	0.123	0.025	4.9
sigma12	0.123	0.044	2.8	0.124	0.054	2.3	0.117	0.037	3.1	0.127	0.0547	2.3	0.113	0.0378	3.0	0.094	0.042	2.3	0.112	0.040	2.8
sigma13	0.251	0.021	12.1	0.251	0.021	12.0	-0.263	0.021	-12.6	0.251	0.0224	11.2	0.332	0.0270	12.3	0.337	0.027	12.5	0.331	0.036	9.3
sigma14	0.244	0.040	6.2	0.244	0.042	5.9	0.267	0.040	6.7	0.245	0.0405	6.0	0.385	0.0643	6.0	0.388	0.057	6.8	0.386	0.080	4.8
sigma15	-0.115	0.011	-10.1	-0.115	0.011	-10.2	0.118	0.011	10.5	-0.114	0.0141	-8.1	0.152	0.0139	11.0	0.153	0.015	10.3	0.151	0.020	7.7
sigma16	-0.143	0.028	-5.1	-0.143	0.029	-5.0	0.152	0.030	5.1	0.143	0.0347	4.1	0.201	0.0253	7.9	0.202	0.040	5.1	0.200	0.047	4.2
sigma17	-0.068	0.016	-4.2	-0.068	0.017	-4.1	0.071	0.016	4.5	0.069	0.0199	3.5	0.087	0.0169	5.2	0.082	0.021	3.8	0.089	0.021	4.3
sigma18	0.127	0.026	4.8	0.127	0.026	4.8	-0.131	0.027	-4.9	0.131	0.0362	3.6	0.078	0.0162	4.8	0.083	0.017	4.8	0.078	0.020	4.0
sigma19	0.095	0.031	3.1	0.095	0.032	3.0	0.094	0.018	5.3	0.090	0.0449	2.0	0.172	0.0550	3.1	0.177	0.048	3.7	0.172	0.082	2.1
sigma20	-0.187	0.059	-3.1	-0.187	0.059	-3.2	-0.214	0.092	-2.3	0.185	0.0693	2.7	0.305	0.0862	3.5	0.311	0.097	3.2	0.303	0.129	2.4
sigma21	-0.107	0.020	-5.2	-0.107	0.022	-5.0	0.112	0.015	7.5	0.107	0.0291	3.7	0.165	0.0195	8.4	0.169	0.033	5.1	0.163	0.037	4.4
sigma22	0.056	0.014	4.0	0.056	0.014	3.9	-0.056	0.012	-4.5	0.056	0.0181	3.1	-0.061	0.0185	-3.3	-0.065	0.016	-4.1	0.060	0.018	3.4
Likelihood	-2025.5			-2027.9			-2062.8			-2074.8			-2886.8			-2884.8			-2771.1		
BIC	4622.7			4627.5			4697.4			4675.0			6129.0			6132.7			5943.9		
Parameters	74			74			74			68			46			47			52		
BIC Weight	0.916			0.084			0			0			0			0			0		

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The log-likelihoods, number of parameters, BIC and frequentist weights displayed at the bottom of Table 8 are also presented in Table 9, below. The table provides results for models A-G. Three other joint models have weight between 10^{-5} and 10^{-7}.[40]

Table 9: <u>Select</u> models, likelihoods, BIC, and frequentist weights[41]

Model	Catch terms	Choice terms	Log Likelihood	Parameters	BIC	BIC Fequentist Model Weight
A	HP x Age	miles, HP, age, length, HPxAge, HPxLength, Age x Length	-2026	74	4705	0.916
B	HP x Age	miles, tons, HP, age, len, tons x HP, tons x age, HPxAge	-2028	74	4709	0.084
C	HP	miles, HP, age, length, HPxAge, HPxLength, Age x Length	-2063	74	4780	5.6E-17
D	HP x Age		-2075	68	4757	4.0E-12
E		miles	-2887	46	6129	0
F			-2887	47	6133	0
G		miles, HP, age, length, HPxAge, HPxLength, Age x Length	-2771	52	5944	0

As discussed above, in order to assess whether or not there are error correlation issues between the alphas and unobserved errors, we compared the results of the EPM models in Table 2 with coefficients from a conditional logit with zone-specific constants. As shown in Table 10 for Model A, the best-fitting model, the difference between the coefficients is very small, which we interpret as an indication of minimal bias from error correlation in the EPM.[42]

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[40] In our model averaging results, Models A and B account for 99.9974 percent of the model weight.

[41] In order to make the coefficients comparable from the two models, we rescaled the alphas by *sigmachoice* and differenced all coefficients from zone 1. In the zonal logit, we modeled the zone-specific constants as proportional to prices rather than 1's, which makes the two models directly comparable.

[42] The pseudo-R^2 for the zonal logit is shown in the table as well as 0.464. Interestingly modeling the zonal logit as proportional to prices improves the pseudo-R^2 slightly—without prices the pseudo-R^2 of the zonal logit is 0.462. The pseudo-R^2 for the discrete choice element of the above EPM is 0.463, while it is 0.473 for the best-fitting EPM model, Model A.

Table 10: Model A with re-scaled Alpha coefficients and Logit with zone-specific constants[43]

Coefficient	EPM coefficient (rescaled & differenced w.r.t. zone 1)	Logit estimate	Logit SE		Coefficient	EPM coefficient (rescaled & differenced w.r.t. zone 1)	Logit estimate	Logit SE
alpha1	**0**	**0**			epsilon1	**0**	**0**	
alpha2	1.04	1.01	0.49		epsilon2	0.67	0.73	0.21
alpha3	0.18	0.15	0.55		epsilon3	0.09	0.17	0.67
alpha4	-0.38	-0.45	0.38		epsilon4	0.67	0.80	0.79
alpha5	-0.43	-0.53	0.68		epsilon5	-0.11	0.05	0.80
alpha6	0.15	0.15	0.30		epsilon6	2.25	2.23	0.11
alpha7	-1.08	-1.09	0.62		epsilon7	0.95	0.96	0.74
alpha8	0.99	0.98	0.32		epsilon8	1.76	1.77	0.38
alpha9	1.03	1.01	0.84		epsilon9	0.79	0.83	0.20
alpha10	-0.30	-0.34	0.39		epsilon10	1.27	1.35	0.37
alpha11	-0.40	-0.47	10.73		epsilon11	0.45	0.55	0.80
alpha12	-1.61	-1.58	1.41		epsilon12	1.16	1.12	10.36
alpha13	-1.47	-1.45	0.25		epsilon13	2.69	2.66	0.29
alpha14	-2.40	-2.36	0.36		epsilon14	2.78	2.72	1.03
alpha15	-0.26	-0.26	0.28		epsilon15	1.53	1.53	0.37
alpha16	-1.31	-1.32	0.65		epsilon16	1.78	1.81	0.26
alpha17	0.12	0.09	0.54		epsilon17	-0.21	-0.14	0.87
alpha18	-0.62	-0.70	0.62		epsilon18	0.86	1.00	0.34
alpha19	-0.79	-0.88	0.72		epsilon19	0.47	0.62	0.65
alpha20	-1.73	-1.72	0.60		epsilon20	1.78	1.78	0.63
alpha21	-1.06	-1.08	0.51		epsilon21	1.67	1.71	0.54
alpha22	-0.82	-0.88	0.83		epsilon22	0.96	1.06	0.69
					miles	-17.73	-17.73	1.24
initial LL		-6929.0			HP	15.03	15.23	1.70
LL		-3661.9			len	15.91	15.97	1.30
pseudo R-sq		0.472			age	14.84	14.81	2.93
					HP*len	-2.28	-2.33	0.31
					HP*age	-10.28	-10.61	1.64
					len*age	-15.37	-15.30	2.89

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[43] To make the results of the two models comparable, the *alpha* coefficient from zone 1 is subtracted from the *alpha* coefficients of zones 2-22. The resulting value is then divided by the scale factor, *sigmachoice*. For the miles coefficient and the coefficients on boat characteristics, the EPM value is rescaled by *sigmachoice* and the zonal logit is rescale by prices.

4.1 Predictions

Table 11 displays BIC model average predictions for 1995-2002, compared with the actual percentage of trips taken to each of the 22 zones in the model. Both the zonal logit and the EPM are used to make predictions. The results of the models are highly comparable. On the one hand we interpret this as an indication that the EPM accurately captures the relative value of being able to fish in different zones, but it also shows how the relatively straightforward zonal logit predicts choice very well, though it cannot predict the welfare impacts in the manner that we can with the EPM.

Table 11: BIC model average percentage of trips predicted per zone, by time period[44]

	1995-98			1999			2000c			2000d			2001			2002		
STAT22 Zone	Actual Trips	BIC averaged Prediction	Mean-squared-error	Actual Trips	BIC averaged Prediction	Mean-squared-error	Actual Trips	BIC averaged Prediction	Mean-squared-error	Actual Trips	BIC averaged Prediction	Mean-squared-error	Actual Trips	BIC averaged Prediction	Mean-squared-error	Actual Trips	BIC averaged Prediction	Mean-squared-error
1	0.5	0.6	0.001	0	0.3	0.1	0	0.04	0.002	0	0.0	0.0	0	0.3	0.11	0	0.3	0.08
2	8.1	8.1	0.0	3.3	6.1	7.7	18.8	1.3	308	0	0.0	0.0	5.0	7.5	6.2	2.2	7.2	25
3	0.7	0.7	0.002	1.1	0.4	0.4	2.9	0.06	8.1	0.4	0.0	0.2	0.4	0.4	0.003	0.4	0.4	0.00
4	0.7	0.6	0.009	0.9	10.6	93	13.8	21.4	57	21.6	24.7	10	0.0	0.3	0.1	0	0.2	0.05
5	0.2	0.2	0.001	0.2	2.7	6.1	0.7	4.6	15	5.4	5.3	0.0	0.0	0.1	0.004	0	0.05	0.003
6	24	24	0.2	0	0	0	0	0	0	0	0	0	38.6	25.4	176	21.4	25.4	16.3
7	0.3	0.3	0.00	0.2	0.1	0.00	0	0.01	0.0002	0	0	0	0.3	0.1	0.02	0.8	0.1	0.5
8	45.8	44.9	0.9	26.1	36.1	101	11.6	9.8	3.2	0	0	0	45.2	50.1	24	50.1	51.7	3
9	8.3	8.1	0.03	17.4	6.1	129	13.0	1.3	137	0	0	0	5.4	7.6	4.7	5.6	7.3	3.1
10	1.6	1.6	0.00	7.6	1.0	44	2.2	0.1	4.3	0.7	0	0.5	0.4	1.0	0.4	0	0.9	0.8
11	0.40	0.34	0.00	7.2	6.6	0.4	10.1	13.0	8.3	46.7	15.0	1005	0.6	0.2	0.2	0	0.1	0.02
12	0.18	0.17	0.00	0	0.08	0.006	0	0.006	0.0	0	0	0	0	0.06	0.004	0.9	0.0	0.8
13	3.3	3.4	0.01	0	2.4	5.6	0	0.42	0.18	0	0	0	0.6	2.7	4.4	1.7	2.5	0.77
14	0.8	0.8	0.01	0	0.5	0.2	0	0.06	0.0033	0	0	0	0	0.5	0.2	0.5	0.4	0.0
15	2.4	2.8	0.2	0.2	1.9	2.8	0	0.28	0.08	0	0	0	1.5	2.0	0.243	9.7	1.8	61.9
16	0.6	0.5	0.00	2.4	0.3	4.5	0	0.030	0.001	0	0	0	0.1	0.3	0.02	2.6	0.2	5.7
17	0.4	0.4	0.001	15.2	7.3	62.3	5.1	16.4	128.0	0.4	19.0	345.1	0.1	0.2	0.0	0	0.2	0.03
18	0.5	0.5	0.006	6.8	8.3	2.4	18.1	16.0	4.3	18.2	18.5	0.1	1.7	0.2	2.1	0	0.2	0.03
19	0.2	0.2	0.001	0.4	3.0	6.8	2.9	4.8	3.4	1.8	5.5	13.7	0	0.1	0.005	0	0.06	0.003
20	0.2	0.3	0.004	0	0.1	0.0	0.0	0.0	0.0	0	0	0	0	0.1	0.01	0.1	0.1	0.0
21	0.6	0.7	0.0	1.7	0.4	1.8	0.0	0.0	0.0	0	0	0	0	0.4	0.1	4.1	0.3	15
22	0.4	0.3	0.002	9.4	5.4	16.2	0.7	10.0	87.3	4.7	11.6	47.8	0	0.1	0.02	0	0.1	0.01
Total	100	100	1.32	100	100	484	100	100	765	100	100	1422	100	100	219	100	100	132

Table 11 presents BIC model average predictions for the EPM for both the in-sample period (1995-1998) and the out-of-sample periods for which we would like to make predictions. Not surprisingly, the model performs best in-sample. The model also does quite well predicting for the 2001-2002 seasons when all areas are open. However, as is most striking in the 2000d period when the

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[44] For each time period, we present the percentage of actual trips to each zone, the percentage of trips predicted by the BIC model-averaged EPM, and the mean-squared error of the two terms. The mean-squared error is calculated by the following expression: ((actual % of trips to a zone)-(predicted % of trips to a zone))^2.

emergency closure was in place, the model's accuracy declines when we try to predict what happens with the non-SCA zones that prior to 1999 made up less than 3 percent of fishing trips.[45] When we predict what happens when a large amount of fishing effort is redirected to an infrequently fished area, we experience less accurate predictions and higher MSE's, which is one of the challenges of this type of *ex-ante* prediction.

Interestingly most of the error from the 2000d period is due to an underestimate of the number of trips to one zone – zone 11 in Table 11. While the EPM predicted that 13.9 percent of trips would be taken there, 46.7 percent of trips actually were. The EPM was also off substantially for zone 17, where the 0.4 percent of trips were made in contrast with the EPM prediction of 17.2 percent.[46] Both of these zones had accounted for 0.4 percent of total trips in 1995-1998, but clearly zone 11 was vastly preferable during the emergency closure period. There was no past evidence to suggest this pattern of fishing.

Winter 1999 was an extremely cold season in the Bering Sea. This pushed the pollock population and thus the fishery to the west. If we were conducting an *ex-post* analysis, we could explain location choice for that year in part by this environmental variable. This was not foreseeable, however, so could not be included in our *ex-ante* predictions.

4.2 Welfare estimates

Using the welfare methodology described for the EPM above, we are able to calculate explicit estimates of the welfare loss associated with the SCA emergency closure. Table 12 displays the welfare estimates for the two models with the greatest FMA weight and the BIC model-averaged welfare predictions.

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[45] Note that two trips show up inside the SCA. Because the trips are centroids of hauls, these trips are essentially error and appear in the dataset.

[46] The MSE measure used here is very sensitive to error, particularly here where the total amount is a percentage. An overestimate in one zone also is counted as an underestimate elsewhere.

Table 12: Welfare loss (in dollars) of SCA closure according to different models and weighted averages (with median and confidence intervals)

Model	0.025	0.05	median	0.95	0.975
A	-8498	-7344	-3423	-316	0
B	-8289	-7132	-3290	-35	179
BIC model averaged	**-8542**	**-7337**	**-3403**	**-290**	**0**

These values were estimated using the Krinsky-Robb (1986) estimation procedure to simulate confidence intervals, as described above in Section 2.4. For each observation in the data set, we perform 1000 random draws from the variance-covariance matrix of the relevant models. We display the median as well as the 0.025, 0.05, 0.95 and 0.975 levels. Several comments about the results are warranted. The first is that the two models with significant weight give similar predictions. There is more variance in the random parameters models, due it appears to the variation generated by the random parameter.

The expected profit per trip was reduced by $3,403 by the emergency closure, as shown in Table 13. Given that there were 1,060 trips taken during the emergency closure, the total predicted cost of the closure is $3.6 million.

Table 13: Expected loss per trip of 2000 SCA Emergency Closure

Expected profit or net revenue	$/Trip
Before SCAemergency closure	53,850
With SCA emergency closure	50,447
Net loss from closure	3,403
Percentage loss per trip	6.3%

5. Discussion and conclusions

It is clear that closing a portion of a fishery is costly, but it is difficult to make an *ex-ante* prediction of what the welfare impacts of a closure will be, particularly without direct knowledge of the costs of the fishery. Through the development of the expected profit model (EPM), we are able to do just this using a seasonal model. In Monte Carlo experiments presented in Appendix 2, we have shown the consistency and efficiency of the EPM. We estimate a per-trip cost of the emergency closure in summer 2000, and use a frequentist model-averaging framework to incorporate model variation into the welfare estimates. We examine predictions of different models and show, not surprisingly, that it is much more difficult to predict the outcome of a closure when we have little information about alternative areas.

The Bering Sea pollock fishery is a reasonably good empirical experiment for the EPM. The ideal fishery for the EPM would have several features. First, it would possess a number of discrete zones with differing fish densities and travel distances that are constant across time. Second, each zone would have an infinite population growth rate, so that any fishing in the area would have zero impact on the stock. Third, there would be little value of skipper-specific intellectual capital (e.g. knowledge of *the* best spots for fishing). In the pollock fishery there is limited value in skipper-specific intellectual capital and congestion does not have a significant effect on location choice, so the later two requirements are met. However, fish are moderately mobile throughout the fishery and are present in differing densities throughout time. As no fishery will perfectly fulfill all of the above requirements, we believe that given its characteristics the pollock fishery is a good empirical testing ground for this model.

Discrete zones have been criticized as being in some sense limiting, but when we begin the analysis with spatial catch data at the one minute scale of latitude and longitude, we can redraw boundaries of where zones begin and end and then utilize the EPM to evaluate the effect of any shape or size of closure. As part of our research we experimented with making the EPM *alpha* coefficients functions of latitude and longitude, but preliminary work has shown this to be challenging. This is an important avenue for future research.

In addition to the criticisms that the standard two-stage model may be biased and is certainly inefficient, there are additional problems with this model. First is the problem of how to handle zero values for a time period. When a moving average version of expected catch is utilized, there are typically many periods for which there are no values for a given zone. Authors have approached this differently, by assuming that the zonal average is a zero or is an average value. Holland and Sutinen (1999, 2000) conclude that there was not a clear choice, and used different methods in the two presentations of their work. A second significant problem is the standardization of average catch. A 100-ton catch is not the same for a small vessel as a large vessel, and there is not a clear method for standardizing catch for a trip. Further, in many fisheries we do not have a reliable knowledge of the number of days spent fishing on a given trip, which makes standardization per day of fishing infeasible.

With joint estimation, we are able to estimate not only the relative importance but the actual monetary value of one zone to another through observations of how we fishers trade off expected catch in a zone with the cost of going to that zone. One promising avenue of future research is to utilize the EPM in situations where fishery costs are known, as this will help to validate the cost predictions derived from our current EPM model.

Informal discussions with industry have indicated that the welfare losses predicted by this model appear to correspond reasonably well with the actual costs of the SCA emergency closure. However, some industry representatives have suggested that our estimates may be too low. Due to our confidence in the consistency of the EPM due to Monte Carlo work, we interpret the possible low cost estimates as likely being the result of intra-seasonal variation. The model presented in this paper is a seasonal model, so does not handle potentially predicable intra-seasonal variation. For the assessment of the impacts of a seasonal closure we believe that this is a reasonable simplification, but future work should explore the performance of the EPM with time variation and in fisheries (or other location choice environments) where there is not substantial intra-seasonal variation in site quality.

Typically with joint estimation, the primary modeling advantage is an increase in efficiency over a two-stage model. However in this case we find that there are issues of bias in the two-stage model so that the standard comparison of the EPM with its two-stage analog is not a test of the success of the model. The EPM and the zonal logit give similar predictions and a comparison of a rescaled EPM model with a zonal logit generates very similar relative weighting of expected return from zones, which we interpret as an indication of the relative consistency of the EPM.

Future research should incorporate predictable intra-seasonal variation, bycatch avoidance, and the winter roe season.

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Appendices

Two appendices are attached. Appendix 1 provides results from several additional models, both EPM and zonal logit. Appendix 2 provides a brief summary of Monte Carlo experiments that we conducted to compare the EPM to other models.

Appendix 1: Additional Model Results

The results of several additional models are presented here for comparison purposes. The results of the three "best" models, plus the most basic model, are presented in Table 8. Model descriptions are presented in Table 1. The particular versions of Model 5 results presented here are chosen because they are the 3 additional models with the most weight.

- Model 1 RP: miles only with random parameter on miles
- Model 2: miles^2 only
- Model 3.4: the best performing type 3 model
- Model 4.4: the best performing type 4 model
- Model 5: linear terms for all boat characteristics plus interactive terms—this model has a BIC weight of 1.3E-05.
- Model 5 RP: an RP version of the same model, with a BIC weight of 6.6E-07.
- Model 5.4 RP: linear terms for all boat characteristics except length, plus interactive terms – this model has a BIC weight of 0.0009.

At the bottom of each table the log-likelihood is disaggregated. 'ldcatch3' is the term $\exp\left[-\frac{1}{2}\left(\frac{Y_{i1} - \alpha_1}{\sigma_1}\right)^2\right]$ from Equation 5 in Section 2, while 'ldcatch' is the sum of the continuous portions of the likelihood and 'ldchoice' is the log-likelihood for the discrete portion of the likelihood function, Equation 5.

$$\ell_1 = \underbrace{\frac{1}{\sigma_1\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{Y_{i1} - \alpha_1}{\sigma_1}\right)^2\right]}_{continuous} \times \underbrace{\frac{e^{\left(\frac{P\,\alpha_1 - X_{i1}\,\beta}{\sigma_\varepsilon}\right)}}{\sum_{j=1}^{J} e^{\left(\frac{P\,\alpha_j - X_{ij}\,\beta}{\sigma_\varepsilon}\right)}}}_{discrete} \qquad (5)$$

Table 14: Model 1 RP

MODEL 1 RP: EPM						***MODEL 1 RP: Zonal Conditional Logit***		
	Estimate	SE	Est./SE			Estimate	SE	Est./SE
alpha1	0.17916	0.007749	23.12		Zone 1	**0**		
alpha2	0.20908	0.003796	55.081		zone 2	3.032	0.303	10.00
alpha3	0.18583	0.007148	25.997		zone 3	0.828	0.401	2.06
alpha4	0.18596	0.007338	25.342		zone 4	1.145	0.421	2.72
alpha5	0.17448	0.010197	17.111		zone 5	0.144	0.621	0.23
alpha6	0.21343	0.003549	60.136		zone 6	3.187	0.306	10.42
alpha7	0.16808	0.00943	17.825		zone 7	-1.134	0.503	-2.25
alpha8	0.22273	0.003894	57.2		zone 8	4.217	0.293	14.39
alpha9	0.20788	0.003799	54.714		zone 9	2.878	0.299	9.61
alpha10	0.19419	0.005651	34.363		zone 10	1.593	0.346	4.60
alpha11	0.18068	0.008291	21.794		zone 11	0.600	0.467	1.28
alpha12	0.14922	0.016042	9.3017		zone 12	-2.306	0.638	-3.61
alpha13	0.19144	0.005391	35.511		zone 13	1.038	0.335	3.10
alpha14	0.17091	0.010012	17.071		zone 14	-0.599	0.428	-1.40
alpha15	0.19358	0.005038	38.428		zone 15	1.185	0.324	3.66
alpha16	0.17969	0.007702	23.332		zone 16	0.178	0.399	0.45
alpha17	0.17793	0.008634	20.608		zone 17	0.231	0.447	0.52
alpha18	0.18409	0.007624	24.146		zone 18	0.903	0.445	2.03
alpha19	0.17645	0.009925	17.779		zone 19	0.384	0.585	0.66
alpha20	0.1706	0.009449	18.055		zone 20	-0.958	0.531	-1.80
alpha21	0.18336	0.007173	25.562		zone 21	0.416	0.396	1.05
alpha22	0.17822	0.008502	20.963		zone 22	0.235	0.469	0.50
mu	-4.0991	0.056713	-72.278		mu	0.269	0.171	1.58
s	0.88032	0.18786	4.686		s	-0.491	0.234	-2.10
sigmachoice	0.019549	0.003608	5.4189					
sigma1	0.14164	0.029222	4.8469		initial LL	-7001.2		
sigma2	0.11729	0.006391	18.352		LL	-3884.1		
sigma3	0.12571	0.023926	5.2539		pseudo F	0.445		
sigma4	0.16245	0.029621	5.4842					
sigma5	0.15637	0.043455	3.5985					
sigma6	0.20884	0.006417	32.544					
sigma7	-0.12832	0.040385	-3.1775					
sigma8	0.1458	0.003205	45.496					
sigma9	0.10463	0.00606	17.267					
sigma10	0.137	0.016571	8.2675					
sigma11	0.13037	0.031582	4.128					
sigma12	0.09399	0.04174	2.2518					
sigma13	0.33747	0.027019	12.49					
sigma14	0.38844	0.057271	6.7825					
sigma15	0.15328	0.014934	10.264					
sigma16	0.20239	0.039611	5.1095					
sigma17	0.081911	0.021467	3.8156					
sigma18	0.083031	0.017199	4.8277					
sigma19	0.17734	0.048103	3.6867					
sigma20	0.31056	0.097161	3.1964					
sigma21	0.16894	0.03327	5.0778					
sigma22	-0.0649180	0.016	-4.12					
- 0.5*ln(2*pi)	- ln(sigmaa)	ldcatch3**	ldcatch	ldchoice	ld			
-2081.4	4198.6	-1131.9	985.24	-3870	-2884.8			

Table 15: Model 2 EPM and Zonal Logit

MODEL 2: EPM					***MODEL 2: Zonal Conditional Logit***			
	Estimate	SE	Est./SE			Estimate	SE	Est./SE
alpha1	0.17315	0.013079	13.239		Zone 1	**0**		
alpha2	0.20692	0.004484	46.148		zone 2	3.031	0.280	10.83
alpha3	0.18167	0.011072	16.408		zone 3	0.883	0.383	2.30
alpha4	0.18459	0.010285	17.947		zone 4	1.313	0.385	3.41
alpha5	0.17634	0.014165	12.449		zone 5	0.488	0.584	0.84
alpha6	0.2167	0.003619	59.881		zone 6	3.356	0.296	11.34
alpha7	0.16369	0.01566	10.453		zone 7	-1.032	0.489	-2.11
alpha8	0.22393	0.004158	53.862		zone 8	4.262	0.268	15.89
alpha9	0.20554	0.004684	43.879		zone 9	2.871	0.275	10.44
alpha10	0.1905	0.008336	22.852		zone 10	1.618	0.324	5.00
alpha11	0.17798	0.012645	14.076		zone 11	0.745	0.443	1.68
alpha12	0.15656	0.018917	8.276		zone 12	-1.809	0.546	-3.31
alpha13	0.19406	0.006836	28.391		zone 13	1.283	0.324	3.96
alpha14	0.17663	0.011479	15.388		zone 14	-0.193	0.401	-0.48
alpha15	0.19159	0.007575	25.292		zone 15	1.256	0.300	4.19
alpha16	0.1737	0.013022	13.339		zone 16	0.179	0.387	0.46
alpha17	0.17187	0.014265	12.048		zone 17	0.259	0.438	0.59
alpha18	0.1819	0.010785	16.867		zone 18	1.056	0.419	2.52
alpha19	0.17831	0.012673	14.07		zone 19	0.749	0.561	1.34
alpha20	0.16423	0.01628	10.088		zone 20	-0.927	0.523	-1.77
alpha21	0.17783	0.011867	14.986		zone 21	0.419	0.386	1.08
alpha22	0.17307	0.013384	12.932		zone 22	0.291	0.432	0.67
miles	0.01223	0.014829	0.82471		miles	-0.772	0.532	-1.45
miles^2	-0.015291	0.008196	-1.8656		miles^2	-0.272	0.214	-1.27
sigmachoice	0.022141	0.006327	3.4998					
sigma1	0.14178	0.027931	5.076		initial LL	-7001.2		
sigma2	0.11639	0.005705	20.401		LL	-3883.6		
sigma3	0.12406	0.017025	7.2871		pseudo F	0.445		
sigma4	0.16112	0.028322	5.689					
sigma5	0.15507	0.054484	2.8461					
sigma6	0.20793	0.006144	33.845					
sigma7	-0.12898	0.045014	-2.8652					
sigma8	0.14577	0.003065	47.568					
sigma9	0.1036	0.00551	18.804					
sigma10	0.13759	0.01674	8.2193					
sigma11	-0.13163	0.029533	-4.4569					
sigma12	-0.10028	0.023418	-4.2821					
sigma13	0.33362	0.02518	13.249					
sigma14	0.39022	0.056353	6.9245					
sigma15	0.15392	0.014777	10.416					
sigma16	-0.2043	0.040133	-5.0906					
sigma17	-0.078959	0.018375	-4.2971					
sigma18	-0.084212	0.015514	-5.428					
sigma19	-0.17757	0.056267	-3.1559					
sigma20	0.31265	0.067866	4.6069					
sigma21	0.17132	0.032845	5.2161					
sigma22	-0.0674610	0.021	-3.21					
- 0.5*ln(2*pi)	- ln(sigmaa)	ldcatch3**	ldcatch	ldchoice	ld			
-2081.4	4204.2	-1132.5	990.33	-3872.5	-2882.1			

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Table 16: Model 3.4 EPM and Zonal Logit

MODEL 3.4: EPM					***MODEL 3.4: Zonal Conditional Logit***		
	Estimate	SE	Est./SE			Estimate	SE
alpha1	0.19445	0.002925	66.478		Zone 1	**0**	
alpha2	0.21225	0.001389	152.78		zone 2	3.099	0.312
alpha3	0.19902	0.002157	92.272		zone 3	0.932	2.669
alpha4	0.19903	0.002585	76.983		zone 4	1.261	0.362
alpha5	0.19241	0.004481	42.943		zone 5	0.250	12.850
alpha6	0.21382	0.00149	143.49		zone 6	3.017	0.072
alpha7	0.18767	0.003569	52.582		zone 7	-1.238	1.098
alpha8	0.21941	0.001658	132.3		zone 8	4.147	0.406
alpha9	0.21116	0.001362	154.99		zone 9	2.882	0.312
alpha10	0.20338	0.001293	157.3		zone 10	1.654	0.211
alpha11	0.19572	0.002966	65.993		zone 11	0.689	0.374
alpha12	0.17816	0.004746	37.535		zone 12	-2.810	0.497
alpha13	0.20077	0.001559	128.8		zone 13	0.742	0.158
alpha14	0.1894	0.002638	71.809		zone 14	-1.043	0.331
alpha15	0.20222	0.001468	137.71		zone 15	1.057	0.141
alpha16	0.19455	0.002516	77.32		zone 16	0.154	0.301
alpha17	0.1941	0.002998	64.742		zone 17	0.275	0.360
alpha18	0.19745	0.002708	72.926		zone 18	0.978	0.404
alpha19	0.19334	0.004256	45.433		zone 19	0.457	0.530
alpha20	0.18901	0.003445	54.871		zone 20	-1.049	0.984
alpha21	0.19667	0.001997	98.482		zone 21	0.406	2.196
alpha22	0.1937	0.003566	54.323		zone 22	0.279	0.385
miles	0.061688	0.01363	4.526		miles	4.975	1.319
tons*miles	-0.013124	0.003824	-3.4319		tons*miles	-1.216	0.273
HP*miles	-0.0069151	0.003076	-2.2484		HP*miles	-0.608	0.236
age*miles	-0.056269	0.013603	-4.1364		age*miles	-4.924	0.389
sigmachoice	0.011318	0.000919	12.317				
sigma1	0.1432	0.031132	4.5997		initial LL	-7001.2	
sigma2	0.11865	0.005071	23.398		LL	-3813.5	
sigma3	0.13127	0.020251	6.4821		pseudo R	0.455	
sigma4	0.15691	0.021688	7.235				
sigma5	0.14148	0.064461	2.1948				
sigma6	-0.20875	0.00644	-32.413				
sigma7	-0.12787	0.033285	-3.8417				
sigma8	-0.14592	0.00389	-37.516				
sigma9	0.10597	0.005094	20.805				
sigma10	-0.13555	0.018248	-7.4282				
sigma11	0.12088	0.034352	3.5189				
sigma12	0.1193	0.039291	3.0362				
sigma13	0.33022	0.034999	9.4352				
sigma14	0.38255	0.076659	4.9903				
sigma15	0.15084	0.014985	10.066				
sigma16	0.19957	0.044645	4.4701				
sigma17	0.091875	0.02066	4.4471				
sigma18	0.075704	0.018608	4.0684				
sigma19	0.16936	0.044883	3.7734				
sigma20	0.30214	0.030303	9.9709				
sigma21	0.16198	0.029578	5.4763				
sigma22	0.058855	0.016633	3.5383				
- 0.5*ln(2*pi)	- ln(sigmaa)	ldcatch3**	ldcatch	ldchoice	ld		
-2081.4	4198.5	-1132.5	984.55	-3803.3	-2818.8		

Table 17: Model 4.4 EPM and Zonal Logit

MODEL 4.4: EPM					***MODEL 4.4: Zonal Conditional Logit***			
	Estimate	SE	Est./SE			Estimate	SE	Est./SE
alpha1	0.18441	0.007659	24.077		Zone 1	**0**		
alpha2	0.20964	0.003604	58.164		zone 2	3.067	0.194	15.85
alpha3	0.18995	0.006725	28.247		zone 3	0.860	0.334	2.57
alpha4	0.19034	0.006832	27.86		zone 4	1.140	0.347	3.28
alpha5	0.1816	0.009654	18.811		zone 5	0.070	0.562	0.12
alpha6	0.21488	0.003243	66.257		zone 6	3.026	0.116	26.17
alpha7	0.17604	0.009438	18.652		zone 7	-1.224	0.428	-2.86
alpha8	0.22176	0.003101	71.526		zone 8	4.159	0.056	74.08
alpha9	0.20862	0.003706	56.288		zone 9	2.877	0.148	19.44
alpha10	0.19673	0.00539	36.502		zone 10	1.611	0.263	6.13
alpha11	0.18563	0.007894	23.516		zone 11	0.590	0.420	1.40
alpha12	0.16489	0.012154	13.567		zone 12	-2.852	0.602	-4.74
alpha13	0.19639	0.005373	36.551		zone 13	0.736	0.160	4.60
alpha14	0.18096	0.008104	22.328		zone 14	-1.074	0.360	-2.98
alpha15	0.19693	0.005187	37.965		zone 15	1.067	0.178	6.00
alpha16	0.18456	0.007585	24.331		zone 16	0.155	0.294	0.53
alpha17	0.18301	0.008369	21.869		zone 17	0.240	0.437	0.55
alpha18	0.18844	0.007164	26.302		zone 18	0.887	0.365	2.43
alpha19	0.1831	0.009214	19.872		zone 19	0.300	0.524	0.57
alpha20	0.17694	0.009406	18.81		zone 20	-1.042	0.481	-2.17
alpha21	0.1875	0.007015	26.727		zone 21	0.400	0.295	1.35
alpha22	0.18305	0.008166	22.415		zone 22	0.236	0.409	0.58
miles	-0.48966	0.028519	-17.17		miles	-25.896	1.160	-22.32
milesSQ	-0.0069644	0.004613	-1.5098		milesSQ	0.031	0.235	0.13
tons*miles	-0.012108	0.017293	-0.70016		tons*miles	-0.842	1.327	-0.63
tonsSQ*miles	-0.0014425	0.006949	-0.20758		tonsSQ*miles	-0.070	0.616	-0.11
HP*miles	-0.044549	0.011057	-4.0292		HP*miles	-2.730	0.629	-4.34
HPSQ*miles	0.010043	0.002994	3.3547		HPSQ*miles	0.615	0.210	2.93
age*miles	1.1593	0.043705	26.525		age*miles	59.598	2.632	22.65
ageSQ*miles	-0.62612	0.0328	-19.089		ageSQ*miles	-32.531	1.936	-16.81
sigmachoice	0.016568	0.003111	5.3267					
sigma1	0.14213	0.029037	4.895		initial LL	-7001.2		
sigma2	0.11753	0.00625	18.803		LL	-3798.8		
sigma3	0.1273	0.023237	5.4784		pseudo R	0.457		
sigma4	0.15929	0.030996	5.1391					
sigma5	0.15057	0.054934	2.7409					
sigma6	0.20844	0.006397	32.582					
sigma7	0.12789	0.037532	3.4076					
sigma8	0.14583	0.003201	45.55					
sigma9	0.10487	0.005592	18.754					
sigma10	0.13644	0.016553	8.2429					
sigma11	-0.12681	0.030341	-4.1794					
sigma12	0.10744	0.036012	2.9835					
sigma13	0.33241	0.032485	10.233					
sigma14	0.38752	0.067724	5.7221					
sigma15	-0.15229	0.01489	-10.228					
sigma16	0.20155	0.040898	4.9282					
sigma17	0.084962	0.019454	4.3673					
sigma18	0.080384	0.017362	4.6298					
sigma19	-0.17491	0.062949	-2.7787					
sigma20	0.30674	0.10006	3.0656					
sigma21	0.16634	0.034011	4.8909					
sigma22	0.0626070	0.017	3.61					
- 0.5*ln(2*pi)	- ln(sigmaa)	ldcatch3**	ldcatch	ldchoice	ld			
-2081.4	4201	-1132.5	987.06	-3788.3	-2801.2			

Table 18: Model 5 EPM and Zonal Logit

MODEL 5: EPM						*MODEL 5: Zonal Conditional Logit*			
	Estimate	SE	Est./SE			Estimate	SE	Est./SE	
alpha1	0.18788	0.011963	15.705		Zone 1	**0**			
alpha2	0.20835	0.004134	50.397		zone 2	3.022	0.294	10.29	
alpha3	0.19067	0.010729	17.772		zone 3	0.785	1.671	0.47	
alpha4	0.19015	0.011255	16.895		zone 4	1.048	0.472	2.22	
alpha5	0.18256	0.015631	11.679		zone 5	-0.030	1.113	-0.03	
alpha6	0.21299	0.003329	63.985		zone 6	3.069	0.303	10.14	
alpha7	0.1834	0.014936	12.28		zone 7	-1.177	2.384	-0.49	
alpha8	0.21911	0.003989	54.928		zone 8	4.193	0.285	14.70	
alpha9	0.20826	0.004251	48.994		zone 9	2.870	0.292	9.81	
alpha10	0.19818	0.008033	24.671		zone 10	1.557	0.332	4.68	
alpha11	0.1881	0.012628	14.895		zone 11	0.505	0.466	1.08	
alpha12	0.16564	0.023433	7.0687		zone 12	-3.134	0.613	-5.12	
alpha13	0.19787	0.008235	24.029		zone 13	0.717	0.328	2.18	
alpha14	0.18419	0.01446	12.737		zone 14	-1.255	0.406	-3.09	
alpha15	0.19973	0.007494	26.652		zone 15	1.110	0.316	3.51	
alpha16	0.18947	0.012042	15.734		zone 16	0.161	0.398	0.40	
alpha17	0.18349	0.013544	13.548		zone 17	0.194	1.162	0.17	
alpha18	0.18904	0.012072	15.659		zone 18	0.805	1.410	0.57	
alpha19	0.18486	0.014637	12.63		zone 19	0.200	1.232	0.16	
alpha20	0.18009	0.014935	12.058		zone 20	-1.009	38.008	-0.03	
alpha21	0.19029	0.010996	17.305		zone 21	0.392	0.899	0.44	
alpha22	0.18629	0.013021	14.307		zone 22	0.183	1.165	0.16	
miles	-0.34738	0.17293	-2.0087		miles	-20.062	1.171	-17.13	
tons	-0.12777	0.10417	-1.2266		tons	-9.427	5.055	-1.86	
HP	0.3129	0.16419	1.9057		HP	22.904	0.813	28.18	
length	0.32909	0.16474	1.9976		length	18.679	0.362	51.57	
age	0.39732	0.22704	1.75		age	21.699	3.024	7.18	
tons*HP	0.015367	0.01087	1.4138		tons*HP	1.345	0.466	2.89	
tons*len	-0.01381	0.027179	-0.50812		tons*len	-0.308	0.078	-3.95	
tons*age	0.11781	0.08912	1.3219		tons*age	7.757	4.280	1.81	
HP*len	-0.064116	0.037358	-1.7162		HP*len	-4.623	0.853	-5.42	
HP*age	-0.26963	0.14416	-1.8704		HP*age	-20.427	2.206	-9.26	
len*age	-0.35817	0.21284	-1.6828		len*age	-19.054	3.832	-4.97	
sigmachoice	0.013344	0.006087	2.1922						
sigma1	0.18797	0.025161	7.4706		initial LL	-7001.2			
sigma2	0.11708	0.005707	20.514		LL	-3763.3			
sigma3	-0.13562	0.021979	-6.1704		pseudo R	0.462			
sigma4	-0.16451	0.03053	-5.3884						
sigma5	-0.56796	0.007808	-72.739						
sigma6	-0.20793	0.006407	-32.452						
sigma7	0.096429	0.035186	2.7405						
sigma8	-0.14567	0.003207	-45.426						
sigma9	0.10676	0.005127	20.825						
sigma10	0.13276	0.016848	7.8799						
sigma11	0.11697	0.035105	3.3321						
sigma12	0.58318	0.024531	23.774						
sigma13	-0.33277	0.032188	-10.338						
sigma14	0.39425	0.063279	6.2303						
sigma15	-0.15079	0.015868	-9.5026						
sigma16	0.18131	0.040078	4.5238						
sigma17	0.088711	0.01744	5.0866						
sigma18	0.09557	0.064467	1.4825						
sigma19	0.19155	0.054246	3.5312						
sigma20	0.38465	0.09823	3.9158						
sigma21	0.17957	0.034276	5.2388						
sigma22	0.0886730	0.016	5.60						
- 0.5*ln(2*pi)	- ln(sigmaa)	ldcatch3**	ldcatch	ldchoice	ld				
-2081.4	4180.9	-1124.1	975.46	-3759.7	-2784.3				

Table 19: Model 5.4 EPM and Zonal Logit

MODEL 5.4 RP: EPM					*MODEL 5.4 RP: Zonal Conditional Logit*			
	Estimate	SE	Est./SE			Estimate	SE	Est./SE
alpha1	0.195	0.0048	40.26		Zone 1	**0**		
alpha2	0.212	0.0030	69.65		zone 2	2.979	0.298	9.99
alpha3	0.197	0.0044	45.32		zone 3	0.662	0.656	1.01
alpha4	0.196	0.0049	39.87		zone 4	0.790	0.470	1.68
alpha5	0.187	0.0074	25.11		zone 5	-0.486	0.733	-0.66
alpha6	0.214	0.0031	68.92		zone 6	3.021	0.303	9.98
alpha7	0.188	0.0059	31.89		zone 7	-1.197	0.502	-2.38
alpha8	0.220	0.0035	63.51		zone 8	4.193	0.286	14.64
alpha9	0.211	0.0030	69.68		zone 9	2.867	0.293	9.80
alpha10	0.202	0.0038	53.96		zone 10	1.486	0.348	4.27
alpha11	0.193	0.0054	36.03		zone 11	0.298	0.498	0.60
alpha12	0.175	0.0092	18.99		zone 12	-3.373	0.659	-5.12
alpha13	0.200	0.0038	52.86		zone 13	0.622	0.338	1.84
alpha14	0.187	0.0058	32.53		zone 14	-1.444	0.448	-3.22
alpha15	0.203	0.0035	57.55		zone 15	1.099	0.319	3.44
alpha16	0.195	0.0048	40.55		zone 16	0.159	0.400	0.40
alpha17	0.193	0.0056	34.26		zone 17	0.127	0.475	0.27
alpha18	0.195	0.0050	38.63		zone 18	0.599	0.469	1.28
alpha19	0.189	0.0071	26.63		zone 19	-0.212	0.683	-0.31
alpha20	0.190	0.0062	30.62		zone 20	-1.016	0.529	-1.92
alpha21	0.197	0.0047	42.09		zone 21	0.368	0.406	0.91
alpha22	0.192	0.0054	35.45		zone 22	0.076	0.518	0.15
tons	-0.112	0.0815	-1.38		tons	10.097	5.066	1.99
HP	0.282	0.0888	3.18		HP	-23.828	4.344	-5.48
length	0.231	0.0392	5.90		age	-19.603	1.744	-11.24
age	0.257	0.1049	2.45		length	-23.218	5.243	-4.43
tons*HP	0.014	0.0093	1.46		tons*HP	-1.393	0.586	-2.38
tons*len	-0.001	0.0259	-0.05		tons*len	0.288	1.551	0.19
tons*age	0.093	0.0705	1.32		tons*age	-8.325	4.431	-1.88
HP*len	-0.055	0.0260	-2.10		HP*len	4.864	1.558	3.12
HP*age	-0.249	0.0803	-3.10		HP*age	21.150	3.657	5.78
len*age	-0.231	0.1068	-2.16		len*age	20.483	5.541	3.70
mu	-1.422	0.1441	-9.87		mu	3.047	0.054	56.55
s	0.045	0.0180	2.47		s	0.042	0.023	1.79
sigmachoice	0.011	0.0023	4.83					
sigma1	0.143	0.0253	5.67		initial LL	-7001.2		
sigma2	0.118	0.0054	22.06		LL	-3762.6		
sigma3	-0.130	0.0233	-5.59		pseudo R	0.463		
sigma4	-0.158	0.0266	-5.94					
sigma5	-0.146	0.0591	-2.47					
sigma6	-0.209	0.0065	-32.15					
sigma7	0.128	0.0331	3.86					
sigma8	-0.146	0.0031	-47.27					
sigma9	0.106	0.0044	24.16					
sigma10	0.136	0.0171	7.95					
sigma11	0.122	0.0326	3.75					
sigma12	0.116	0.0285	4.08					
sigma13	-0.330	0.0297	-11.12					
sigma14	0.384	0.0648	5.92					
sigma15	-0.151	0.0155	-9.74					
sigma16	0.200	0.0335	5.95					
sigma17	0.091	0.0171	5.35					
sigma18	0.077	0.0191	4.02					
sigma19	0.172	0.0651	2.64					
sigma20	0.301	0.0925	3.26					
sigma21	0.162	0.0360	4.50					
sigma22	0.059	0.0177	3.35					
- 0.5*ln(2*pi)	- ln(sigmaa)	ldcatch3**	ldcatch	ldchoice	ld			
-2081.4	4198.6	-1132.5	984.74	-3750.6	-2765.9			

Appendix 2: Monte Carlo Experimental Design and Results

In order to assess the efficiency of the expected profit model, we designed a series of Monte Carlo experiments to assess how the EPM performed in comparison to two benchmark models. Key parameters are adjusted, as described in the experimental design section, below. These experiments allow us to test how easily the EPM can be estimated using data that are known before the EPM is used with empirical data from the pollock fishery. These simulations are intended to evaluate how well the models predict location choice.

A2.1 Design of Models

In these simulations we compare the performance of three models. The first model is the EPM defined above. In addition, we run simulations using a conditional logit model with area-specific constants, and a two-stage expected catch model. In all three models, we normalize prices equal to 1. Details of the three models are presented below.

- *Expected Profit Model.* The form of the EPM is as described in the body of the paper. For the Monte Carlo experiments, the $\beta's$ consist of two parameters that vary by zone (e.g. mileage and weather).
- *"Basic" zonal conditional logit model.* This model consists of area-specific constants (c_j) for each zone (relative to a "base" zone) plus two β parameters that vary by zone. To be more explicit, we create dummy variables (c_j) for each of the zones. No variances are estimated here.

  $$E(\pi_{ij}) = c_j + X_{ij}\beta + \varepsilon_{ij} \tag{13}$$

- *Two-Stage Expected Catch Model.* As in the other models, this model includes two β parameters that vary by zone plus an estimated parameter (γ) on the average revenue per zone calculated in the first stage of the model (Z_j). No variances are estimated in this model.

  $$E(\pi_{ij}) = X_{ij}\beta + Z_j\gamma + \varepsilon_{ij} \tag{14}$$

A2.2 Experimental Design

The experimental design consists of running 8 different scenarios. All of the scenarios share the following characteristics:

- 8 zones

- 1000 runs
- 1000 trips
- Betas = [-2, 1]

The 8 different scenarios were created using permutations of the following parameters[47]:

- α's (the zone-specific means): "close" or "far"
    - α -close = [3.1, 3.15, 3.2, 3.25, 3.3, 3.35, 3.4, 3.5]
    - α -far = [2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5]
- σ_ε: 0.5 or 2.00.
- σ_j's: "narrow" or "wide"
    - σ_j - narrow = [0.1, 1, 1,1,1,1,1, 2]
    - σ_j - wide = [0.1, 0.5, 1, 1.5, 2, 2.5, 3, 3.1]

Note that these parameters yield very different sets of choice probabilities, and thus the model is evaluated across a wide range of feasible environments.

A2.3 Qualitative results of Monte Carlo experiments

As can be seen in Table 20, in 6 of 8 of the scenarios, the EPM predicts the chosen zone better than the zonal conditional logit or the standard two-stage expected catch model. In 5 of the 8 scenarios, the MSE of the catch[48] is smallest for the EPM. As can be seen in Appendix 3, the standard errors for the estimates of the expected profit model are lower than the coefficient estimates in either of the alternative models. As can be seen in Table 20, the EPM performs better in the simulations with

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[47] Actually, in addition to the core models, we altered the number of zones and the number of trips per run. The impact of the change in zones was not significant, but the number of trips per run was important. When we reduced the number of trips to 500, the betas were not estimated to scale for the models with "close" alphas. This lead to a smaller number of correct predictions, but interestingly did not change the rankings of MSEs. When we increased the number of observations to 2500, the EPM performed better relative to the other models, but with significant additional simulation time.

[48] The squared difference of the actual from the predicted catch.

σ_{ε} = 0.5 than with σ_{ε}=2.0. In terms of the number of correct predictions, the two-stage model is the worst performer; in terms of MSE, the zonal conditional logit is the worst performer.

Table 20: Summary Results from 8 simulations

					Ranking of # of Correct Predictions			Ranking of MSE		
Name	Zones	Alphas	Sigmacatch	SigmaChoice	Exp Profit	Cond Logit	2-Step Avg Catch	Exp Profit	Cond Logit	2-Step Avg Catch
Model 1	8	close	narrow	0.50	1	2	3	1	3	2
Model 2	8	close	wide	0.50	1	2	3	1	3	2
Model 3	8	far	narrow	0.50	1	2	3	1	2	3
Model 4	8	far	wide	0.50	1	2	3	1	2	3
Model 5	8	close	narrow	2.00	1	3	2	1	1	1
Model 6	8	close	wide	2.00	2	3	1	3	2	1
Model 7	8	far	narrow	2.00	2	3	1	2	3	1
Model 8	8	far	wide	2.00	1	2	3	2	3	1

Figure 4 displays the number of correct predictions for each run by the EPM minus the number of correct predictions for the standard two-stage model. The mean difference between the number of correct predictions is positive, but not large, equaling 8/1000. However the bulk of the mass in the figure is clearly to the right of zero (as indicated by the dotted line on the figure), implying that the EPM is more likely to be correct. Importantly, it is much less likely to be significantly wrong.

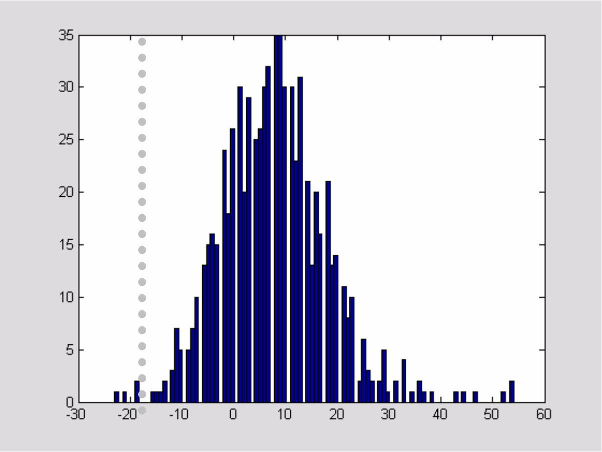

Figure 4: Difference in # of Correct Predictions (EPM – TSEC) for each model run

The Monte Carlo results show that with generated data the EPM generally performs better than the alternatives, although the improvement is not by itself exceptional. One issue raised by this model is that it is in some sense more complicated than the standard approach— it is a more involved model with considerably more parameters to estimate. This is an issue to be aware of in empirical work, but so far the EPM has proven to be reasonably easy to estimate and the improved information usage in the model has translated into increased efficiency.

A number of steps were taken to test the robustness of the models. With a non-linear function, there is no guarantee that the solution is a global maximum. We ran the EPM with a wide range of starting values, and always had convergence to the same values. One issue that arises in some models is that some of the beta coefficients will be in the right ratio but the mean of the runs will be improperly scaled. In order to evaluate the scaling issues in some of the Monte Carlo models, we trimmed the means and found that the means do converge to the correct values. The models are always consistent in the median, and this scaling problem does not eliminate the predictive advantage of the EPM.

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Robust Experimental Designs for Economic Valuation Choice Experiments[♦][♠]

Daniel K. Lew[*]
Alaska Fisheries Science Center
NOAA Fisheries

David F. Layton
Daniel J. Evans School of Public Affairs
University of Washington

Robert D. Rowe
Stratus Consulting

June 28, 2006

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ABSTRACT

A method for incorporating model and parameter uncertainty into experimental designs for choice experiments is developed. The approach combines recent innovations in choice-based experimental design that explicitly assume utility parameters are unknown but with a known distribution with model averaging techniques to incorporate prior information about correct model specification. Monte Carlo methods are used to illustrate how the approach compares with standard D-efficiency based design methods.

[♦] The views and opinions expressed in this paper are the authors' own, and do not necessarily reflect those of the National Oceanic and Atmospheric Administration or the U.S. Department of Commerce. This is a draft paper and should not be circulated without permission from the authors.

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[*] Presenter; Alaska Fisheries Science Center, Bldg 4, 7600 Sand Point Way NE, Seattle, WA 98115-0070; (206) 526-4252; Dan.Lew@noaa.gov.

Introduction

Survey-based choice experiments, which involve respondents choosing between alternatives that differ in attributes, have been used primarily in the marketing literature to understand consumer preferences for market goods. In recent years, however, their usefulness for gaining insights into preferences for non-market goods has become apparent, and stated preference researchers are increasingly turning to choice experiments to value public goods (Alpizar, Carlsson, and Martinsson, 2001).[49]

In constructing choice experiment questions, researchers must determine the set of attributes and attribute levels that respondents see in each question. This is a critical judgment, as a poor experimental design can preclude estimating important marginal effects, or conversely, a good design can significantly increase the precision of estimated parameters or provide justification for reducing the sample size. The latter is particularly important in light of how expensive carefully-constructed and tested stated preference surveys are.

Researchers commonly evaluate the experimental design based on efficiency criteria. Most commonly, linear-in-parameters utility specifications and a D-efficiency criterion related to the determinant of the information matrix are used to determine the most efficient design (see, for example, Bunch, Louviere, and Anderson [1996]). In choice experiments, which often employ logit modeling approaches, efficiency-based measures are dependent upon the utility

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[49] Adamowicz, Louviere, and Williams (1994) were the first to apply choice experiments to valuing public goods in a study of recreational opportunities in Canada. Since then, several studies have used choice experiment approaches to estimate use values for activities like hunting (Adamowicz, et al., 1997) and climbing (Hanley, Wright, and Koop, 2002). Wielgus, et al. (2003) used a choice experiment approach to value damage to coral reefs used by recreational divers in Israel. Choice experiments have also been used to estimate non-consumptive use values associated with forests in the United Kingdom (Hanley, Wright, and Adamowicz, 1998), forest loss due to global climate change (Layton and Brown, 2000) and Woodland caribou habitat in Canada (Adamowicz, et al., 1998). Tsuge, Kishimoto, and Takeuchi (2005) applied choice experiment methods to the valuation of mortality risk in Japan.

parameters; however, utility parameters are often assumed to be zero in constructing the experimental design. Huber and Zwerina (1996) point out that the assumption of a zero coefficient vector is overly restrictive and note that researchers frequently have some prior information about coefficients that can be employed in generating the experimental design.

Recognizing that the true utility coefficients are unknown, Sandor and Wedel (2001) proposed developing choice-based experimental designs using an approach that incorporates parameter uncertainty by explicitly evaluating the design efficiency over a distribution of parameter values. The resulting experimental design is efficient over a range of preferences for a specific utility specification. Still, if the utility is specified incorrectly, the experimental design will not be truly efficient. This misspecification can be mitigated by incorporating researcher uncertainty about the true form of utility.

In this paper, we propose an approach for selecting experimental designs that are robust to uncertainties in certain model selection decisions and parameter estimates. The approach involves applying model averaging to the evaluation of designs (Hoeting, et al., 1999). Model averaging is a technique for acknowledging researcher uncertainty regarding the true underlying model. To date, most applications have used model averaging to introduce model uncertainty into parametric model estimates and results (e.g., Koop and Tole [2004] and Layton and Lee [2006]). To our knowledge, model averaging has not been applied to choice-based experimental designs.

We apply frequentist (as opposed to Bayesian) model averaging principles to choice-based experimental design construction (Buckland, Burnham, and Augustin, 1997). The efficiency-based objective function used to select the design is weighted to account for the probability that each of several competing utility specifications correctly explains respondent choices. Additionally, following Sandor and Wedel (2001), the prior parameter estimates are assumed stochastic, thus requiring us to evaluate the design efficiency over a distribution of parameter values. In this way, the “robust” experimental design, which is chosen to maximize statistical efficiency, incorporates both model and parameter uncertainty.

Monte Carlo methods are used to illustrate how experimental designs that incorporate model and parameter uncertainty perform in estimating underlying preferences compared to experimental designs chosen based on standard efficiency-based approaches. As expected, the results suggest that the choice-based experimental design that accounts for both types of uncertainty generally performs well in estimating the true preferences, sometimes outperforming designs that were constructed by correctly assuming the true model. However, in this application efficient designs not accounting for parameter or model uncertainty sometimes outperformed the designs that accounted for uncertainty when the true utility was closely approximated in the development of the design. These mixed results suggest the robust experimental design approach may not be clearly better than other efficiency-based designs in all cases, and further research is needed to understand in which situations researchers would benefit from employing the robust experimental design approach.

Experimental Design Strategies for Multinomial Logit Models

A variety of options are available to researchers for choosing an experimental design for choice experiments. Full factorial designs include all possible combinations of attribute levels and have useful statistical properties for linear models (Louviere, Hensher, and Swait, 2000). However, full factorial designs are almost always too large to feasibly implement, both from a cost and logistical perspective. For example, in a choice experiment with three choices each with three 3-level attributes, there are a total of $3^3 \times 3^3 \times 3^3 = 19{,}683$ possible choice sets, which would be too large of a design to implement in virtually any study. As a result, experimental designs are usually fractional factorial designs, designs that use a subset of the full factorial design. Although fractional factorial designs based on orthogonal arrays have been used frequently in the past (e.g., Adamowicz, Louviere, and Williams [1994] and Lusk and Schroeder [2004]),[50] experimental designs chosen to maximize statistical efficiency are increasingly common. In part, this is due to the availability of software to construct such designs (Kuhfeld, 2003), but also reflects the growing acknowledgment that orthogonal designs are not always appropriate for choice experiments since choice models are non-linear.[51]

To develop an efficient choice experimental design, one must determine the model with which to analyze the data. In this case, a multinomial logit (MNL) model is employed because of its frequent use in analyzing choice-based stated preference data in the literature. Suppose the individual chooses the *j*th alternative ($j = 1,\ldots,J$) in the *n*th choice set ($n = 1,\ldots,N$), which is described by $\boldsymbol{x}_{jn}$, a $K\times 1$ vector of attribute levels. Assuming linear indirect utility and a Type I extreme value (TEV), or Gumbel, error, the probability of observing this choice is

$$\mathrm{P}_{jn} = \frac{\exp(\beta' x_{jn})}{\sum_{i=1}^{J} \exp(\beta' x_{in})}. \tag{1}$$

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[50] Louviere, Hensher, and Swait (2000) and Lusk and Norwood (2005) review several strategies for selecting manageably-sized choice-based experimental designs that do not explicitly optimize efficiency.

[51] Still, researchers often need to balance efficiency considerations with other practical considerations related to experimental design construction, such as the complexity of the choice experiment and realism of the choices. Overly complicated experimental designs, such as those with too many attributes, or asking a respondent to answer too many choice questions, can lead to respondent fatigue and low response rates.

In developing efficient choice-based experimental designs, it is useful to analyze differences in the information matrix associated with the choice models. McFadden (1974) showed that the coefficient covariance matrix associated with the conditional logit model is

$$\Omega^{-1} = (Z'PZ)^{-1} = \left(\sum_{n=1}^{N} \sum_{j=1}^{J} z_{jn}' P_{jn} z_{jn} \right)^{-1}, \tag{2}$$

where Z is a $(J \times N) \times K$ matrix composed of elements $z_{jn} = x_{jn} - \sum_{i=1}^{J} x_{in} \cdot P_{in}$, and P is a $(J \times N) \times (J \times N)$ diagonal matrix of probabilities. Note that when $\beta = 0$, equation (2) reduces to

$$\Omega^{-1} = \left(\sum_{n=1}^{N} \frac{1}{J} \cdot \sum_{j=1}^{J} z_{jn}' z_{jn} \right)^{-1} \qquad \text{where } z_{jn} = x_{jn} - \frac{1}{J} \sum_{i=1}^{J} x_{in} . \tag{3}$$

Several measures of efficiency can be obtained from the Fisher information matrix, Ω. Perhaps the most common efficiency measure used to evaluate experimental designs is D-error, which is based on the determinant of the information matrix (Kuhfeld, Tobias, and Garratt, 1994). Two useful one-dimensional measures that are scaled by the dimension of the design are D_0-error and D_p-error:

$$D_0\text{-error} = |\Omega_0|^{-1/K} \tag{4}$$

$$D_p\text{-error} = |\Omega_\beta|^{-1/K}, \tag{5}$$

where the 0 subscript on the information matrix denotes the information matrix evaluated at a zero parameter vector and the β subscript denotes an information matrix using a non-zero parameter vector. Note that these efficiency measures rely on the researcher's assumption about the true parameter values, which are unknown.

To account for the uncertainty surrounding the true parameter values, it is useful to consider evaluating efficiency of designs over a distribution of coefficient vectors. This approach is more realistic in that we will never know the true population preferences beforehand (or even after), though we might have an idea about the likely distribution of those preferences. This in essence is the Bayesian approach suggested by Sandor and Wedel (2001). In the approach, they assume a prior distribution of likely parameter values and optimize the experimental design over the distribution. Specifically, assuming the coefficient vector β follows a distribution $f(\beta)$, the expected value of the D_p-error over this distribution (denoted D_b-error) is

$$D_b\text{-error} = \int_{\mathbf{R}^K} \left|\Omega_\beta\right|^{-1/K} f\left(\beta\right) d\beta . \tag{6}$$

For a set of R coefficient vectors drawn from $f(\cdot)$, the D_b-error can be approximated by (6′):

$$D_b\text{-error} = \frac{1}{R} \cdot \sum_{r=1}^{R} \left|\Omega_{\beta_r}\right|^{-1/K} . \tag{6′}$$

Sandor and Wedel compared designs with the smallest D_b-error to those with the smallest D_p-error and found using Monte Carlo methods that designs that minimize the D_b-error are increasingly more efficient (and require fewer observations) than standard designs that minimize D_p-error as uncertainty about the true parameter values increases. In their marketing application, Sandor and Wedel used subjective input from a panel of marketing managers to infer a likely distribution of parameter values. However, for the valuation of environmental public goods, input from focus groups and other pretesting activities may be more informative than subjective expert beliefs. However, as will be discussed in the next section, parameter uncertainty is only one type of uncertainty that may affect the efficiency of the experimental design.

Before proceeding, it is important to clarify what is meant by an "efficient" design in this paper. An efficient design is an experimental design that is locally statistically efficient by the D-efficiency criterion for the selected choice model (multinomial logit model). Other statistical efficiency criteria are sometimes used to summarize the error information in the Fisher information matrix (e.g., A-efficiency and G-efficiency), but since D-efficiency is most commonly used by researchers, we stick to this convention. The efficient designs are only locally efficient since we restrict the designs to specific numbers of attributes and levels, and the selection algorithm is unable to cover the entire design space. However, globally efficient designs are possible under certain conditions. For instance, Kanninen (2002) showed it is possible to determine a globally efficient design using a numerical optimization method for a main effects MNL when all attributes are continuous and all effects are linear. The optimal design in this case is composed of attributes with two levels set at the extremes of the design space. In the following, we pursue constructing an experimental design that has a mix of continuous and categorical variables, and therefore cannot apply the approach of Kanninen.

Incorporating Model Uncertainty into Experimental Designs

D-efficient designs always assume an underlying utility specification. A critical judgment researchers must make when analyzing choice experiment data is how to specify utility. The simplest models are linear in parameters and attributes that ignore any alternative-specific effects or interactions between variables. Often, researchers will estimate a suite of utility specifications that differ in the variables used. This researcher model uncertainty may result from not knowing the true functional form, whether alternative specific constants will be needed to explain differences in choice responses, or whether certain variables interact with other variables to affect utility or other functional form uncertainty.

Researchers will often estimate a main effects model and one with main effects and interactions to determine whether the interaction effects are statistically significant. Among the considerations that should be kept in mind in determining an appropriate experimental design in this example are the following: First, researchers want to ensure the experimental design is constructed to allow identification of these interaction effects and efficient estimation of the full model with both main and interaction effects. Second, the design should allow the efficient estimation of the main effects only model as well, since this may be the true model.

One way to account for uncertainty about the utility specification is by employing a model averaging approach (Hoeting, et al., 1999). Model averaging is a way of accounting for researcher uncertainty regarding the true underlying model. Applied to estimation, model averaging involves estimating a range of models, then applying weights to the results of each model in calculating the statistic of interest (e.g., willingness to pay). In Bayesian model averaging, weights are based on Bayes factors (Kass and Raftery, 1995). This type of model averaging has recently been employed to estimate economic models in environmental and natural resource settings (Koop and Tole, 2004; Layton and Levine, 2005). Buckland, Burnham, and Augustin (1997) proposed a frequentist alternative to the Bayesian model averaging approach that uses relative statistical fits of the models as weights. This frequentist model averaging approach was recently applied by Layton and Lee (2006) to the valuation of saltwater fishing trips in Alaska.

In this paper, we apply a model averaging approach to efficient experimental design construction by proposing selection of experimental designs that minimize a weighted D-error function that encompasses several competing model specifications. This new objective function includes consideration for multiple objectives to be considered in choosing the experimental design. As such, the approach is in the spirit of Bayesian experimental designs (Chaloner and Verdinelli, 1995). One would expect that this approach would lead to experimental designs that could be used to efficiently estimate utility parameters and willingness to pay (WTP) estimates for a wider set of models than the designs based on assuming a single true underlying model.

Suppose there are M utility specifications (models) being considered to analyze the choice data, and we wish to use an experimental design that will lead to efficient estimates for each of the models. Assuming there is no prior information available about the preference parameters such that a zero parameter vector in each model is assumed, the weighted D-efficiency design would be selected to minimize

$$\mathrm{wD_0\text{-}error} = \Sigma_m \, \mathrm{w}_m \cdot | \Omega_{0m} |^{-1/K_m}, \qquad (7)$$

where m=1,…,M denotes the mth model, $\mathrm{w_m}$ is the weight placed on the mth model in the weighted D-error, K_m and Ω_{0m} are the number of utility parameters and information matrix in the

mth model, and $\Sigma_m w_m = 1$. The weights are chosen based on the researcher's beliefs about the likelihood of each model being the "true" model, which can be determined empirically using past studies and results or using expert opinion.

If prior information about parameter values is available, a weighted D-efficiency criterion based on D_p- or D_b-efficiency can be used, depending upon whether the researcher wishes to assume only the likely parameter values (weighted D_p-efficiency) or the likely distribution of the parameters (weighted D_b-efficiency):

$$\text{wD}_\text{p}\text{-error} = \Sigma_m \, w_m \, |\Omega_{\beta m}|^{-1/Km}, \tag{8}$$

$$\text{wD}_\text{b}\text{-error} = \Sigma_m \, w_m \int \left|\Omega_{\beta_r m}\right|^{-1/K_m} f(\beta_m) d\beta_m \tag{9}$$

Monte Carlo Experiment

To assess how well the model averaging-based experimental designs fare relative to other efficiency-based designs, a Monte Carlo (MC) experimental approach was employed. For each design and true model, pseudo-choice data are generated and used to estimate MNL models WTP. The parameter estimates and WTP over R iterations are then compared to the true values to assess how well the experimental design performs in recovering the true preferences. This approach allows us to compare the ability of differing efficient designs to estimate a set of true parameters and WTP and investigate the effects on estimation of incorrectly specifying the underlying utility specification in the selection of the experimental design.

In the MC, twelve 18-choice set experimental designs are evaluated for each of 9 "true" utility specifications that differ in functional form and parameter values. This results in 108 separate Monte Carlo experiments.

For the purposes of this experiment, we assume a choice between three alternative programs that are described by three attributes: A, B, and cost. Further, suppose attribute A is a 3-level categorical variable, B is a 3-level variable, and the cost attribute has 6 levels. Consistent with much of the literature, cost is assumed to be linear in the utility specification. The specific levels seen by respondents for each attribute are listed in Table 1.

Kuhfeld, Tobias, and Garratt (1994), among others, point out that the number of levels chosen for quantitative attributes affects efficiency. Having more levels than are needed to identify the type of functional relationship being modeled will lead to diminished design efficiency. To estimate a linear function, two levels set at the extremes of the design space are efficient since only two are needed to define a line. Similarly, only three levels are needed to estimate a quadratic relationship.

Often, however, practical considerations outweigh statistical efficiency concerns, as discussed earlier. In the Monte Carlo, we assume six cost levels are desired to span the likely range of WTP and provide respondents with a more continuous spectrum of costs for the alternatives they will see. Although cost is modeled as linear, with only two costs respondents may be faced with unrealistic choices between vastly different alternatives that cost the same, or conversely, very similar choices with a large cost difference. Since respondents almost always see multiple choice questions in each survey, they may become wary of such limited choices, which would ultimately be evidenced by item or unit non-response.

Several other items are useful to note about the Monte Carlo experiment. We assume two simple rules, or prohibitions, apply to the possible alternatives seen by respondents. These are necessary to maintain realism in the choices. First, clearly better alternatives should cost more, and second, no two alternatives in the same choice set can be the same. The latter is a trivial restriction, since a choice between identical choices yields no information and will not be chosen when maximizing efficiency. However, the first rule is needed to ensure respondents do not see unrealistic choices. For many applications, additional rules are needed to ensure respondents only see feasible choices. As noted above though, this comes at the expense of design efficiency. Another important aspect of the designs in this experiment is the absence of a status quo or opt-out alternative. The effect of status quo alternatives on designs selected using weighted efficiency criteria is left for future research, but is a relatively straightforward extension of the present work.

In addition, we confine the MC experiment to MNL models since they are commonly used to analyze CE data in marketing, transportation, and environmental economics applications, and since the information matrix has a closed-form and is readily calculated. Note, however, that the model averaging technique can be easily extended to other estimation models for which there is an analytic solution to the information matrix.

Three model specifications are defined that represent the set of models the researcher is interested in estimating once SP choice data have been collected. Suppose the sources of model uncertainty arise from (a) not knowing whether to treat one variable as categorical or continuous and (b) whether alternative specific constants (ASC) will need to be included in the estimation model. Other possible sources of model uncertainty could be handled using the approach suggested here, such as uncertainty surrounding which interaction effects to model. However, for the purposes of illustrating the technique, we confine ourselves to these two sources of model uncertainty.

Each of the three competing "true" models used in the design selection assumes the cost attribute is linear and continuous, and attribute A is categorical and effects-coded. They differ primarily in their treatment of attribute B and the inclusion or exclusion of ASCs. Model 1 assumes utility does not depend upon ASCs and treats attribute B as a categorical, effects-coded variable. For the *j*th alternative, the conditional indirect utility in Model 1 is:

$$\mathrm{V}_j = \beta_2 \cdot D_{A2j} + \beta_3 \cdot D_{A3j} + \gamma_2 \cdot D_{B2j} + \gamma_3 \cdot D_{B3\,j} + \delta \cdot cost_j, \tag{10}$$

where β_2, β_3, γ_2, γ_3, and δ are parameters to be estimated and D_{A2j} is an effects-coded variable that equals 1 if attribute A in the *j*th choice alternative equals Level 2, 0 if it equals Level 3, and -1 if it equals the reference level, Level 1 in this case. D_{A3j}, D_{B2j}, and D_{B3j} are similarly defined. This effects coding scheme allows us to recover the marginal effects of the reference levels of categorical attributes A and B (Louviere, Hensher, and Swait, 2000).

In Models 2 and 3, attribute B is continuous and represented by linear (x_B) and quadratic (x_B^2) terms.

$$\mathrm{V}_j = \beta_2 \cdot D_{A2j} + \beta_3 \cdot D_{A3j} + \gamma_1 \cdot x_{Bj} + \gamma_{11} \cdot x_{Bj}^{\;2} + \delta \cdot cost_j. \tag{11}$$

Model 3 differs from Model 2 in assuming non-zero alternative specific constants associated with selection of Alternative B (α_B) and Alternative C (α_C), respectively:

$$\mathrm{V}_j = \alpha_B \cdot D_B + \alpha_C \cdot D_C + \beta_2 \cdot D_{A2j} + \beta_3 \cdot D_{A3j} + \gamma_1 \cdot x_{Bj} + \gamma_{11} \cdot x_{Bj}^{\;2} + \delta \cdot cost_j, \tag{12}$$

where D_B equals 1 when Alternative B is chosen and zero otherwise, and D_C equals 1 when

Alternative C is chosen and zero otherwise.

Three variants of Models 1, 2, and 3 are used in the Monte Carlo experiment—a low-, medium-, and high-parameter version of each model. Every model variant assumes the same marginal utility of cost parameter (δ = -0.05), but the other utility parameters are different. The low-parameter variants (denoted 1L, 2L, and 3L) assume non-cost utility parameters are half the magnitude as those in the medium-parameter model (denoted 1M, 2M, and 3M), while the high-parameter variants (denoted 1H, 2H, and 3H) have 50% larger parameter values than the medium parameter models. Parameter values for each of the 9 models are presented in Table 2. Only the medium parameter versions of each model are used in the experimental design construction.

For each of the medium-parameter model specifications, 1M, 2M, and 3M, and each alternative D-efficiency criterion, we select an experimental design. There are six competing D-efficiency criteria based on the standard, unweighted D-efficiency measures (D_0-, D_p-, and D_b-efficiency) and the corresponding weighted D-efficiency measures (wD_0-, wD_p-, and wD_b-efficiency). The D_0- and wD_0-efficient designs assume the parameter vector is a zero vector for each model. The non-zero parameter values assumed to be true for the D_p- and wD_p-efficient designs are contained in Table 2. For the D_b- and wD_b-effiency based designs, the non-cost utility parameters are assumed to be normally distributed around the assumed true parameter values with standard deviations equal to 0.2 times the parameter value (the parameters are also assumed to be uncorrelated). In these designs, 500 draws from the parameter distributions are used in calculating the D_b- or wD_b-error for each design. For each of these efficiency criteria, 18 choice set designs are selected using a computer-based algorithm written in GAUSS that calculates the D-efficiency of 50,000 designs from the candidate design set and identifies the design that minimizes D-error, which we select as the efficient design.[52]

This process results in a total of 12 efficient designs each consisting of 18 choice sets.[53] The design that minimizes D_0-error and assumes Model 1M is the true model is D01. The D02 and D03 designs minimize D_0-error too, but for Models 2M and 3M, respectively. Designs minimizing D_p-error are denoted DP1, DP2, and DP3, corresponding to assumptions that Model 1M, 2M, and 3M are the true models, respectively. Following this naming convention, DB1, DB2, and DB3 are designs that minimize D_b-error and assume Models 1M, 2M, and 3M, respectively, are true. The designs that minimize the weighted D-error account for efficiency considerations of all 3 models. Design D0W maximizes weighted D_0-efficiency, DPW maximizes weighted D_p-efficiency, and DBW maximizes weighted D_b-efficiency. In selecting these weighted efficiency-based designs, we assume equal model weights, such that in equations (7) – (9) $w_1 = w_2 = w_3 = 1/3$, since we have no priors about which model is more likely to be chosen. These weights could be different, of course, and should be if information is available that suggests one is better than another.[54]

Table 3 lists the D_0-, D_p- and D_b-errors of the efficient designs. Note that because each design assumes a different underlying utility model and maximizes a different type of D-efficiency, the D-errors generally are not directly comparable across designs. For a given assumed utility model, however, comparing the designs for a single efficiency criterion is possible. Thus, for instance, we can compare the relative D_0-efficiency of D01, DP1, and DB1

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[52] The algorithm is similar to ones available for SAS (Kuhfeld, 2003).

[53] As mentioned above, these designs are locally, not globally, efficient according to the specific D-efficiency criterion used since we constrain the design to a specific number of attributes and levels, and do not search over the entire design space.

[54] For example, if data from pretesting is available to estimate the models, information criteria like AIC or BIC could be used as in other model averaging applications to determine model weights.

and conclude that D01 is the most D_0-efficient of the three, as we would expect. In general, the table suggests that designs that maximize D_0-efficiency for a given utility model will generally be more D_0-efficient than other designs that maximize D_p- or D_b-efficiency assuming the same utility model. The same generally holds true for the other types of D-efficiency. This need not be the case, however. For instance, DB2 has a smaller D_p-error than DP2, the design that minimizes D_p-error. This should not be a surprise since the selection of the most efficient design by any design efficiency measure was not over the entire design space, but rather only a subset of the entire candidate design set space.[55]

In each MC experiment, we assume one of the 9 true models described above (1L, 1M, 1H, 2L, 2M, 2H, 3L, 3M, and 3H). The true willingness to pay (WTP) associated with a change from the lowest levels of attributes A and B to the highest is reported for each of these models in Table 2. It is calculated as the difference in conditional indirect utilities associated with the low level state (V^0) and the high level state (V^1) divided by the marginal utility of money (δ): WTP = $(-1/\delta)\cdot[V^1 - V^0]$. Note that the true WTP values for Models 2 and 3 are the same. This is due to the fact that we ignore alternative-specific constants in the welfare calculations, which is the only distinguishing difference between Models 2 and 3.

Given an experimental design and true model, pseudo-choice data are constructed for REPS replications of the experimental design, which simulates n = 18×REPS observed choices, since there are 18 choice sets in each design. In the MC that follows, we assume REPS equals 25, resulting in a sample size of 450.[56] By assuming the unobservable component of utility is a TEV disturbance, the true utilities associated with Alternatives A, B, and C for each choice set in

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[55] Bunch, Louviere, and Anderson (1996) suggest several strategies to cover more of the design space in the selection of efficient choice designs.

[56] The Appendix includes tables that summarize the results for the assumption that REPS is 15, so that the sample size is 270.

the design can be calculated, and subsequently we can determine which alternative would be chosen. With this simulated choice data and the experimental designs, we estimate each MNL model to assess how well each design recovers these preferences. Note that this implicitly assumes we are using the correct functional form for the indirect utility function in estimation, even though the experimental design may have been chosen assuming a different utility specification.

For each design, the MC simulation is repeated R = 1,000 times. That is, for each of R iterations, pseudo-choice data is generated and the MNL model is estimated, leading to R estimated parameter vectors and WTP estimates. The performance of each design is evaluated with respect to how well it estimates willingness to pay and how close the overall set of parameter estimates are to the true values. To evaluate how well each design estimates WTP, we calculate the root mean squared error (RMSE) and mean absolute proportion error (MAPE) of WTP for each design. The RMSE of WTP, which provides a measure of the aggregate deviation of estimated WTP across iterations in the MC, is

$$\text{RMSE(WTP)} = [(1/R)\cdot\Sigma_r\,(WTP^{\text{True}} - WTP^{\text{r}})^2]^{1/2} \qquad \text{where } r = 1,\ldots,R \qquad (13)$$

An alternative performance measure is the mean absolute proportion error (MAPE) of WTP, which provides a measure of the average deviation of estimated WTP across iterations in the MC:

$$\text{MAPE(WTP)} = (1/R)\cdot\Sigma_r\,[|WTP^{\text{True}} - WTP^{\text{r}}|/\text{WTP}^{\text{True}}] \qquad \text{where } r = 1,\ldots,R \qquad (14)$$

In comparing across designs, a lower RMSE and MAPE are indicative of less bias between simulated models.

A measure of the overall performance of the design to estimate the true parameters is the sum of squared log-likelihood error (SSLLE). SSLLE is defined as the mean squared difference between the log-likelihood value of the true model (LL^{True}) and estimated model for each of $r = 1,\ldots, R$ iterations (LL^{r}):

$$\text{SSLLE} = (1/R)\cdot\Sigma_r \, (LL^{\text{True}} - LL^{r})^2, \text{ where } r = 1,\ldots,R \qquad (15)$$

Since the true parameter values should maximize the log-likelihood function, we expect SSLLE to be small for designs that estimate parameters close to the true values. If the design always estimates the true values, SSLLE equals zero.

Monte Carlo Results

What would we expect to observe from the Monte Carlo experiment? For a correctly specified model, we would expect that the design that maximized D_p-efficiency will be the best since the design assumed the correct utility model. Thus, for instance, if Model 1M is the true model, then design DP1 should lead to better results than other designs. When the functional form is correct, but the utility parameters are not, we would expect the design that assumed the parameters closest to the true values or the D_b-efficiency design to work best. This occurs, for instance, when the true model is Model 1L or 1H instead of Model 1M as in the example above. In this case, we would expect either DB1 or D01 to perform better relative to others. Which of the two designs will lead to better estimates depends upon whether the parameter value range accounted for in DB1 contains the true parameters and the closeness of the true parameters to zero. When the estimation model is different from the one assumed in the construction of the design, the weighted D-efficiency designs are likely to lead to the best results since the correct specifications (though perhaps not the correct parameter values) are accounted for in the weighted designs. Continuing with the example started above, if the true model is Model 2M, or any other model based on the Model 2 or Model 3 utility specifications, we expect the weighted efficiency designs, D0W, DPW, and DBW, to yield better results in general than the D01, DP1, or DB1 designs. With respect to estimating WTP specifically, we would expect that designs based on Models 2M and 3M should lead to similar results when the estimation models are based on Models 2 or 3 given that WTP in the two models excludes the parameters that differ between the models, namely, the ASCs.

For the large sample designs, which assume 25 replications of each 18 choice set design resulting in a pseudo-dataset of 450 choices, the Monte Carlo WTP results are presented in Tables 4, 5, and 6. In each table, the mean, RMSE, and MAPE of WTP over 1000 model iterations are presented for each of the 3 variants of each model's utility specification. Generally, each of the 12 efficient designs do a reasonably good job estimating WTP for each of the 9 true models over repeated trials, with the vast majority of mean WTP estimates differing from the true WTP by less than 1%. In fact, only a few designs have a mean WTP that is more than 2% different from true WTP.[57] These slight discrepancies occur for only four true model-design combinations. Therefore, the discussion of the Monte Carlo WTP results will focus primarily on the RMSE and MAPE achieved by each experimental design for each true model.

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[57] The maximum discrepancy between true and simulated WTP is observed for Model 3B using DB1. The observed difference is 5%, which is larger than the next largest discrepancy by about 42%.

Table 4 presents the WTP results for Models 1M, 1L, and 1H associated with each of the 12 efficient experimental designs. Since DP1 was constructed assuming Model 1M is the true model, we would expect this design to do the best in estimating WTP. Surprisingly, several other designs lead to lower RMSE and MAPE values, including DBW, the design based on the proposed robust design approach that incorporates both model and parameter uncertainty. In fact, this design leads to the lowest RMSE and MAPE values across all 12 designs for Model 1M. The second best design based on both the RMSE and MAPE criteria is the DPW design. Still, the DP1 design outperforms the D_0-efficiency based designs, except the model-weighted D0W design, which has almost the same RMSE and MAPE as DP1. It also did better in estimating WTP than the DP2, DB2, and DB3 designs, as we would expect. Also as expected, the weighted designs (D0W, DPW, and DBW) outperform the corresponding designs that were based on Models 2M and 3M. Note that the MAPE across the designs for Model 1M are between 0.034 and 0.066, indicating the mean absolute discrepancy between the true WTP and estimated WTP is not large.

For Model 1L, among the designs constructed using Model 1M as the true model (D01, DP1, and DB1), D01 has the lowest RMSE and MAPE, which is consistent with our expectations given the small non-cost utility parameter values are outside the range covered by DB1, and the true parameter values are closer to the zero parameter vector assumed by D01. Between the weighted designs (D0W, DPW, and DBW), DBW has the lowest RMSE and MAPE and is the second-best design overall in estimating WTP. Somewhat surprising is the fact that D02 performs the best by the two criteria and DB2 is third-best among all designs. Interestingly, the D0W design does poorly compared with D02 and D03, even though the DPW and DBW designs do better than their unweighted counterparts based on Models 2M and 3M. The MAPE across models range from a low of 0.076 (for D02) to a high of 0.119 (for DP2).

For estimating WTP for Model 1H, which has the largest non-cost utility parameters, DB1 has the lowest RMSE and MAPE among models that were designed assuming Model 1M is true. This is consistent with our expectations since the parameter values are larger than those accounted for in DP1, and DB1 accounts for a range of parameter values closest to the true ones. Also consistent with our priors is the relatively poor performance of D01 due to the large true utility parameters and the assumed zero parameters used to construct the design. Still, several surprising results are worth noting. First, the two best designs based on RMSE and MAPE are D03 and DP3, which are designs assuming Model 3M is the true model. However, the DB3 design does the worst according to the RMSE criterion and second-worst by the MAPE criterion. Second, the weighted designs do better than the corresponding designs based on Model 1M, with all three weighted designs performing comparably. And third, the D01 design is not just the worst at estimating WTP among designs based on Model 1M, but across all designs by the MAPE criterion (it is second-worst by RMSE). MAPE range from 0.037 to 0.086 across the designs.

Turning to the MC results in Table 5 for Models 2M, 2L, and 2H, we note that the MAPE values calculated for each true model and design in this table are generally larger than the corresponding MAPE values seen in Table 4. The range of MAPE values for Model 2M is from 0.077 to 0.1199, which is larger than the observed range of 0.034 to 0.066 reported for Model 1M. Similarly, for Model 2L MAPE ranges from a low of 0.144 to a high value of 0.303 and for Model 2H from 0.0545 to 0.0824, which are generally larger than the corresponding MAPE values seen for designs estimating Models 1L and 1H, respectively. This suggests that the average absolute deviation between the estimated WTP and true WTP is generally larger when estimating the Model 2 utility specifications.

In contrast, the estimated RMSE values in Table 5 are usually lower than the corresponding values in Table 4. For Model 2M, \$4.40 is the low, and \$7.57 is the high RMSE. Compare this to the generally higher RMSE values corresponding to each design for Model 1M, which range from a low of \$4.51 to a high of \$8.72. With a few exceptions, a similar observation can be made for the RMSE values for Models 2L and 2H compared to those for Models 1L and 1H. Since calculating the RMSE involves summing squared deviations from the true WTP and then taking the square root, RMSE is more sensitive to larger deviations than MAPE. As a result, the usually smaller RMSE combined with larger MAPE values suggest the Model 2 WTP estimates tend to have fewer large deviations from the true WTP even though the absolute deviations tend to be slightly larger compared to Model 1.

Examining Table 5 more closely, we see that for Model 2M, D02 has the lowest RMSE (\$4.40) and MAPE (0.0765) instead of DP2, which we would expect to perform the best based on its construction based on the true utility specification and parameter values. As in Model 1M, the design that incorporates parameter uncertainty, DB2, does better than DP2 in estimating WTP, which is not surprising given DP2 does the worst out of all designs (RMSE = \$7.57, MAPE = 0.1318). Interestingly, DP3 and DB3 have relatively low RMSE and MAPE values and both outperform DP2 in this respect. However, as noted above, this is somewhat expected due to the similarities in utility structure and the WTP calculation between Models 2 and 3. For Model 2M, DBW does better than six other designs.

As expected, for Model 2L D02 has the lowest RMSE (\$4.18) and MAPE (0.1441) among all designs, and DB2 outperforms DP2, which again is the worst design. Among the weighted designs, DPW does marginally better than D0W, with DBW doing the worst. Only two designs, DP1 and DB1 do worse in estimating WTP than DBW. The designs based on Model 3 all have low RMSE and MAPE values and are better than all designs except D02 and D01.

Across all designs for Model 2H, DBW has the lowest RMSE ($4.75) and MAPE (0.0545), indicating it does the best in estimating WTP when Model 2H is the true model. Between designs that assume Model 2M is the true model, DB2 predictably outperforms D02 and DP2 since it was constructed to account for larger parameter values than either of the other two. However, somewhat surprisingly, D02 has a lower RMSE and MAPE than DP2.

Table 6 presents the WTP results associated with true Models 3M, 3L, and 3H. The magnitudes and ranges of RMSE and MAPE for these models are similar to those for Models 2M, 2L, and 2H, suggesting that the designs as a group do a similar job in estimating WTP for these models as they do for the variants of Model 2.

For Model 3M, we expect DP3 to better D03 and DB3 because it is based on the true utility specification and utility parameters. The results support this, suggesting DP3 estimates WTP better than either D03 or DB3, with RMSE equal to $5.26 and a MAPE of 0.090. The only two designs with lower RMSE and MAPE values are D01 and D02. For this model, the DPW design does the best among the weighted designs, having a RMSE of $6.41 and MAPE of 0.111. The next best weighted design is DBW, which is marginally worse at estimating WTP than DPW according to the two evaluation criteria.

As for Model 3M, D01 and D02 are the best designs in terms of RMSE and MAPE for Model 3L. These designs do slightly better than the designs based on Model 3M—D03, DP3, and DB3. Between those designs, DP3 has the lowest RMSE and MAPE, followed closely by DB3, and then D03. The three worst designs for estimating WTP for Model 3L are DB1, DBW, and DP2, which have MAPE values of 0.325, 0.271, and 0.261, and RMSE values of $9.50, $7.80, and $7.69, respectively. The best weighted design for this model is D0W, then DPW. The lowest RMSE and MAPE are associated with D02, which achieves a RMSE of $4.32 and MAPE of 0.147.

The design with the lowest RMSE and MAPE for Model 3H is DP3, which achieves a RMSE of $4.90 and MAPE of 0.0563. In this case, DB3 has lower RMSE and MAPE values than D03. However, neither of these designs does better than DB2, DBW, D01, or D02 by the two criteria. For Model 3H, DBW is clearly the best weighted design, followed by DPW.

Table 7 presents the SSLLE values for each design and true utility model. For each model, the design with the lowest SSLLE estimates the collective model parameters closest to the true ones. From the table, it is clear that no single design consistently estimates the utility parameters of all models better than the others. Two designs, DP1 and DB3, have the lowest SSLLE for two models apiece (Models 2L and 2H and Models 1L and 2M, respectively), although both have large SSLLE values for at least one other model. Other designs that have the lowest SSLLE for a true model are D02 (for Model 3L), DP2 (for Model 1H), DB1 (for Model 1M), DB2 (for Model 3H), and DBW (for Model 3M).

Note that in general the best designs for estimating WTP are not always the best at estimating the true utility parameters. In fact, in only one true model, Model 3L, does the same design (D02) do the best job estimating WTP and the utility parameters. Furthermore, the best design for estimating WTP may be the worst design for estimating utility parameters, as the case of Model 2M illustrates. For this model, the design with the lowest RMSE and MAPE is D02, which has the lowest SSLLE (0.0042).

Looking at individual designs and models, it is difficult to get a sense of overall trends.

A simplistic way of evaluating how the designs do over all the models is to compare the overall performance of each design using a rank-sum approach. For each of the three evaluation criteria (RMSE, MAPE, or SSLLE) and nine true models, we determine the rank of each design, with the lowest value out of the 12 designs receiving a rank of 1 (best) and the largest criterion value a rank of 12 (worst). The rankings are summed over the models for each design and evaluation criterion, and a relative ranking is then assigned to each of the 12 designs based on the sum over the design's rankings. The resulting rank-sum ordering for each criterion is displayed in Table 8.

Both the RMSE and MAPE lead to similar rank-sum orderings, with the only difference between them the ranking of D0W and DP1. Along with DP2, D0W and DP1 form the bottom three performers in estimating WTP across all models. By both criteria, DP3 does the best in estimating WTP across the models. DB2 is the next best design in this regard. The third best design is DBW.

By the rank-sum measure for SSLLE, the design that estimates the true utility parameters best is DP1, followed by two designs incorporating parameter uncertainty, DB2, and DB3. The design that accounts for both parameter and model uncertainty, DBW, is in the middle of the rankings with DB1 and DPW. The designs ranked the worst according to the SSLLE criterion are three designs that assumed a zero parameter vector in their construction, D01, D0W, and D03.

The last column in Table 8 presents a weighted score for each design that represents a cumulative performance measure for the design across all models and evaluation criteria. Since the RMSE and MAPE criteria are competing measures of the same thing (ability to accurately estimate WTP), these two criteria are given equal weight in calculating the weighted score. Together, the RMSE and MAPE rankings are given a weight of 50%. The ranking for SSLLE receives the other 50% weighting. These cumulative scores suggest the designs that do the best in estimating the models and welfare values are DB2 and D02. The next best designs are DP3 and DB3, followed by DBW. Three of the four worst performing designs are the remaining D_0-efficient designs, D01, D03, and D0W. Their poor performance is undoubtedly due in large part to their inability to estimate the overall model parameters accurately as reflected by the low SSLLE rankings in Table 8.

Discussion

Recall that a main purpose of this paper is to assess the performance of robust experimental designs, exemplified by DBW, to estimate model parameters and WTP compared to other efficient designs. As the results above suggest, for this Monte Carlo experiment a design that incorporates both model and parameter uncertainty did not perform better than all other competing designs, nor did it do the worst. The robust design did better than most other designs in estimating WTP across the models, even outperforming all other designs for three separate models. With respect to its overall ability to estimate model parameters, the design was fairly middle-of-the-road. In the overall assessment based on relative rankings across models and evaluation criteria, this design was ranked higher than most designs.

Two other designs that incorporate model uncertainty were evaluated as well. The design based on weighting D_0-efficiency across utility models (D0W) generally faired worse than the design based on weighted D_p-efficiency (DPW), both in terms of estimating WTP and the utility model parameters. In fact, the D0W design was often worse at estimating WTP than the other, unweighted D_0-efficient designs.

Along the way, there were several surprising results. First, all designs estimated WTP with low bias, with the largest estimated bias being about a 5% difference from the true WTP. Most measured WTP bias were less than 1% different from the true WTP. Second, for Models 1M, 2M, and 3M, the designs expected to perform best due to their construction assuming the true model, namely DP1, DP2, and DP3, respectively, did not estimate WTP as well as other designs. In each case, these designs did not do as well as the corresponding designs that included parameter uncertainty (i.e., DB1, DB2, and DB3). And third, designs that were based on a different underlying utility model were often better at estimating WTP than the models constructed assuming the correct model. Some of these surprising results may be an artifact of the efficiency-optimizing design approach, which finds locally efficient, but not globally efficient, designs. It remains to be seen whether algorithms that search over more of the design space (see, for example, Bunch, Louviere, and Anderson [1996]) will lead to designs that further clarify the trends seen in the MC experiment.

It is also important to emphasize the fact that these results are for a specific experiment conducted to compare several competing MNL-based main-effects efficient designs using 9 specific, and researcher-chosen, true utility models. The design was assumed to have 18 choice sets, which is a manageable size for empirical studies. The Monte Carlo also assumed 25 replications of each choice set, which results in 450 data points for estimating the models. The Appendix includes tables of the MC results when we assume only 15 replications, such that the estimation is based on 270 choices. Those tables suggest the results are fairly robust to sample size. Future research should explore the effects of changing the number of choice sets. Additional research is also needed to determine if the addition of other models and parameter values affect the overall results. Other types of model misspecifications should be explored by Monte Carlo methods, including extending the set of models that are estimated by the designs to include utility specifications with interaction effects, other types of variables, etc. Moreover, research is needed to determine how well designs based on non-efficiency criteria, such as those based on orthogonal designs (Louviere, Hensher, and Swait, 2000) perform relative to the robust experimental designs illustrated here. And although this design approach was applied assuming multinomial logit models, it is important to point out that the method can be extended to other choice models, such as the mixed logit model, in a straightforward way.

Although the design rankings information is useful for summarizing the overall performance of individual designs to estimate the conditional indirect utility and associated welfare estimates, one should be careful not to place too much weight on the conclusions drawn from the weighted scores. The weighted scores only considered three evaluation criteria. Inclusion of others would likely have an impact on the relative rankings. Possible evaluation criteria to explore in future research include the RMSE and MAPE associated with estimates of each utility parameter.

Taken as a whole, these results suggest that experimental designs based on maximizing D-efficiency that explicitly and jointly account for model and parameter uncertainty may be worthwhile. There is also evidence to suggest that accounting for model uncertainty using D_0-efficiency as a selection criterion is not desirable. At the same time, the results indicate that all designs, regardless of the efficiency criterion used in their construction, are able to estimate unbiased WTP. This suggests researchers primarily interested in calculating WTP may wish to stick with standard approaches that lead to D-efficient designs, whether based on D_0-efficiency, D_p-efficiency, or D_b-efficiency, to avoid the additional work needed to construct experimental designs robust to parameter and model uncertainty. However, for those interested in ensuring a wide variety of models are estimable, the robust design approach seems attractive.

Before concluding, it is important to say a few things about implementing this design approach. Existing information about preferences and researcher judgment are central to developing robust experimental designs. Empirical implementation of the robust experimental design approach requires some knowledge about preference parameters.[58] Focus groups, cognitive interviews, and formal pretests sometimes provide enough data to estimate simple models. In such cases, the model estimates can be used in the construction of the experimental design for the full survey implementation. Otherwise, researchers must rely on past studies, expert opinions, or other sources for preference information. In the Monte Carlo, the robust design was constructed by assuming the prospective utility specifications should receive equal weight in calculating wD_b-error. If real-world data is available and capable of being used to estimate the models, the researcher can instead weight the models using measures of information criteria (AIC, AICc, and BIC) as model weights in the model averaging calculation using the approach of Buckland, Burnham, and Augustin (1997). Beyond model weights, determination of the set of models to account for in the experimental design is a critical judgment the researcher must make. This requires researchers to look ahead to the types of questions that they wish answered with the data and to then choose the appropriate mix of model specifications that will answer those questions.

Conclusion

Experimental design construction is only one of many important steps in stated preference-based choice experiment studies. However, as has been emphasized elsewhere (e.g., Louviere, Hensher, and Swait [2000]), it is a critical step, and one that can limit the study's

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[58] In this sense, the information needs for implementing the robust design approach are no different from the information needed to choose a D_b-efficient design.

results if done incorrectly. In this paper, we developed an approach for constructing efficient experimental designs that incorporate both parameter and model uncertainty. The approach was illustrated and evaluated using a Monte Carlo approach that also compared the robust design against designs constructed using standard efficiency criteria. The results in this example indicate the robust design approach may be useful for studies where multiple utility specifications are being considered, but further research is needed to confirm these results and explore other issues.

Empirical implementation of the approach also poses challenges to researchers, who may not have readily-available information about consumer preferences or time to invest in the process to gather the requisite information needed to implement the approach. These are significant hurdles, particularly given readily-available alternatives, such as the SAS macros developed by Warren Kuhfeld (2003) for constructing D-efficient choice experiment designs. When considering whether the design approach proposed in this paper should be used, researchers will need to weigh the benefits of safeguarding the ability to estimate multiple models against the costs of investing the time into developing robust experimental designs.

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Table 1. Monte Carlo Experimental Design Attributes and Attribute Levels

Attribute	**No. levels**	**Levels**
Attribute A (x_A)	3	Level 1, Level 2, Level 3
Attribute B (x_B)	3	2, 5, 10
Cost ($)	6	5, 10, 20, 40,80,120

Table 2. True Utility Functions and Willingness to Pay

True utility parameter	Associated Variable	Model 1M	Model 1L	Model 1H	Model 2M	Model 2L	Model 2H	Model 3M	Model 3L	Model 3H
α_B	ASC_B							0.25	0.125	0.375
α_C	ASC_C							0.50	0.25	0.75
β_2	D_{A2}	0.25	0.125	0.375	0.25	0.125	0.375	0.25	0.125	0.375
β_3	D_{A3}	0.50	0.25	0.75	0.50	0.25	0.75	0.50	0.25	0.75
γ_2	D_{B2}	1	0. 5	1.5						
γ_3	D_{B3}	1.50	0.75	2.25						
γ_1	x_B				0.25	0.125	0.375	0.25	0.125	0.375
γ_{11}	x_B^2				-0.01	-0.005	-0.015	-0.01	-0.005	-0.015
δ	Cost	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
	WTP	$105.00	$52.50	$157.50	$45.80	$22.90	$68.70	$45.80	$22.90	$68.70

NOTE: For each model, WTP is calculated for a change from the lowest levels of attributes A and B to the highest levels of A and B. WTP = $(-1/\delta)\cdot[V^1 - V^0]$, where V^1 is the conditional indirect utility associated with attributes A and B at their lowest levels, and V^0 is the utility associated with attributes A and B at their highest levels.

Table 3. D-Efficiency of Experimental Designs for Assumed Utility Model

Design Name	Assumed Model	Design Criterion	D_0-error	D_p-error	D_b-error
D01	1M	D_0-efficiency	0.0256	0.1623	0.1840
DP1	1M	D_p-efficiency	0.0312	0.0364	0.1803
DB1	1M	D_b-efficiency	0.0373	0.0390	0.0423
D02	2M	D_0-efficiency	0.0060	0.0212	0.0259
DP2	2M	D_p-efficiency	0.0082	0.0104	0.0217
DB2	2M	D_b-efficiency	0.0079	0.0094	0.0095
D03	3M	D_0-efficiency	0.0184	0.0944	0.1124
DP3	3M	D_p-efficiency	0.0208	0.0629	0.1033
DB3	3M	D_b-efficiency	0.0216	0.0602	0.0612
D0W	All	wD_0-efficiency	0.0171	0.0965	0.1102
DPW	All	wD_p-efficiency	0.0212	0.0321	0.0831
DBW	All	wD_b-efficiency	0.0217	0.0393	0.0404

NOTE: The “assumed model” is the conditional indirect utility specification assumed for experimental design construction: All specifications are main effects models with linear cost variables. Model 1M treats all non-cost variables as effects coded categorical (ordinal) variables; Model 2M treats attribute 1 as effects coded variable, attribute 2 as a quadratic continuous variable; and Model 3M is the same as Model 2M except with alternative specific constants for two of the choices. The weighted model uses all three models.

Table 4. Mean, RMSE, and MAPE of WTP for True Models 1L, 1M, and 1H (18-choice set design, 25 replications)

	D01	**D02**	**D03**	**D0W**	**DP1**	**DP2**	**DP3**	**DPW**	**DB1**	**DB2**	**DB3**	**DBW**
Model 1L												
Mean WTP (true = $52.50)	$52.55	$52.35	$52.66	$52.57	$52.57	$52.09	$52.77	$52.53	$52.28	$52.45	$52.54	$52.54
RMSE(WTP)	$5.98	$4.94	$6.81	$7.00	$6.18	$7.89	$5.87	$5.83	$6.81	$5.66	$6.55	$5.48
MAPE(WTP)	0.0909	0.0761	0.1039	0.1052	0.0942	0.1187	0.0890	0.0888	0.1045	0.0863	0.0996	0.0830
Model 1M												
Mean WTP (true = $105)	$105.27	$105.45	$104.79	$105.19	$105.44	$105.18	$105.01	$105.10	$105.00	$104.73	$105.38	$105.02
RMSE(WTP)	$8.72	$8.51	$7.42	$6.73	$6.76	$8.40	$5.79	$5.62	$6.52	$7.47	$8.45	$4.51
MAPE(WTP)	0.0660	0.0658	0.0568	0.0508	0.0506	0.0634	0.0441	0.0434	0.0487	0.0573	0.0640	0.0340
Model 1H												
Mean WTP (true = $157.50)	$161.07	$156.72	$157.61	$157.16	$158.46	$157.16	$157.78	$158.39	$157.25	$158.18	$161.99	$158.01
RMSE(WTP)	$25.27	$11.78	$8.22	$8.33	$12.63	$10.18	$7.32	$8.50	$9.90	$9.12	$27.15	$8.51
MAPE(WTP)	0.0860	0.0600	0.0416	0.0429	0.0626	0.0519	0.0370	0.0421	0.0492	0.0462	0.0843	0.0423

NOTE: Estimated WTP averaged over 1000 iterations using 18-choice set designs.

Table 5. Mean, RMSE, and MAPE of WTP for True Models 2L, 2M, and 2H (18-choice set design, 25 replications)

	D01	D02	D03	D0W	DP1	DP2	DP3	DPW	DB1	DB2	DB3	DBW
Model 2L												
Mean WTP (true = $22.90)	$22.80	$22.86	$22.83	$22.87	$22.76	$22.67	$22.94	$22.72	$22.56	$22.89	$22.86	$22.82
RMSE(WTP)	$4.99	$4.18	$5.81	$6.39	$7.33	$8.70	$5.18	$6.10	$7.39	$5.29	$5.74	$7.15
MAPE(WTP)	0.1733	0.1441	0.2038	0.2249	0.2557	0.3033	0.1816	0.2127	0.2555	0.1835	0.2026	0.2495
Model 2M												
Mean WTP (true = $45.80)	$45.56	$45.71	$45.45	$45.36	$45.74	$45.29	$45.67	$45.54	$45.61	$45.69	$46.02	$45.70
RMSE(WTP)	$5.28	$4.40	$6.31	$6.47	$6.87	$7.57	$5.33	$5.93	$6.49	$5.18	$5.45	$5.57
MAPE(WTP)	0.0925	0.0765	0.1075	0.1155	0.1199	0.1318	0.0938	0.1033	0.1132	0.0895	0.0946	0.0961
Model 2H												
Mean WTP (true = $68.70)	$68.86	$68.63	$68.69	$68.72	$68.75	$68.85	$69.00	$68.76	$68.49	$68.67	$68.45	$68.75
RMSE(WTP)	$5.64	$5.73	$6.71	$7.00	$6.63	$6.85	$5.42	$5.91	$6.05	$5.36	$6.03	$4.75
MAPE(WTP)	0.0653	0.0660	0.0782	0.0824	0.0767	0.0779	0.0629	0.0685	0.0690	0.0622	0.0687	0.0545

NOTE: Estimated WTP averaged over 1000 iterations using 18-choice set designs.

Table 6. Mean, RMSE, and MAPE of WTP for True Models 3L, 3M, and 3H (18-choice set design, 25 replications)

	D01	**D02**	**D03**	**D0W**	**DP1**	**DP2**	**DP3**	**DPW**	**DB1**	**DB2**	**DB3**	**DBW**
Model 3L												
Mean WTP (true = $22.90)	$23.07	$22.73	$22.87	$23.01	$22.29	$22.50	$22.66	$22.70	$21.75	$22.99	$22.92	$22.86
RMSE(WTP)	$4.98	$4.32	$6.06	$6.49	$7.69	$8.50	$5.40	$6.83	$9.50	$5.75	$5.91	$7.80
MAPE(WTP)	0.1743	0.1472	0.2114	0.2228	0.2610	0.2914	0.1901	0.2351	0.3253	0.1988	0.2012	0.2712
Model 3M												
Mean WTP (true = $45.80)	$45.96	$45.76	$45.76	$45.76	$45.56	$45.88	$45.50	$45.86	$45.56	$45.95	$45.38	$45.49
RMSE(WTP)	$5.15	$4.37	$6.75	$7.07	$7.35	$7.30	$5.26	$6.41	$7.93	$5.53	$5.66	$6.65
MAPE(WTP)	0.0885	0.0762	0.1182	0.1254	0.1255	0.1268	0.0900	0.1107	0.1383	0.0974	0.0984	0.1147
Model 3H												
Mean WTP (true = $68.70)	$68.99	$69.04	$68.69	$68.94	$68.57	$68.52	$68.67	$68.88	$68.26	$68.66	$68.60	$68.75
RMSE(WTP)	$5.75	$5.93	$6.88	$7.78	$7.14	$6.82	$4.90	$6.19	$6.42	$5.60	$6.08	$5.72
MAPE(WTP)	0.0670	0.0685	0.0792	0.0901	0.0834	0.0789	0.0563	0.0711	0.0744	0.0651	0.0698	0.0665

NOTE: Estimated WTP averaged over 1000 iterations using 18-choice set designs.

Table 7. Mean Sum of Squared Log-Likelihood Errors of 18-Choice Set Designs (25 replications)

Model	**D01**	**D02**	**D03**	**D0W**	**DP1**	**DP2**	**DP3**	**DPW**	**DB1**	**DB2**	**DB3**	**DBW**
Model 1L	0.00088	0.00082	0.00219	0.00162	0.00081	0.00098	0.00122	0.00106	0.00106	0.00162	0.00082	0.00089
Model 1M	0.00237	0.00145	0.00115	0.00105	0.00194	0.00200	0.00109	0.00099	0.00083	0.00103	0.00243	0.00091
Model 1H	0.00098	0.00163	0.00091	0.00213	0.00090	0.00081	0.00099	0.00490	0.00137	0.00136	0.00210	0.00218
Model 2L	0.00083	0.00081	0.00090	0.00110	0.00069	0.00311	0.00087	0.00085	0.00121	0.00074	0.00065	0.00116
Model 2M	0.00172	0.00419	0.00104	0.00169	0.00075	0.00094	0.00078	0.00093	0.00198	0.00136	0.00075	0.00291
Model 2H	0.00181	0.00107	0.00860	0.00129	0.00089	0.00352	0.00242	0.00125	0.00100	0.00081	0.00079	0.00141
Model 3L	0.00534	0.00063	0.00168	0.00117	0.00298	0.00101	0.00095	0.00116	0.00084	0.00067	0.00096	0.00108
Model 3M	0.00337	0.00122	0.00143	0.00117	0.00099	0.00082	0.00556	0.00101	0.00279	0.00447	0.00084	0.00078
Model 3H	0.00229	0.00118	0.00128	0.00165	0.00179	0.00074	0.00202	0.00136	0.00152	0.00070	0.00338	0.00179
Total	**0.01960**	**0.01301**	**0.01918**	**0.01287**	**0.01175**	**0.01394**	**0.01589**	**0.01350**	**0.01259**	**0.01276**	**0.01272**	**0.01311**

Table 8. Design Rankings Over All Models

Design	Rank by RMSE(WTP)	Rank by MAPE(WTP)	Rank by SSLLE	Weighted Score
D01	5	5	12	8.5
D02	4	4	4	4
D03	8	8	10	9
D0W	10	11	11	10.75
DP1	11	10	1	5.75
DP2	12	12	5	8.5
DP3	1	1	9	5
DPW	6	6	6	6
DB1	9	9	7	8
DB2	2	2	2	2
DB3	7	7	3	5
DBW	3	3	8	5.5

NOTE: Designs were ranked for each model according to each of the three criteria (RMSE, MAPE, and SSLLE) across all models. The weighted score assumes the following criteria weights: ranks for RMSE and MAPE are each 25% of the weighted score and the SSLLE rank is 50% of the weighted score.

Appendix: Results for Smaller Sample (15 replications)

Table A1. Mean, RMSE, and MAPE of WTP for True Models 1L, 1M, and 1H (18-choice set design, 15 replications)

	D01	**D02**	**D03**	**D0W**	**DP1**	**DP2**	**DP3**	**DPW**	**DB1**	**DB2**	**DB3**	**DBW**
Model 1L												
Mean WTP (true = $52.50)	$52.41	$52.38	$52.94	$52.27	$52.58	$52.42	$52.87	$52.10	$52.16	$52.35	$52.34	$52.29
RMSE(WTP)	$7.39	$6.00	$8.64	$8.84	$7.87	$10.00	$7.57	$7.70	$8.92	$7.45	$8.69	$6.92
MAPE(WTP)	0.1137	0.0916	0.1312	0.1347	0.1168	0.1490	0.1125	0.1164	0.1348	0.1116	0.1304	0.1043
Model 1M												
Mean WTP (true = $105)	$105.74	$105.22	$104.67	$105.05	$105.30	$105.39	$105.29	$104.71	$104.98	$105.12	$105.40	$104.90
RMSE(WTP)	$11.29	$11.03	$9.34	$8.63	$8.84	$11.03	$7.78	$7.28	$7.87	$9.82	$10.73	$5.74
MAPE(WTP)	0.0846	0.0844	0.0708	0.0651	0.0661	0.0827	0.0594	0.0569	0.0593	0.0744	0.0796	0.0436
Model 1H												
Mean WTP (true = $157.50)	**$186.16**	$157.40	$157.58	$157.88	$159.25	$158.31	$157.59	$158.59	$158.83	$157.84	**$170.93**	$158.40
RMSE(WTP)	$89.73	$14.79	$10.51	$10.58	$16.20	$12.83	$9.72	$10.62	$13.07	$11.51	$60.65	$10.56
MAPE(WTP)	0.2576	0.0746	0.0527	0.0538	0.0796	0.0650	0.0491	0.0525	0.0648	0.0581	0.1559	0.0524

NOTE: Estimated WTP averaged over 1000 iterations using 18-choice set designs.

Table A2. Mean, RMSE, and MAPE of WTP for True Models 2L, 2M, and 2H (18-choice set design, 15 replications)

	D01	D02	D03	D0W	DP1	DP2	DP3	DPW	DB1	DB2	DB3	DBW
Model 2L												
Mean WTP (true = $22.90)	$22.47	$22.91	$23.05	$23.19	$22.07	$22.64	$22.90	$22.59	$22.19	$22.58	$22.47	$22.79
RMSE(WTP)	$6.52	$5.59	$7.73	$8.61	$9.81	$11.26	$7.07	$8.35	$10.13	$6.93	$7.36	$9.36
MAPE(WTP)	0.2262	0.1934	0.2668	0.3024	0.3322	0.3877	0.2439	0.2909	0.3503	0.2394	0.2510	0.3240
Model 2M												
Mean WTP (true = $45.80)	$45.65	$45.72	$45.77	$45.75	$45.66	$45.27	$46.02	$45.75	$44.95	$45.42	$46.24	$45.31
RMSE(WTP)	$7.03	$5.93	$7.78	$8.55	$8.88	$9.66	$6.60	$7.94	$8.38	$6.61	$7.42	$7.52
MAPE(WTP)	0.1232	0.1039	0.1363	0.1496	0.1511	0.1675	0.1147	0.1382	0.1443	0.1161	0.1279	0.1303
Model 2H												
Mean WTP (true = $68.70)	$68.74	$68.21	$68.82	$68.38	$68.12	$68.21	$68.62	$68.87	$68.49	$68.49	$68.83	$68.53
RMSE(WTP)	$7.62	$7.11	$8.92	$8.75	$8.26	$8.65	$6.56	$7.54	$7.66	$6.90	$7.99	$6.04
MAPE(WTP)	0.0893	0.0824	0.1037	0.1021	0.0965	0.0991	0.0764	0.0869	0.0891	0.0794	0.0923	0.0697

NOTE: Estimated WTP averaged over 1000 iterations using 18-choice set designs.

Table A3. Mean, RMSE, and MAPE of WTP for True Models 3L, 3M, and 3H (18-choice set design, 15 replications)

	D01	**D02**	**D03**	**D0W**	**DP1**	**DP2**	**DP3**	**DPW**	**DB1**	**DB2**	**DB3**	**DBW**
Model 3L												
Mean WTP (true = $22.90)	$23.10	$22.85	$22.85	$22.78	$21.95	$22.60	$22.84	$22.36	$21.60	$22.30	$22.59	$21.93
RMSE(WTP)	$6.40	$5.57	$7.69	$8.86	$10.52	$11.03	$7.09	$8.65	$12.16	$7.14	$7.53	$10.91
MAPE(WTP)	0.2221	0.1927	0.2624	0.3011	0.3560	0.3822	0.2506	0.3012	0.4122	0.2456	0.2572	0.3716
Model 3M												
Mean WTP (true = $45.80)	$46.17	$45.83	$45.94	$46.32	$45.50	$45.15	$45.65	$45.98	$45.12	$45.55	$45.91	$45.49
RMSE(WTP)	$6.81	$6.07	$8.57	$9.45	$9.39	$9.58	$6.58	$8.02	$9.90	$6.94	$7.36	$8.45
MAPE(WTP)	0.1187	0.1071	0.1509	0.1629	0.1611	0.1658	0.1150	0.1396	0.1725	0.1226	0.1284	0.1460
Model 3H												
Mean WTP (true = $68.70)	$69.10	$68.78	$68.95	$68.38	$69.01	$69.19	$69.06	$68.63	$68.11	$68.57	$69.22	$68.70
RMSE(WTP)	$7.35	$7.58	$9.00	$10.07	$9.44	$8.69	$6.33	$7.51	$8.66	$6.86	$7.83	$7.64
MAPE(WTP)	0.0840	0.0876	0.1048	0.1169	0.1098	0.1018	0.0731	0.0867	0.0989	0.0796	0.0906	0.0883

NOTE: Estimated WTP averaged over 1000 iterations using 18-choice set designs.

Table A4. Mean Sum of Squared Log-Likelihood Errors of 18-Choice Set Designs (15 replications)

Model	D01	D02	D03	D0W	DP1	DP2	DP3	DPW	DB1	DB2	DB3	DBW
Model 1L	0.0017	0.0127	0.0035	0.0020	**0.0014**	0.0021	0.0026	0.0061	0.0015	0.0024	0.0032	0.0015
Model 1M	0.0013	0.0089	0.0035	0.0017	0.0027	**0.0015**	0.0022	0.0037	0.0021	0.0068	0.0019	0.0026
Model 1H	0.0027	0.0031	0.0031	0.0057	0.0017	0.0017	0.0017	0.0025	0.0033	0.0016	**0.0013**	0.0022
Model 2L	0.0020	0.0023	0.0019	0.0020	0.0026	0.0013	0.0059	0.0028	0.0016	0.0017	**0.0011**	0.0028
Model 2M	0.0018	0.0009	0.0053	0.0032	0.0019	0.0020	**0.0012**	0.0053	0.0061	0.0033	0.0014	0.0016
Model 2H	0.0021	0.0026	0.0047	0.0030	0.0017	0.0029	0.0016	0.0033	0.0020	**0.0013**	0.0025	0.0018
Model 3L	0.0027	**0.0008**	0.0063	0.0021	0.0059	0.0015	0.0028	0.0017	0.0015	0.0018	0.0010	0.0035
Model 3M	0.0040	0.0021	0.0016	0.0021	0.0016	0.0051	0.0018	0.0017	0.0046	**0.0015**	0.0047	0.0030
Model 3H	0.0018	0.0025	0.0019	0.0028	0.0016	0.0020	0.0016	0.0051	0.0124	0.0114	**0.0015**	0.0020

Recent and Historic Demographic Trends in Bering Sea and Aleutian Island Fishing Communities
[Draft Project Report and Working Paper, 2006]

Amanda Poole
Alaska Fisheries Science Center and University of Washington
and
Jennifer Sepez
Alaska Fisheries Science Center

INTRODUCTION

This report examines demographic change in Bering Sea and Aleutian Island (BSAI) fishing communities since 1920. We undertook this research in an attempt to begin introducing human population dynamics as an indicator for regional ecosystem analyses. We focus here on human inhabitants of the Bering Sea coast, using total population by community and by Census area as the primary indicator, with some analysis of other population characteristics such as ethnicity. This approach is concordant with research on arctic communities that uses crude population growth or loss as a general measure to determine community viability, as this indicator is easy to understand, locally meaningful, and points to the capacity of people in these places to "dwell and prosper for some period, finding sources of income and meaningful lives" (Aarsaether et.al. 2004).

An understanding of recent and historic demographic data in the region is a preliminary step to developing models that will attempt to predict demographic effects of changes in fish populations, fisheries management, industry conditions and markets, and climate characteristics.

This research project examined birth rates, migration, indigeneity, boom-bust economic cycles, and seasonality as factors in understanding population trends in the region. This report discusses community selection methodology and challenges, describes and analyzes the causes of demographic trends in BSAI fishing communities since 1920, points to the impacts of population decline or growth on local communities, and finally, suggests opportunities for including demographic indicators in future research on fisheries science and policy.

METHODS

Demographic indices used in this study include population change by community and aggregated Census areas or boroughs for each decade between 1920─2000 (data from U.S. Census), and yearly between 1990─2005 (data from the Alaska Department of Labor and Workforce Development (ADLWD)). A borough is the Alaskan administrative unit most similar to a county. A Census area is a U.S. Census designated geography most similar to a county, which is applied by the Census to areas where there is no county equivalent (such as much of Southwestern Alaska). Statistics on percent Alaska Native population in each community were also considered, along with aggregate data on ethnicity and migration statistics for Census Areas and boroughs provided by the ADLWD.

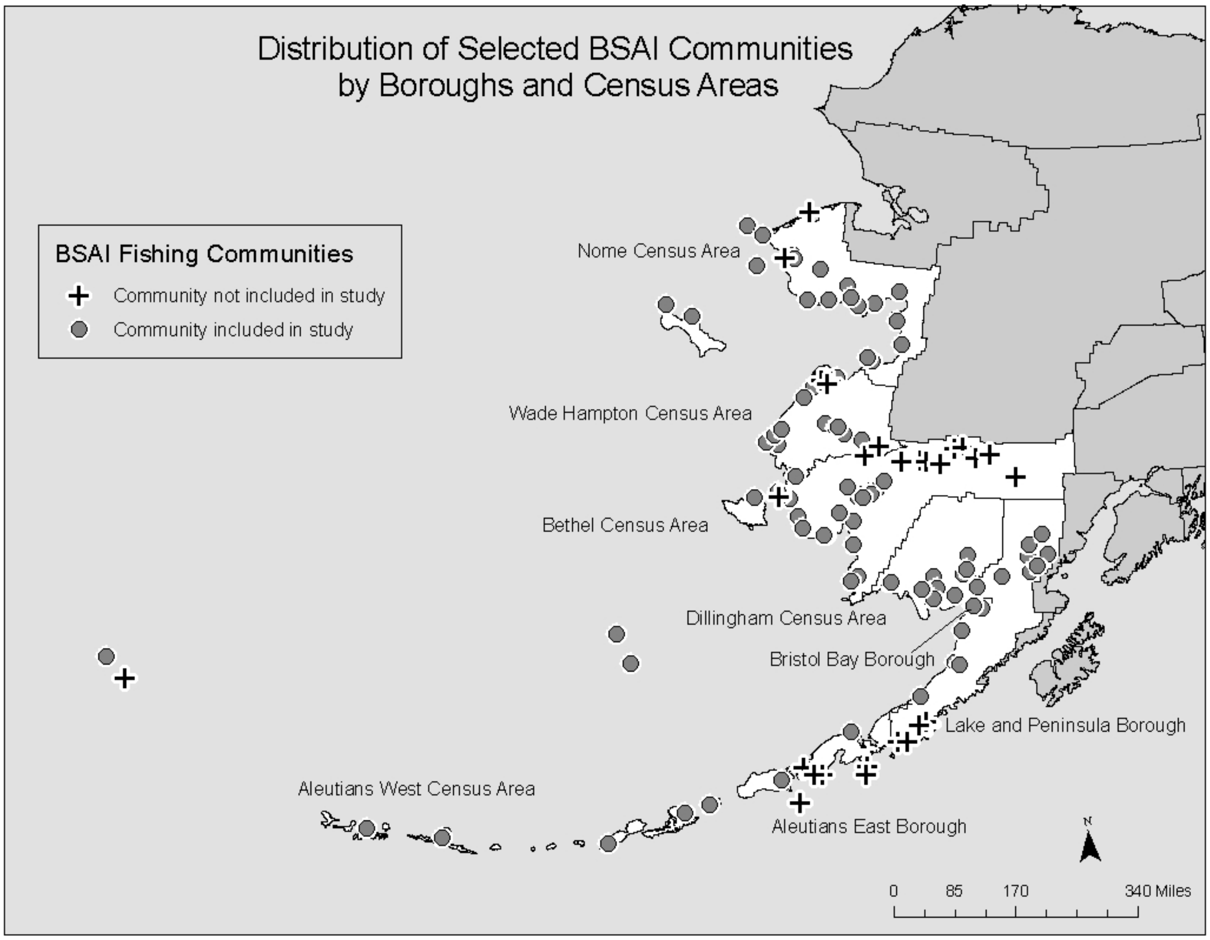

Figure 1. Location of all communities considered, indicating those selected and those not selected for the study.

This project involved a total of 94 communities from 7 Census areas or boroughs of Southwestern and Western Alaska (see Figure 1). Census areas and boroughs considered were those contiguous to the Eastern Bering Sea Large Marine Ecosystem. The 94 BSAI fishing communities selected for use in the study comprise most of the population in each of these Census areas (between 79% for Aleutians East and West and 99% for Dillingham Census Area, (see Figure 2) and were chosen due to their proximity and historical involvement in Bering Sea subsistence or industrial fisheries. Most communities were analyzed within their Census area for ease of attaining and comparing data. However, boroughs and Census areas were aggregated for analysis in two cases: Aleutians East Borough and Aleutians West Census Area were joined due to the low number of communities, their geographic proximity, and historical continuity as part of demographic dynamics on the Aleutian island chain; also, Bristol Bay Borough was combined with Lake and Peninsula Borough because the geographic position of the three selected Bristol Bay communities is entirely surrounded by the Lake and Peninsula area, and the likelihood that these towns may serve as something of a regional hub to the surrounding communities.

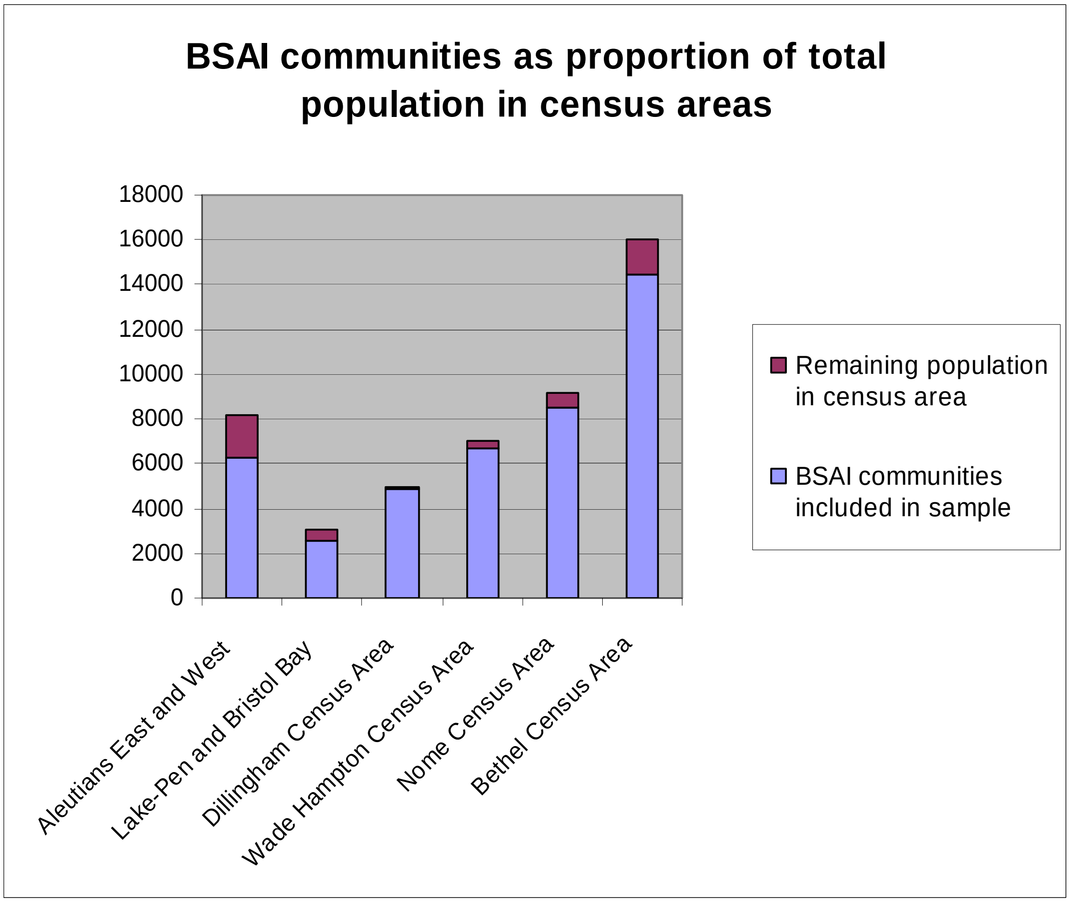

Figure 2. Population of each Census area or borough showing proportion residing in the communities selected for analysis.

For the purposes of this paper, selected BSAI fishing communities are representative of nearly all communities already found to meet the criteria set out by the Community Development Quota (CDQ) program[59] for Bering Sea coastal communities (64 out of 65 CDQ communities), as well as non-CDQ communities centered around the Bering Sea and Aleutian Islands that were found to meet the selection criteria for profiling of fishing communities established by Sepez et al. (2005) in *Community Profiles for*

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[59] The CDQ program was initiated in 1992 with 55 communities and expanded in 1999 to its current membership number of 65 communities. According to conditions for inclusion in the CDQ program, all CDQ communities are located within 50 nautical miles of the BSAI Large Marine Ecosystem (LME) region. In addition to proximity, the CDQ community must conduct at least half of their commercial or subsistence activities in the BSAI waters, they must not be located on the other two LMEs, and they must be certified as a Native village. CDQ communities must meet further criteria, including having underdeveloped capabilities to participate substantially in BSAI groundfish fisheries. All of the CDQ communities were included in this study except for Grayling in the Yukon-Koyukuk Census Area. Most of this Census Area is not centered around the Bering Sea and consequently, is not included in this study, but may be relevant for future research.

North Pacific Fisheries – Alaska (an additional 10 communities).[60] However, the current project also takes a more historical and spatial approach to the selection of relevant communities (see Table 1). The criteria established for the CDQ program and the *Community Profiles* does not consider communities that have lost their population and currently exist as seasonal use areas. The CDQ program does not include some villages that exist around CDQ communities. This project includes these historical and geographically positioned communities as important for an analysis of demographic change linked to fisheries resources and industries.[61]

Table 1. Communities Selected for the Analysis

BSAI Fishing Communities Selected for Inclusion

Community	Borough/Census Area	Reason for Inclusion
Adak	Aleutians West Census Area	Listed in *Community Profiles*
Akutan	Aleutians West Census Area	CDQ community
Atka	Aleutians West Census Area	CDQ community
Attu Station	Aleutians West Census Area	Historically a Native Alaskan community
False Pass	Aleutians East Borough	CDQ community
Nelson Lagoon	Aleutians East Borough	CDQ community
Nikolski	Aleutians West Census Area	CDQ community
Saint George	Aleutians West Census Area	CDQ community
Saint Paul	Aleutians West Census Area	CDQ community
Unalaska	Aleutians West Census Area	Listed in *Community Profiles*
Egegik	Lake and Pen Borough	CDQ community
Igiugig	Lake and Pen Borough	Participates in Bristol Bay Fisheries
Iliamna	Lake and Pen Borough	Participates in Bristol Bay Fisheries
Kokhanok	Lake and Pen Borough	Participates in Bristol Bay Fisheries
Levelock	Lake and Pen Borough	CDQ community
Newhalen	Lake and Pen Borough	Participates in Bristol Bay Fisheries
Nondalton	Lake and Pen Borough	Participates in Bristol Bay Fisheries
Pedro Bay	Lake and Pen Borough	Participates in Bristol Bay Fisheries

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[60] This document used multiple indicators drawn from quantitative data from the year 2000 to assess community involvement with commercial fisheries. These indicators included, among other things, commercial fisheries landings, registered vessel homeports, and documented participants in the fisheries (i.e., vessel owners, Gear Operator Permit holders, and Commercial Crewmember licensees).

[61] Twenty communities were included that were neither CDQ communities nor included in the *Community Profiles*. These are: communities that may currently have no permanent residents but had a recorded population sometime since 1920 (Council, King Island, Mary's Igloo); a current military base that once had a resident Native population (Attu Station); communities in the Lake and Peninsula Borough that participate in the Bristol Bay Salmon fisheries and are not on the Gulf of Alaska (Igiugig, Iliamna, Kokhanak, Newhalen, Nondalton, Pedro Bay, Pope-Vannoy Landing); Communities which are predominately seasonal-use but which have a small residential population (Paiumut, Stebbins); Communities surrounding Bethel and those located on the Lower Kuskokwim (Akiak, Atmautluak, Kasigluk, Kwethluk, Nunapitchuk, Tuluksak) and finally a community close to CDQ communities in Wade Hampton (Pitka's Point).

Pilot Point	Lake and Pen Borough	CDQ community
Pope-Vannoy Landing	Lake and Pen Borough	Participates in Bristol Bay Fisheries
Port Alsworth	Lake and Pen Borough	Listed in *Community Profiles*
Port Heiden	Lake and Pen Borough	CDQ community
Ugashik	Lake and Pen Borough	CDQ community
King Salmon	Bristol Bay Borough	CDQ community
Naknek	Bristol Bay Borough	CDQ community
South Naknek	Bristol Bay Borough	CDQ community
Aleknagik	Dillingham Census Area	CDQ community
Clark's Point	Dillingham Census Area	CDQ community
Dillingham	Dillingham Census Area	CDQ community
Ekuk	Dillingham Census Area	CDQ community
Ekwok	Dillingham Census Area	CDQ community
Koliganek	Dillingham Census Area	Listed in *Community Profiles*
Manokotak	Dillingham Census Area	CDQ community
New Stuyahok	Dillingham Census Area	Listed in *Community Profiles*
Portage Creek	Dillingham Census Area	CDQ community
Togiak	Dillingham Census Area	CDQ community
Twin Hills	Dillingham Census Area	CDQ community
Alakanuk	Wade Hampton Census Area	CDQ community
Chevak	Wade Hampton Census Area	CDQ community
Emmonak	Wade Hampton Census Area	CDQ community
Hooper Bay	Wade Hampton Census Area	CDQ community
Kotlik	Wade Hampton Census Area	CDQ community
Marshall	Wade Hampton Census Area	Listed in *Community Profiles*
Mountain Village	Wade Hampton Census Area	CDQ community
Nunam Iqua	Wade Hampton Census Area	CDQ community
Paimiut	Wade Hampton Census Area	On Bering Sea, historically a seasonal use village, has had a population of 2 since 2000
Pilot Station	Wade Hampton Census Area	Listed in *Community Profiles*
Pitka's Point	Wade Hampton Census Area	Proximity to CDQ communities
Saint Mary's	Wade Hampton Census Area	Listed in *Community Profiles*
Scammon Bay	Wade Hampton Census Area	CDQ community
Brevig Mission	Nome Census Area	CDQ community
Council	Nome Census Area	Now a seasonal use area for Nome residents, but historically populated
Diomede	Nome Census Area	CDQ community
Elim	Nome Census Area	CDQ community
Gambell	Nome Census Area	CDQ community
Golovin	Nome Census Area	CDQ community
King Island	Nome Census Area	Now a seasonal use area, but historically populated
Koyuk	Nome Census Area	CDQ community
Mary's Igloo	Nome Census Area	Now a seasonal use area, but historically populated
Nome	Nome Census Area	CDQ community
Saint Michael	Nome Census Area	CDQ community

Savoonga	Nome Census Area	CDQ community
Shaktoolik	Nome Census Area	CDQ community
Solomon	Nome Census Area	Located on Bering Sea, population of 8
Stebbins	Nome Census Area	CDQ community
Teller	Nome Census Area	CDQ community
Unalakleet	Nome Census Area	CDQ community
Wales	Nome Census Area	CDQ community
White Mountain	Nome Census Area	CDQ community
Akiachak	Bethel Census Area	Listed in *Community Profiles*
Akiak	Bethel Census Area	Proximity to CDQ communities, residents hold fishing permits;
Atmautluak	Bethel Census Area	Proximity to CDQ communities, residents hold fishing permits;
Bethel	Bethel Census Area	Listed in *Community Profiles*
Chefornak	Bethel Census Area	CDQ community
Eek	Bethel Census Area	CDQ community
Goodnews Bay	Bethel Census Area	CDQ community
Kasigluk	Bethel Census Area	Proximity to CDQ communities, residents hold fishing permits;
Kipnuk	Bethel Census Area	CDQ community
Kongiganak	Bethel Census Area	CDQ community
Kwethluk	Bethel Census Area	Proximity to CDQ communities, residents hold fishing permits;
Kwigillingok	Bethel Census Area	CDQ community
Mekoryuk	Bethel Census Area	CDQ community
Napakiak	Bethel Census Area	CDQ community
Napaskiak	Bethel Census Area	CDQ community
Newtok	Bethel Census Area	CDQ community
Nightmute	Bethel Census Area	CDQ community
Nunapitchuk	Bethel Census Area	Proximity to CDQ communities, residents hold fishing permits;
Oscarville	Bethel Census Area	CDQ community
Platinum	Bethel Census Area	CDQ community
Quinhagak	Bethel Census Area	CDQ community
Toksook Bay	Bethel Census Area	CDQ community
Tuluksak	Bethel Census Area	Proximity to CDQ communities, residents hold fishing permits;
Tuntutuliak	Bethel Census Area	CDQ community
Tununak	Bethel Census Area	CDQ community

Communities located within the relevant boroughs or Census areas were excluded (see Table 2) if they met any of the following criteria: they are located on the Gulf of Alaska or Arctic; they are seasonal-use areas that have never had a permanent population; they are within the Census area but geographically distant from the Bering Sea and fisheries data do not indicate that they are predominately focused on the Bering Sea fisheries (including communities from the Bethel census area located in the Upper Kuskokwim school district and one community in the Wade Hampton census area, Russian Mission). Communities excluded from this analysis may still include many residents who work seasonally in BSAI fisheries, or may involve places which lost their populations altogether, such as Belkofski in Aleutians East, as residents were drawn to other BSAI and Gulf of Alaska towns. In addition, dozens of inland villages along the Yukon and Kuskokwim river systems were not included, although they are reliant on resources that spend much of their lifecycle in the Bering Sea.

Table 2. Communities in the Relevant Boroughs/Census Areas Not Selected for the Analysis.

Communities in BSAI Boroughs or Census Areas not selected for the study

Community	**Borough/Census Area**	**Reason for Exclusion**
Belkofski	Aleutians East Borough	Located on the Gulf of Alaska LME
Cold Bay	Aleutians East Borough	most economic activity focused on the Gulf of Alaska
King Cove	Aleutians East Borough	Located on the Gulf of Alaska LME
Pauloff Harbor	Aleutians East Borough	seasonal use, located on the Gulf of Alaska
Sand Point	Aleutians East Borough	Located on the Gulf of Alaska LME
Unga	Aleutians East Borough	Located on the Gulf of Alaska LME
Shemya Station	Aleutians West Census Area	population limited to 27 military caretakers;
Chignik	Lake and Pen Borough	Located on the Gulf of Alaska LME
Chignik Lake	Lake and Pen Borough	Located on the Gulf of Alaska LME
Perryville	Lake and Pen Borough	Located on the Gulf of Alaska LME
Chignik Lagoon	Lake and Pen Borough	Located on the Gulf of Alaska LME
Ivanof Bay	Lake and Pen Borough	Located on the Gulf of Alaska LME
Bill Moore's Slough	Wade Hampton Census Area	Censes have indicated no permanent residents
Ohogamiut	Wade Hampton Census Area	Seasonal use area on Yukon River, distant from Bering Sea
Russian Mission	Wade Hampton Census Area	On the Yukon River, activity mostly not centered on Bering Sea
Chuloonawik	Wade Hampton Census Area	Censes have indicated no permanent residents
Hamilton	Wade Hampton Census Area	Censes have indicated no permanent residents
Port Clarence	Nome Census Area	A military work site
Shishmaref	Nome Census Area	Located on Arctic LME
Aniak	Bethel Census Area	distance from Bering Sea- Upper Kuskokwim
Chuathbaluk	Bethel Census Area	distance from Bering Sea- Upper Kuskokwim
Crooked Creek	Bethel Census Area	distance from Bering Sea- Upper Kuskokwim
Georgetown	Bethel Census Area	distance from Bering Sea- Upper Kuskokwim
Lime Village	Bethel Census Area	distance from Bering Sea- Upper Kuskokwim
Lower Kalskag	Bethel Census Area	distance from Bering Sea- Upper Kuskokwim
Napaimute	Bethel Census Area	distance from Bering Sea- Upper Kuskokwim
Red Devil	Bethel Census Area	distance from Bering Sea- Upper Kuskokwim
Sleetmute	Bethel Census Area	distance from Bering Sea- Upper Kuskokwim
Stony River	Bethel Census Area	distance from Bering Sea- Upper Kuskokwim
Umkumiute	Bethel Census Area	Seasonal use area, since 1880 census, a resident population of 99 was only recorded once in 1950
Upper Kalskag	Bethel Census Area	distance from Bering Sea- Upper Kuskokwim

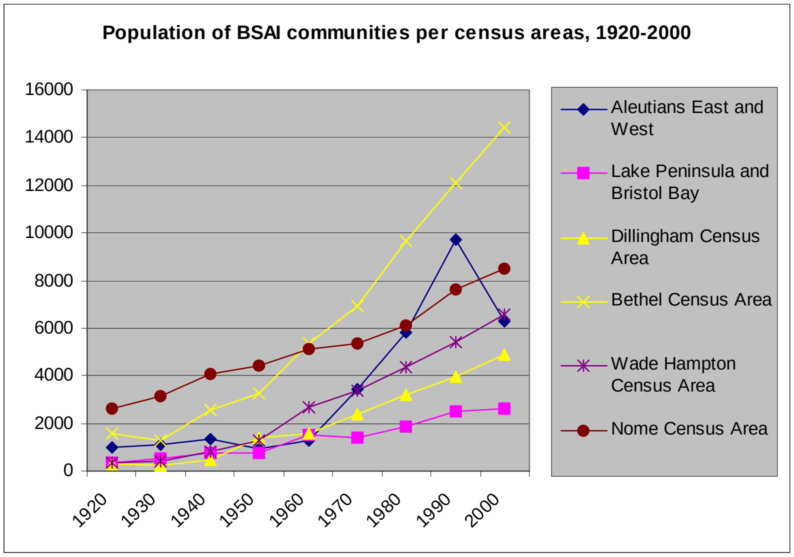
Two of the selected communities, Cherfornak and Egegik, are described in some detail in order to flesh out how communities in this region are configured and what forces might be driving or contributing to population growth or decline. The two communities were chosen as the closest to average of communities with a recent positive average annual population growth (Cherfornak) and the closest to average of those communities showing recent negative average annual population growth (Egegik).

Challenges to any analysis of demographic data in BSAI communities involve both Census data and the selection of communities. Census data on fishing occupations nationwide are problematic due to the low likelihood of a large enough number of fisherman to be randomly sampled in order to draw a composite profile (Hall-Arbor 2006), and the way in which the Census may categorize many fishermen as "self-employed." In Alaska, there are other problems with Census data involving the high seasonality of residence, labor, and migration patterns. The U.S. Census counts populations based on place of residence on April 1 of the Census year, without differentiation between long-term residents and transient workers. In many fishing communities in Alaska, the population fluctuates greatly during the year according to the fishing season. Due to an influx of processing workers, salmon communities may have much higher populations in the summer, crab and groundfish communities in the winter. Those communities with the greatest intra-annual population variability are the least well represented by the Census methodology.

Finally, a nested scales analytical framework in fisheries social science (Sepez et al. 2006) recognizes that community demographics may be interarticulated with global processes. Population trends and migration patterns along the Bering Sea and Aleutian Islands obviously link this region to state centers and global networks. Seafood and labor markets connect BSAI communities to Anchorage and Seattle, as well as Manila and Michoacan, Tokyo and Oslo, and beyond. Large scale environmental factors such as climate change and pollution also have their effect. Focusing the study on regional place-based fishing communities means excluding these non-local communities that may affect and be affected by Bering Sea communities and fisheries. For the limited purposes of this project, these dynamics have been noted, but not substantially considered.

RESULTS

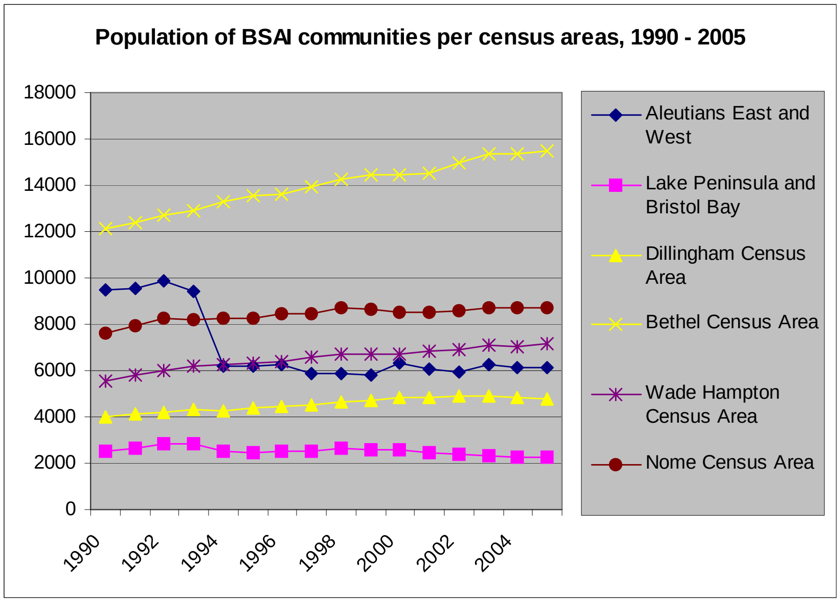
The total population of BSAI fishing communities in 2000 was almost seven times larger than the 1920 population - growing from 6,215 to 43,237. The overall population growth in this region since 1920 reflects state and national trends, although the BSAI growth rate lags behind both. The proportion of people living in BSAI communities relative to the total Alaskan population has declined from around 11% of the state total of 55,036 in 1920 to around 6.8% of the total Alaska population of 626,932 in 2000. Each BSAI borough or Census areas in the study showed an increase in total population since 1920, though to varying degrees, as shown in Figure 3.



Data Source U.S. Census

Figure 3. Populations have increased in all BSAI areas since 1920.

Nearly all of Alaska's rural areas, including the BSAI, have had a positive average population growth rate since 1990. The BSAI as a whole has shown population growth over that time period. As shown in Figure 4 below, only the Aleutians East and West area and the Lake and Peninsula and Bristol Bay boroughs have shown population decreases over that time period. The sharp population decrease in the Aleutians East and West area was exacerbated by the downsizing of a large military base in Adak in the early 1990s (the base was then closed in 1997) (See Figure 5). Military personnel stationed on bases are counted by the Census in the total population of a community.



Data Source: ADLWD

Figure 4. Annual population growth by Borough/Census Area since 1990.

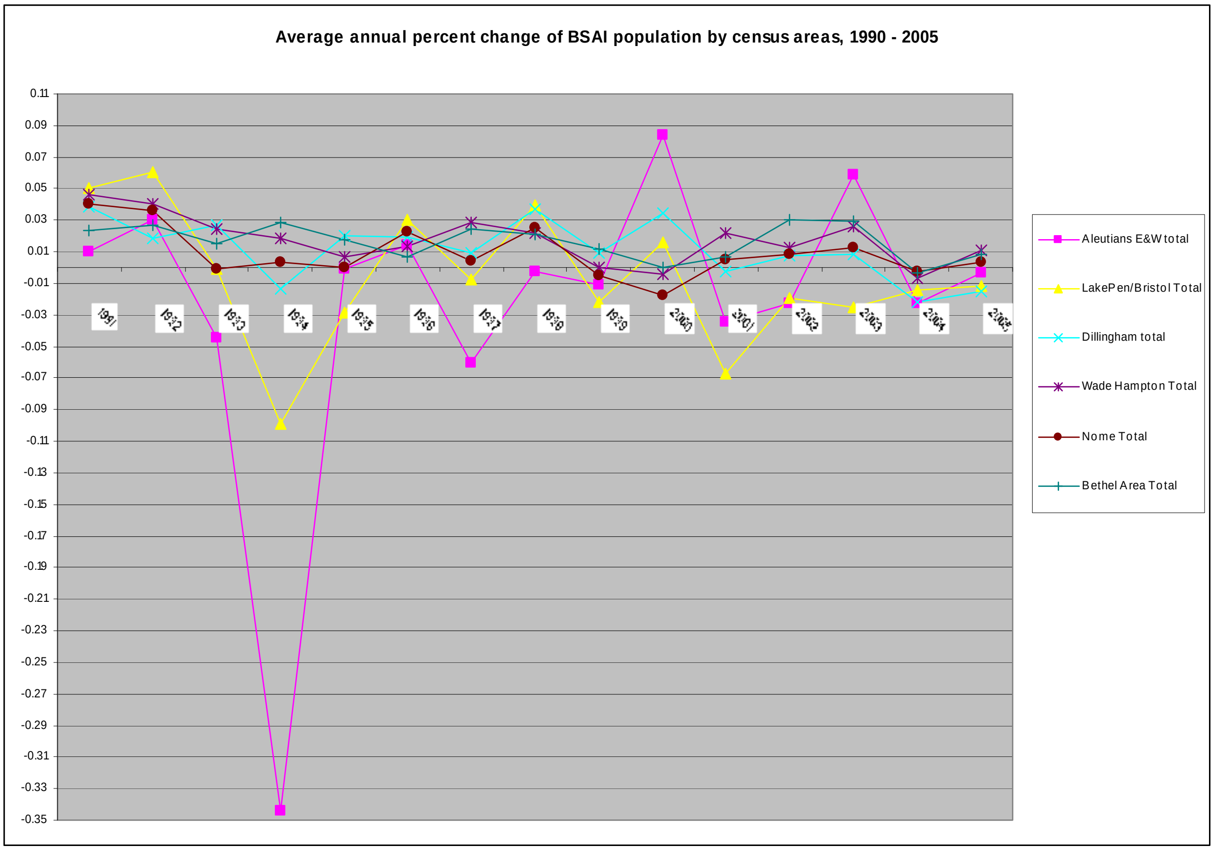


Figure 5. Average annual percent population change by Borough/Census area since 1990.

Figure 6 portrays positive and negative growth rates per community for the BSAI communities in the study. Seventy-nine BSAI fishing communities (or 84%) have had a positive average annual percent change during the period between 1990 and 2000. Three communities showed zero percent average annual change over the same time period and 14 had a negative average annual percent change. Communities with a negative annual percent change during this time period appear to be concentrated in Aleutians East and West along with Lake and Peninsula and Bristol Bay Boroughs. Four of the BSAI communities no longer have a resident population and are categorized as seasonal use areas - three of these (Council, King Island, and Mary's Igloo) lie in the Nome census area and one, Ekuk, in Dillingham Census area. In most cases, the loss of population in these communities reflects the boom and bust history of resource fluctuations in Alaska, particularly as communities grew and collapsed around the gold industry.

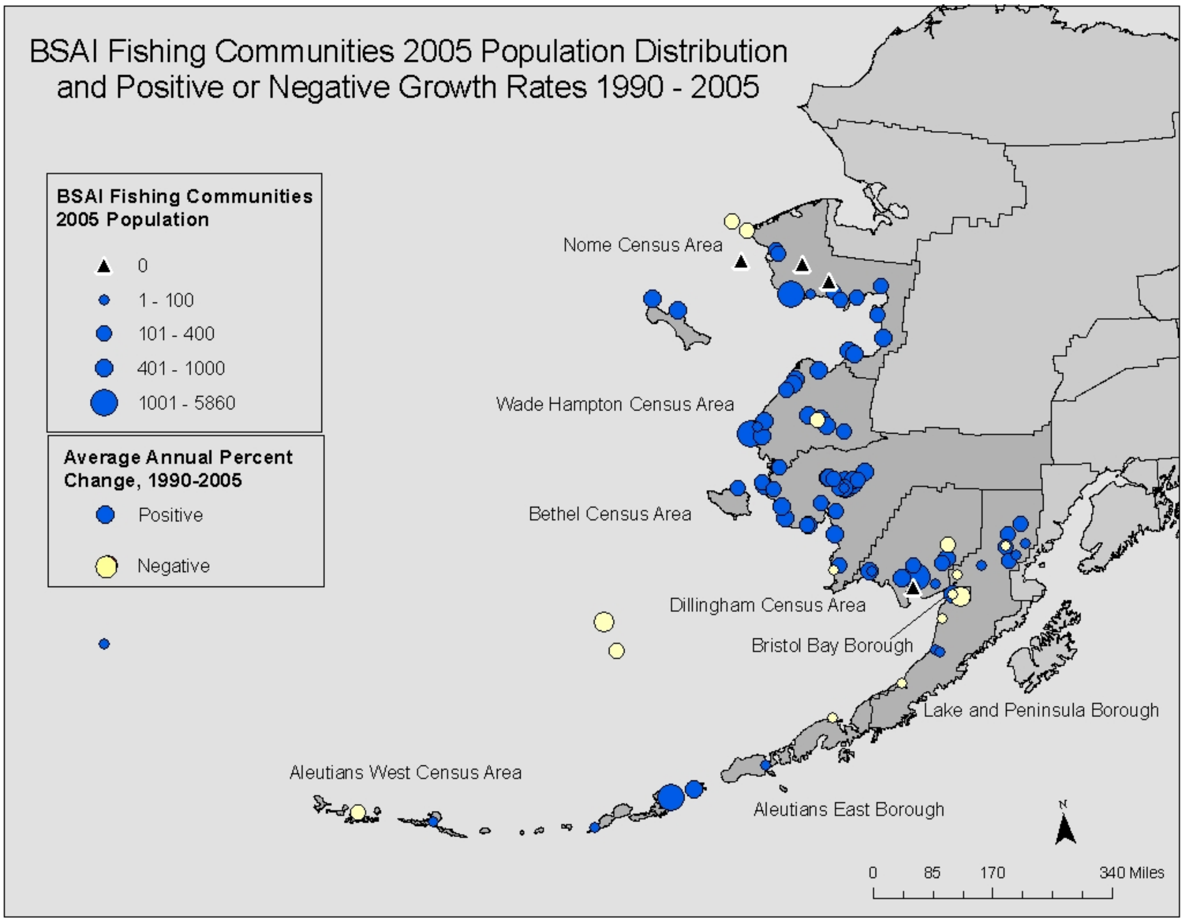


Figure 6. 2005 population distribution (indicated by size of circle) and each community's population trend between 1990 and 2005 (indicated by color of circle).

Overall, Alaska has one of the highest intra and interstate migration levels of any US state (Williams 2004b). However, these figures differ dramatically across BSAI communities. Based on ADLWD 2004 statistics, Lake and Peninsula and Aleutians East and West exhibit some of the highest gross migration rates in Alaska (21 to 30% of the population) compared to the lowest rates of gross migration (9.5 – 11.9%) in Nome, Wade Hampton, and Bethel (Williams 2004a). In Aleutians West, which includes the region's major fishing hub in Unalaska/Dutch Harbor, only 25% of the residents were born in Alaska, compared to 94.1% in Wade Hampton.

Alaska has the highest share of indigenous Americans of any US state (one person in five), and Alaska Natives make up 82% of the population in remote rural census areas, 90% when excluding regional hubs (Goldsmith et al. 2004). In the BSAI, the percent Native population is lowest among the Aleutians East (38.6%) and Aleutians West (22.5%) and highest in Wade Hampton (94.9%) and Bethel (85.5%), though there is significant variation between communities. This ratio is lowest among the Aleutians East and West however, where there are a high number of fishermen and processor employees and the seasonal labor pool outnumbers permanent residents.[62]

Throughout the BSAI region, communities may loosely maintain hub-spoke relationships shaped by demographic, cultural, and infrastructure dynamics. Only five of the 94 BSAI communities have a population over 1000. Three of these communities, Dillingham, Nome, and Bethel, are counted as regional hubs by the State of Alaska -- meaning they serve as transportation, service, communication, and trade centers for surrounding villages. The other two communities are Hooper Bay -- a predominately Native Alaskan community that had an estimated population of 1,133 in 2005 and is characterized as a remote community due to its relative inaccessibility, and Unalaska -- a major fishing industry hub of 4,287 people. Although these larger towns represent only about 5% of the BSAI communities, they bear nearly 39% of the resident BSAI population. Around 61% of the population lives in 85 communities of under 1,000 people, located mostly in coastal and riverine areas. More than 60% of these communities have a population under 400. BSAI settlement show less population concentration in hub communities than other arctic regions; 2/3 of the total Arctic population is concentrated in relatively large settlements of over 5,000 (Bogoyavlenskiy et al. 2004).

DISCUSSION

The two key factors affecting population growth rates anywhere are natural increase (birthrates subtracting mortality), and migration. In fishing communities within the BSAI region both factors affect population dynamics, but they intersect in important ways with issues of seasonality and ethnicity.

High birth rates among Alaska Natives (50% higher than that of non-Natives) account for steady natural increase in many BSAI area populations (particularly Wade Hampton and Bethel), which serves to off-set out-migration from these areas. While relatively low for more industrial fishing areas like Unalaska, the average of births per 1,000 people in rural BSAI communities was well above the Census year 2000 national average of 14.1. In 2001, the birth rate in Wade Hampton was 27.3. With steady increases in the Alaska Native population, the Native labor force will be 40% larger in 2020 than it was in 2000 (Goldsmith et al. 2006).

Swift and dramatic changes in residency and migration patterns account for some of the region's history of population trends and anomalies. The population of the BSAI region experienced disease-induced reduction of population similar to that all over Native North America following contact with Europeans, in this case Russian explorers and traders. Virtual enslavement and armed conflict between Aleuts and Russians were common in the Aleutians with the rise and fall of the fur trade, and led to the settlement of the previously unoccupied Pribilof Islands. In the Aleutian Islands, the population was literally decimated during this period, from an estimate of 12,000 in 1740 to 1,200 in 1800 (APIA 2004).

In the American period, the population of Alaska was low until it doubled with the gold rush at the end of the 19th century and it remained stable until WWII and the construction of the Alaska-Canadian Highway. Historically, the gold mining industry accounted for community growth, decline, and in some cases abandonment (e.g., Council and Mary's Igloo) in the Nome area, while the fishing industry accounts for similar boom-bust dynamics in the Aleutians and Bethel, Dillingham, and Lake and Peninsula areas. Dutch Harbor/Unalaska expanded into an international hub of the fishing industry with the king crab boom in the 1960s. An acute drop in ex-vessel prices for salmon has been the most likely significant driver of negative population growth in the latter two Census Areas in the last decade. Unlike many other parts of the state, the oil and gas industry has not been a direct factor in BSAI population dynamics.

Since WWII, the military has been a significant source of migration in the state, and perhaps the most important factor in sudden population changes in the BSAI region. In the 1940's Dutch Harbor housed a hastily developed, mixed military and civilian population of perhaps 40,000, several times the

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[62] Ships alone house a highly transient population that comprised nearly 20% of Unalaska's total population in 2000.

total population of the rest of the region. This dramatic population spike is not captured in the data because it fell between Census decades. Also in that time period, the Native population in the Aleutian Islands was dramatically redistributed following a forced evacuation off all Aleut villages by the U.S. military. After internment for the duration of the war in southeast Alaska, survivors were returned to the Aleutians, but a number of villages were never reconstituted (Kohlhoff 1995). The military population has declined from 10% of the total population of Alaska in 1990 to 7% in 2002. Downsizing and eventual closure of the military base closure in Adak accounts for Aleutians West population decline between 1992 and 1994, seen as a dramatic downward spike in Figure 5.

Patterns of human settlement and migration in Alaska have a long and continuing relationship to the availability of environmental resources – extending from small villages dependent on a mix of subsistence resources and wage labor, to the large population flows drawn by the fishing industry in industrial hubs like Unalaska. Generally, migration is an important coping strategy in the circumpolar North, where communities have long had to adapt to a highly dynamic environment. Studies of Arctic demography note, "the longevity of many Arctic cultures has been facilitated by adaptive responses such as migrations, rapid subsistence shifts, the development of new technologies, new economic practices, ecological manipulation, and other social and cultural transitions" (Robards and Alessa 2004: 416). The historical distribution of Native Alaskan settlements also depended upon the seasonality of subsistence resources, and migration was an effective adaptation to harsh, remote living conditions before this settlement pattern was replaced with more sedentary communities. Berardi (1999) describes the role played by schools in establishing permanent, or "persistent," villages at many of these remote locations in the early 20th century. He notes that schools today "have become part of the system of public services and transfers that maintains these population centers where they would not otherwise be supported by resource-based production" (Berardi 1999:345).

Although remote communities have become more spatially rooted in the last hundred years in the BSAI, migration in response to ecological and economic opportunities is still a key adaptation in BSAI areas – if in unexpected ways. Given the history of communities that have lost a resident population to become seasonal use areas, one might expect to see a decline in other remote rural areas as people migrate to larger regional hubs or urban centers in search of employment and education, particularly in response to fluctuations in the fishing industry and the expansion or contraction of opportunities for people in small communities. The net effect of migration on growth in rural villages in Alaska is in fact negative. However, in many BSAI communities, positive growth rates dominate. These positive growth rates are likely driven by natural increase, with particularly high birth rates among Native Alaskans. In-migration by foreign-born workers is also a factor in fishing industry hub communities.

In the rural spoke communities, return migration is also a factor. In the Alaska version of the Todaro Paradox, Huskey et al. (2004) describe the out-migration of young Alaska Natives to urban centers for education and work opportunities, and the return migration to remote rural areas despite the high levels of unemployment there. This return migration is partly due to the social benefit of family networks, and the sustenance and income from subsistence activities which are most successful in natal villages where traditional environmental knowledge is an asset (Huskey et al. 2004). Recent research in Bristol Bay Borough (Dunkersloot 2006) suggests that demographic response to economic change in the salmon fishery there has led to decreased out-migration and higher birth rates among Alaska Native women. Since Alaska Native female out-migration accounts for current gender imbalances in many villages, changes in their migration patterns have consequences for population structure and cultural practices (Hamilton et al. 1997). Migration patterns point to the long-standing and growing ties between rural BSAI communities and urban spaces, and between BSAI communities and the BSAI ecosystem.

Marine socioeconomic studies suggest that migration may be a common dynamic among communities dependent on fisheries -- a highly mobile and often seasonal and annually variable resource. Perry and Sumaila (2006) draw from their research in West Africa to demonstrate how migration has long been "an integral part of the fish production system" that has been driven by the seasonality of fish availability along with economic opportunities. Although movement across national borders has often come with challenges, migration of fisherfolk in this region has enhanced the resilience of the fish production system to different scales and patterns of climate, resource, sociopolitical, and economic variability.

Hub-spoke configurations may be characteristic of fishing communities in this region and more broadly. Hubs are large communities with a concentration of available services, such as Dillingham, Nome, Bethel and Unalaska. In the densely populated northeastern US, a recent participatory research project involving local fishing communities identified common concerns with fisheries infrastructure, finding that fishermen in smaller ports prioritized "access to a hub port" (Hall-Arber in press). Access to infrastructure is certainly a concern in Alaskan fishing communities as well, as communities have variable resources (e.g. ice facilities, docks, processing facilities) to participate in seasonal fishing industries. The relation between hubs and surrounding communities (economic, service, administrative, and demographic) deserves more research, as does the potential impact of CDQ programs in supporting the start and development of small processor plants and facilities in remote communities.[63]

BSAI communities are substantially tied to both subsistence and industrial fishing, though many small communities may operate on a scale that may be overlooked by regional or statewide research and administration. For example, fish processors in communities like Quinhagak and Chefornak may have a large local effect, but up until 2005 did not have a port code for the registration of annual government fish ticket reports. Community viability is an important consideration in small arctic communities as these places provide an important space for the flourishing of native Alaskan languages and culture and are important for the use and maintenance of natural resources, particularly due to place-based knowledge developed through a long history of adapting to the arctic environment.

Finally, the issue of seasonality also takes on significance in local demographic composition. As mentioned earlier, communities may swell with thousands of processor workers during peak fishing seasons. Research on social dynamics and impacts of the fishing industry in Unalaska argues that 'resident' becomes a contentious term when long-term locals become a minority with the influx of workers drawn to a fishing industry hub (Lowe 2006). Lowe draws from and refines prior social research in Unalaska to identify a continuum of 'localness' that is premised upon local observations of a person's length of community stay largely based upon profession or type of involvement in the fishing industry. Lowe uses this continuum to examine the significance of place-based knowledge. We believe this typology has the potential to enable predictive measures of differential population level effects of changes in fisheries management, markets, climate regimes, or dynamics within subsistence and industrial fisheries. In assessing the community level impacts of climate change in northern Canada, Duerden (2004) observes that mining communities with a high population turnover and younger population perceive and react to environmental changes differently than largely native communities that are more stable and have a higher population of elders. In the case of BSAI communities, a continuum of residency may identify those populations more likely to ebb and flow with socioeconomic opportunities as opposed to those with other kinds of investment that are more entrenched in the community.

Community Examples: Chefornak and Egegik

In order to understand these population trends more concretely, we selected two communities, Chrefornak and Egigik, for closer examination. To select these two, we first divided the communities into those showing positive average annual growth rates in the last 15 years and those showing negative average annual growth rates. We then selected the communities that were closest to the average in each group (see Figure 7).

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[63] The Coastal Villages Region Fund for example, has initiated small processing plants in Chefornak, Mekoryuk, Quinhagak, Tooksook Bay, Tununak, Hooper Bay, and Kipnuk. For some baseline socioeconomic data regarding the CDQ program, see Northern Economics, 2002.

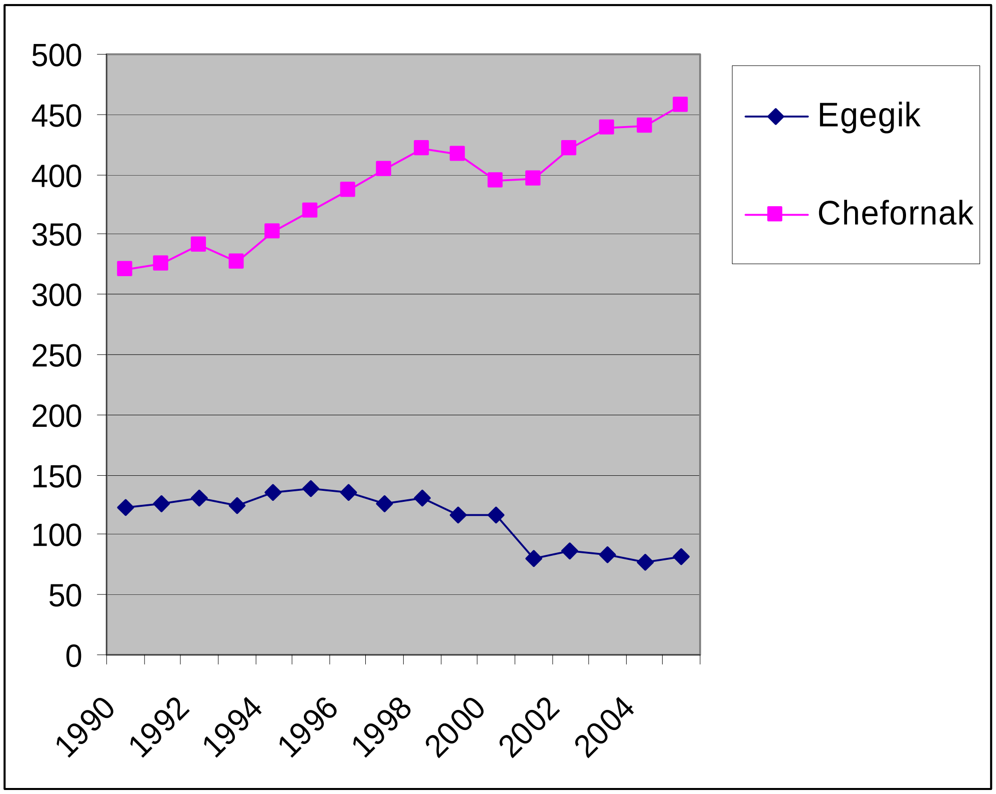

Figure 7. Recent population trends for Cherfornak and Egegik.

Chefornak, in the Bethel Census Area, is a BSAI community whose growth rate falls at the average 2.5% when compared with all the BSAI communities exhibiting a positive annual percent change since 1990. With a 2005 population of 457, Chefornak is only slightly larger than the average sized positive growth community of 373 (excepting hubs). While Chefornak falls in the average of population size and change, it is important to note that it does not represent an average community – the communities and Census areas of the Bering Sea and Aleutian Islands are a heterogeneous conglomeration. However, taking a closer look at Chefornak allows a more detailed portrait of a BSAI fishing community that has been growing steadily since 1920, and provides the opportunity to ground some of the details about demographic change in a local context. Similarly, although Egegik in the Lake and Peninsula Borough bucks the trend of positive average annual percent growth typical of many BSAI communities, it provides an example of a community that has had more erratic population change over time, and has largely been decreasing in population since 1990.

The Native village corporation of Chefornak, Chefarnrmute Inc, received title to their lands under the Alaska Native Claims Settlement Act in 1971 and Chefornak was incorporated as a second class city in 1974. Chefornak lies in the lower Kuskokwim region of the Bethel Census area along with 15 other villages, one of which, Umkumiut, is a seasonal fish camp without a permanent population. The original village site was on the coast, but was moved inland in the 1950's to avoid flooding. This is likely the reason Cherfornak does not appear in the US Census before 1950. All villages in this region are relatively isolated, but have an airport and are located on waterways that are navigable by boat. Chefornak is 98 air miles southwest of the regional hub, Bethel, where the closest offices of ADF&G and NMFS are found. Residents moved to the current village site in the 1950s to avoid flooding, however, flooding and permafrost melt remain challenges to villages in the region due to climate change, and at least one village, Newtok, is planning for relocation to Nelson Island (CVRF 2006). The population in the region grew rapidly in the 1950s and although the growth rate has slowed, it has been steadily increasing in population. The area has historically been occupied by Yup'ik Eskimos and as of the 2000 census, 98% percent of Chefornak residents identified themselves as all or part Alaska Native. The median age in the community was 20.8 years, significantly younger than the US average of 35.3. Population growth has largely been due to high birth rates – in the Bethel Census Area in general, high birth rates have offset out-migration that would otherwise have factored as an annual average net loss of 6.8 people per 1,000 from 1991 to 2003 (DCED 2006). There are no foreign-born immigrants in Chefornak.

Like most of the Bethel Census Area, there is a large variation in unemployment rates in Chefornak over the course of the year due to the seasonal nature of the economic base which has been impacted in recent years by decreased salmon runs and falling prices. While residents from Chefornak and local villages rely on subsistence resources and seasonal commercial fishing work, the school district along with other government positions are often the largest year-round wage employers (Alaska DNR 2005). Chefornak has one school K-12 with 147 students and 8 teachers. The median per capita income of Chefornak residents in 2000 was $8474. Unemployment measured by standard national techniques was 7.9% with 33.7% not seeking employment, although actual unemployment and underemployment is likely higher. Chefornak has wells and septic tanks, but no piped water or sewage. Only 10% of households have plumbing.

Cherfornak has some involvement in commercial fisheries. Chefornak falls under the Coastal Villages Region Fund CDQ group, which describes the village as a distressed community with a 25.2% poverty rate (CVRF 2006). However, through the CDQ program, a halibut buying and processing operation was started in Chefornak, with plans to expand it in the coming years. Coastal Villages Seafood Inc. also processes a small amount of salmon and halibut in the community but until recently did not have a port code. Twenty-four out of 56 locally held commercial fishing permits were fished in 2000, and there were 8 vessel owners in residence from federal fisheries. There are no docking facilities in Cherfornak, although boats do operate in the area.

Egegik, with a 2005 population of 81, outnumbered Chefornak between 1950 and 1970 (See Figure 8), although their populations were within a difference of 20 people during this time. However, by the 1980 census, Egegik fell from 148 people in 1970 to 75 people, while Chefornak increased from 146 to 230. Since then, Egegik has had more erratic fluctuations, and since 2000, is one of 5 communities in the Lake and Peninsula Borough that has fallen under a population of 100. When taking the average population change for all communities experiencing population loss between 1990 and 2000, Egegik falls at the average of –2.2% average annual change. Some of the increases and decreases between Census years in Egegik may be accounted for by the snapshot nature of the Census count in a highly seasonal fishing town; Egegik's population swells by 7 to 13 times its normal population, gaining as many as 1,000 to 2,000 cannery workers and fishermen during peak fishing season. Showing a much more transient population than Chefornak, only 44 houses of 286 were occupied in Egegik at the time of the 2000 Census. This figure compares to 7 houses vacant out of 82 in Chefornak.

The population of Egegik consists of 76.7% all or part Alaska Native of the Alutiiq culture, although the area was historically occupied by Yup'ik, Athabascan and Aleut people. The Native village corporation, the Becharof corporation, received title to lands under the Alaska Native Claims Settlement Act. There were no foreign born residents in Egegik at the time of the Census. The school in Egegik has one teacher and 12 students and the school could be in danger of losing funding if it falls below a student population of 10 (Sepez et al. 2005). Egegik was incorporated as a second class city in 1995.

Egegik's geographical position on the Alaskan Peninsula at the south bank of the Egegik River make it a prime location for salmon harvesting, particularly sockeye that travel through Bristol Bay to spawn in the Egegik. Consequently, the salmon fishery drives most of the local economy and employment, coupled with subsistence activities. Historically, the area was used as a seasonal fish camp by Native Alaskans. A commercial salmon saltery was built there in 1885, followed by a second saltery in 1930. Egegik, along with other Bristol Bay communities, has been highly impacted by a decline in the salmon industry. The DCCED records over $63,000 in salmon disaster relief has been allocated to the community. The Lake and Peninsula Borough has also received salmon disaster funds along with funds to mitigate the effects of closures designed to protect Steller sea lions.

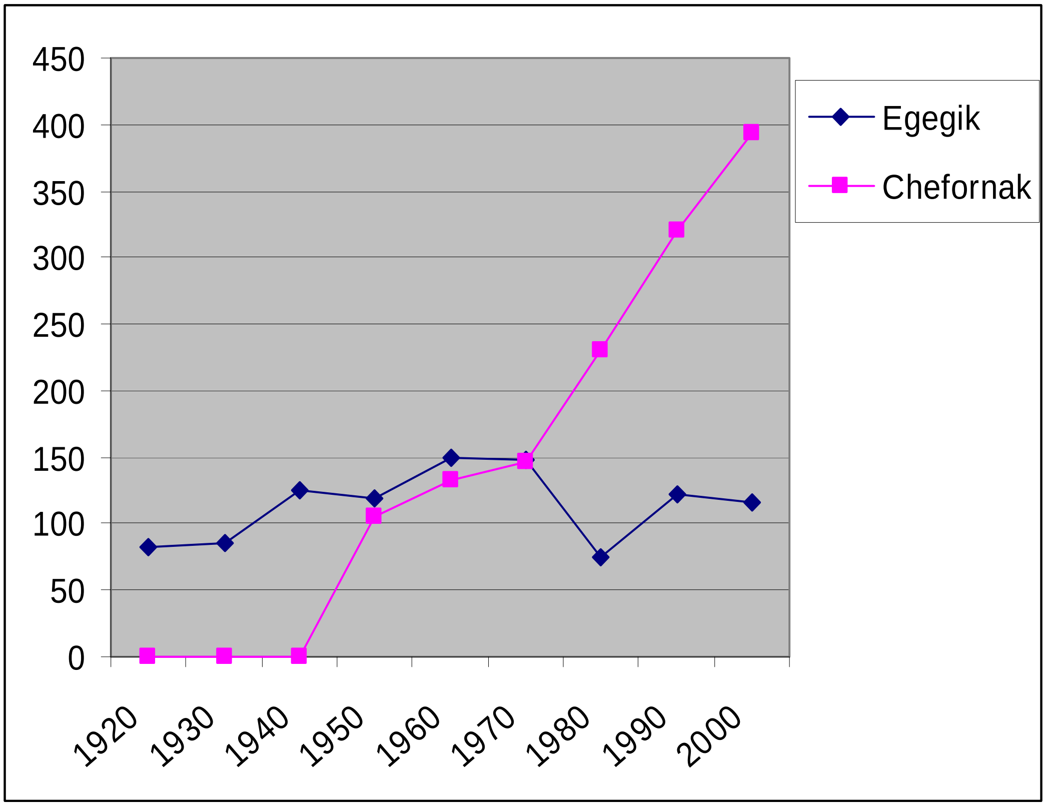

Figure 8. Historic population trends for Cherfornak and Egegik.

There are five on-shore processors around Egegik, along with a number of floating processors. Forty-six of 72 permits were fished in 2000. Local fishing facilities include a number of private docks, a recently constructed public dock, a harbor for up to 150 vessels, a boat haul-out, and marine storage facilities. Other community facilities include a sewage and water system. About 50% of households had plumbing. There are scheduled air flights and charter flights to Egegik, along with barge service from Seattle. Unemployment at the time of the 2000 Census was 27.59%, with an additional 51% of adults not seeking work. The median per capita income was nearly twice that of Chefornak, at $16,352, and 6.9% of residents were living below the poverty level. Egegik is also a CDQ community under the Bristol Bay Economic Development Corporation.

Egegik, with its higher per capita income, much lower poverty levels, and more developed infrastructure and facilities, would seem like a more likely place to grow than Cherfornak if these factors drove population trends. Between 1950 and 1970, both villages appeared to be on a similar growth trajectory. The apparent sudden growth of Cherfornak prior to that is an effect of the entire village having moved a mile inland at that time and does not likely represent a population explosion. It is reasonable to assume that the pre-1950 trajectory of Cherfornak was similar to that of Egegik. What put them on such different paths after that?

The explanation we propose is tied to the ecosystem: Egegik's much greater dependence on Bristol Bay salmon fisheries has been a key influence in its population history. Chefornak is not subject to the influence. At the time of the 2000 Census, Egegik had 39 salmon permit holders and a population of 116, or 34% of residents. This compares to Cherfornak with only 7 salmon permits in a population of 394 (or 2% of residents). Cherfornak residents appear to be involved more in halibut (27 permits) and herring

(22 permits) fisheries. Egegik residents are also involved in these fisheries (10 halibut permits and 21 herring permits). Both communities are tied to other Bering Sea fisheries by participation in CDQ groups.

If reliance on commercial salmon fisheries is an important factor influencing the population in Egegik, we would expect to see population fluctuations that co-occur with significant events in the salmon fishery in the directions expected. That is in fact exactly what we see for Egegik. In 1974 the State implemented a limited entry management system in the salmon fisheries and this has been reported to have had severe negative effects on Native Alaskan participation in this fishery (Langdon 1980, Koslow 1986). The population in Egegik fell. The late 1980's and early 1990's were a boom era for salmon and salmon prices, perhaps accounting for the population increase at that time. The population in Egegik rose. Next came a sharp decline in salmon prices paid to harvest vessels, exacerbated in this region by a series of exceptionally low runs of the primary salmon species, sockeye *(Oncorhynchus nerka),* and a return to negative population growth for Egegik.

Recent research in Bristol Bay Borough villages suggests that salmon prices are in fact a key indicator of demographic patterns in the area, though the specific patterns are intertwined in complicated ways with age, ethnicity, and gender (Dunkersloot 2006). When we selected Chefornak and Egegik for more detailed examination, we had no idea that we would find such a rich contrast. We merely wanted to look at the average places for both positive and negative trends. The fact that we found something suggesting such a strong connection to ecosystem factors implies that further examination of communities could be very productive for the long term goal of modeling BSAI human population dynamics. Research might start with an examination of other BSAI communities dependent on commercial sockeye fisheries in Bristol Bay, in comparison to similar communities not dependent on that fishery. We also suggest examining the array of other BSAI communities in terms of other ecosystem and social factors such as CDQ group inclusion, hub and spoke characteristics, and effects of fisheries management (through such concepts as efficiency and equity, productivity and profit). Research methods should include retrospective modeling to uncover correlations between observed trends and ecosystem events, ethnographic field work to untangle connections between individual characteristics and migration and reproduction behaviors, and forecast development to couple BSAI bioeconomic model outputs with demographic predictions.

Conclusion

This study demonstrated that the BSAI has experienced regional population growth in recent years (since 1990), and population growth as a longer term trend (since 1920). However, this growth has not been experienced uniformly by all communities or all boroughs (and Census areas). Although there is a net outmigration from rural Alaska, many rural communities in the BSAI are experiencing growth. Much of this growth is driven by a high birth rate among Native Alaskans. In-migration consists of both a return migration to Alaska Native villages from urban areas and in-migration to fishing community hubs driven by fishing industry dynamics. Population loss is seen most clearly in the Lake and Peninsula and Bristol Bay Boroughs, also likely in response to fishing industry dynamics. More research is necessary to establish the specific linkages between population dynamics and the ecosystem.

Population decline or growth in small communities can have a variety of impacts, as demographic information affects decision-making in government and private fields, and factors into health care provision, education, land use, environmental impacts, transportation, and other social services (Williams 2004a). Over 36% of federal dollars allocated to Alaska depend in some way on population, and CDQ quota shares are also provisioned in relation to population numbers. In the Gulf of Alaska, local community organization leaders have argued that the loss of fishing jobs due to salmon limited entry programs has led to population decline coupled with other social problems, including the perception of diminished local educational opportunities (Christiansen 2000). A baseline of demographic data and its analysis in relation to other socio-economic and ecological factors can provide a means for evaluating such claims and for assessing how and in what situations demographic change intersects with other scales of change over time, what Robards and Alessa (2004) term “timescapes” of change – the often nonlinear relationships between demographic, social, ecological, seasonal, and institutional dynamics.

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