Report on the Bycatch of Marine Mammals and Seabirds by the US West Coast Groundfish Fleet

Northwest Fisheries Science Center

At-sea Hake Observer Program

West Coast Groundfish Observer Program

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Abstract

Bycatch estimates of incidental takes of marine mammals and seabirds by groundfish fisheries off the West Coast of the United States are presented by species, year, area, and fishery. Ratio estimators were used to calculate the bycatch estimates for each fishery from data collected by the At-Sea Hake Observer Program (A-SHOP) between 2002 and 2006 and the West Coast Groundfish Observer program (WCGOP) between 2002 and 2005. During the years analyzed, six marine mammal species, including eight threatened stellar sea lions and eight seabird species, including one endangered brown pelican, were observed killed or seriously injured in the observed groundfish fisheries. In addition, estimates for one marine mammal group and seven seabird groups which were not identified to the species level were determined.

Introduction

Estimating marine mammal and seabird bycatch in commercial fisheries is an important component to assessing the impact of a fishery on marine mammal and seabird populations. In addition, three key environmental laws in the United States regulate actions concerning marine mammals and seabirds, the Marine Mammal Protection Act (MMPA), the Endangered Species Act (ESA), and the Migratory Bird Treaty Act (MBTA).

Marine Mammal Protection Act

The MMPA was passed in 1972 and was amended in 1994. The act states that marine mammal species and population stocks should not be permitted to diminish below their optimum sustainable population level and that measures must be taken to replenish depleted species or population stocks. Measures include reduction in the taking of marine mammals in US waters, by US citizens on the high seas, and on the importation of marine mammal and marine mammal products into the United States.

The effect each US commercial fishery has on marine mammal populations is determined annually and reported in the List of Fisheries (LOF), which is published by the National Marine Fisheries Service (NMFS) as required by section 118 of the MMPA (16 USC 1387(c)(1)). Each fishery is placed into one of three categories based on the level of marine mammal serious injury and mortality in the fishery. The categorization process often relies on Marine Mammal Stock Assessment Reports (SAR) to provide the allowable biological removal level of the stock that ensures a sustainable population is maintained. The categorization level of a fishery determines if compliance is required with particular provisions of the MMPA, including registration, observer coverage, and take reduction plans. Category I and Category II commercial fisheries are required to comply with MMPA provisions, while Category III commercial fisheries are not.

The West Coast groundfish fisheries included in this report are all classified as Category III commercial fisheries in the context of the MMPA (72 FR 35393). All West Coast groundfish fisheries are included in the LOF, however, fisheries are grouped differently for management purposes and observer program coverage.

Endangered Species Act

The purpose of the ESA of 1973 is to protect and recover imperiled species and the ecosystems upon which they depend. Once a species is listed under the ESA, protective measures are authorized, which may include restrictions on taking, transporting, or selling a species. NOAA Fisher-

ies has jurisdiction over approximately 60 marine and anadromous species listed under the ESA (http://www.nmfs.noaa.gov/pr/species/esa/).

Migratory Bird Treat Act

The Migratory Bird Treaty Act of 1918 is the domestic law that affirms, or implements, the United States' commitment to four international conventions (with Canada, Japan, Mexico, and Russia) for the protection of a shared migratory bird resource. The MBTA decreed that all migratory birds and their parts (including eggs, nests, and feathers) are fully protected. Violation of the Act carries criminal penalties and to date, the Act has been applied to the territory of the United States and coastal waters extending 3 miles from shore.

West Coast Groundfish Fisheries

Fishery Management

The Pacific Fisheries Management Council (PFMC) is responsible for managing the commercial fisheries off the West Coast of the United States under the Pacific Coast Groundfish Fishery Management Plan which contains over 80 fish species. The groundfish fishery is divided into four sectors, limited-entry, open access, recreational, and tribal. The limited-entry fisheries are federally permitted, with the number of available permits capped. Open access fisheries are not federally permitted but state agencies (California Department of Fish and Game and Oregon Department of Fish and Wildlife) instituted permitting in 2003 and 2004 for a portion of the open access fishery, which primarily operates in state waters (0-3 miles from shore). The PFMC uses regulatory landing limits and cumulative periods to strive for maintaining year-round fishing, processing, and marketing opportunities. Landed catch is monitored by a system of state landing receipts (fish tickets).

In May 2001, the NOAA Fisheries (NMFS), in accordance with the Pacific Coast Groundfish FMP (50 CFR Part 660) (66 FR 20609), instituted an observer program to provide total catch monitoring of the non-Pacific hake (whiting) groundfish fisheries off the West Coast of the US. This regulation required all non-Pacific hake vessels that catch and retain groundfish in the United States Exclusive Economic Zone (EEZ) from 3-200 miles offshore carry an observer when notified to do so by NMFS or its designated agent. Subsequent regulations in 2004 provided for mandatory observer coverage for at-sea processing vessels in the Pacific hake fishery (69 FR 31751) and state-issued rulings have extended NMFS's ability to require that California and Oregon vessels that fish in the 0-3 mile state territorial zone to carry observers. The At-Sea Hake Observer Program (A-SHOP) deploys observers on catcher-processors and motherships that target Pacific hake. The West Coat Groundfish Observer Program (WCGOP) deploys observers on vessels that catch groundfish (excluding hake) and deliver to shoreside processors.

At-Sea Hake Observer Program

Observers were first deployed in the Pacific hake fishery in the late 1970's and managed under the North Pacific Groundfish Observer Program (NPGOP) at NMFS's Alaska Fisheries Science Center. Since 2001, the program has been based out of the Northwest Fisheries Science Center.

The A-SHOP places fisheries observers on all vessels that process Pacific hake at-sea. The at-sea fishery consists of eight to fourteen catcher-processor vessels and motherships that target Pacific

hake with mid-water trawl nets. The at-sea hake fishery starts in mid-May and remains open until the quota is taken or bycatch caps are met.

West Coast Groundfish Observer Program

Observers were first deployed in non-Pacific hake groundfish fisheries in 2001. WCGOP observers are placed on vessels using trawl, longline, pot, and a variety of other hook and line gear to target groundfish species. Between 2002 and 2005, the number of active vessels participating in each of these fisheries ranged from 90-150 limited-entry trawlers, 100-150 limited-entry sablefish hook and line or pot vessels, 25-35 limited-entry non-sablefish vessels and 200-300 vessels in the state nearshore fisheries. All retained catch is landed at shoreside processors, with the exception of one sablefish at-sea processor.

The WCGOP observes the limited-entry bottom trawl fishery, the limited-entry sablefish-endorsed and non-sablefish-endorsed fixed-gear fisheries and the Oregon and California state nearshore fisheries, which together catch the majority of non-Pacific hake groundfish. The WCGOP is expanding coverage into the open access fixed gear fleet, but does not observe any recreational fisheries, the Pacific halibut fishery, tribal fisheries nor the shore-base hake fishery. Details on the coverage of each observed fishery varies by year, program priorities and funding. Further detail on the WCGOP Coverage Plan and coverage rates are available at: http://www.nwfsc.noaa.gov/research/divisions/fram/observer/index.cfm.

Methods

The sampling protocols for the A-SHOP are different from the WCGOP, partly because the at-sea hake fishery processes their catch at-sea, while the non-Pacific hake groundfish fisheries deliver retained catch to shoreside processors. One fundamental difference in the sampling between the two fisheries is that on the at-sea hake vessels, the observers subsample total catch, both retained and discarded fish, while on west coast groundfish vessels, observers primarily sample discarded catch. Fish tickets and port sampling data are used to determine the composition of retained catch in WCGOP observed fisheries. The second notable difference in the fisheries is that in the at-sea hake fishery there are two observers on all vessels. Therefore, close to 100% of all tows in the fishery are sampled. In contrast, only a portion of vessels are observed at any given time in the non-Pacific hake groundfish fisheries. Coverage rates (as a percentage of observed landings) by year and fishery ranged from 0% to over 30% from 2002 - 2005. Although there is only one observer on each vessel in WCGOP observed fisheries, since the catch volume is lower and trips are shorter, WCGOP observers generally sample all hauls within a trip.

In all fisheries, observers document all interactions with marine mammals. Observers record a code that best describes the interaction that occurred between the animal and the fishing vessel. Table 1 lists the interaction types available to observers and whether or not they are considered a take. Only those interactions considered takes were used for this analysis.

Due to these differences between the at-sea Pacific hake fishery and the non-Pacific hake fisheries, the methodology used to estimate marine mammal and seabird bycatch is described separately.

TABLE 1. Marine Mammal Interaction Coding

MM Interaction Description	Take or Interaction
Feeding on Catch	Interaction
Deterrence Used	Interaction
Boarded Vessel	Interaction
Killed by Gear	Take
Killed by Propeller	Take
Previously Dead	Interaction
Lethal Removal (trailing gear)	Take
Lethal Removal (Not trailing gear)	Take
Entangled in Gear (trailing gear)	Reviewed for severity of interaction. If it caused a serious injury that likely resulted in death, then it was recorded as a take. If not, then it was recorded as an 'interaction'.
Entangled in Gear (not trailing gear)	Reviewed for severity of interaction. If it caused a serious injury that likely resulted in death, then it was recorded as a take. If not, then it was recorded as an 'interaction'.
Other	Reviewed for severity of interaction. If it caused a serious injury that likely resulted in death, then it was recorded as a take. If not, then it was recorded as an 'interaction'.
Unknown	Reviewed for severity of interaction. If it caused a serious injury that likely resulted in death, then it was recorded as a take. If not, then it was recorded as an 'interaction'.

At-Sea Hake Observer Program

Selection Process

All catcher-processor and mothership vessels over 125 feet in the at-sea hake fishery are required to carry two observers, while those vessels under 125 feet only carry one observer. Since 2002, all catcher-processors and motherships have carried two observers.

Data Collection

At-sea hake fishery observers monitor and record catch data following protocols in the NPGOP and A-SHOP Manuals (AFSC 2006, current manual available at: http://www.afsc.noaa.gov/FMA/Manual_pages/MANUAL_pdfs/manual2007.pdf, NWFSC 2006, current manual available at: http://www.nwfsc.noaa.gov/research/divisions/fram/observer/observermanual/hake_manual2007.pdf).

A-SHOP observers monitor for marine mammals and seabirds in two distinct ways. First, if a marine mammal or seabird was taken and is present in their species composition sample, the appropriate information (including weight, length, etc.) is documented. Observers also monitor the dumping of some tows at the deck level for the presence of marine mammals, as marine mam-

mals are often too large to make it below deck where the observer samples. As sampling catch for species composition is an observer's highest priority, only approximately 50% to 70% of tows are monitored on deck during dumping. Observers also record information on all interactions seen between fishing operations and marine mammals and seabirds and as time allows, document sightings as well. It should be recognized that some incidental marine mammal or seabird interactions resulting in mortality could occur when this fishery's trawl gear is being set or due to collision with the trawl door warp wires while the vessel is fishing. These interactions would be missed as observers do not monitor the setting or fishing of the gear.

As two observers are on-board each vessel, nearly 100% of tows are sampled for species composition. Due to the large volume of the catch (generally >60mt per haul), observers sample, on average, about 50% of each haul for species composition. Therefore, any bycatch of seabirds found in a species composition sample must be expanded within the haul the seabird is caught. Often, this results in the observation of one seabird expanding to two, depending on the observer's sample size of a tow. However, since every vessel is observed and close to 100% of the entire fleet's hauls are sampled, the bycatch expansion to the entire fishery is quite small. Bycatch of marine mammals, which due to their larger size are not missed, do not have to be expanded within the haul, but do have to be expanded to include unmonitored hauls.

Data Quality Control and Management

The A-SHOP uses comprehensive quality control procedures. Every observer in the at-sea hake fishery has a mid-season data check and a final debriefing. Mid-season data checks include data assessment, discussions on methods employed, and resolution of difficulties encountered. A final debriefing interview includes data form checks, observer logbook review and data entry checks.

Data Processing and Analysis

Processing data collected by the A-SHOP is simplified because the total catch is sampled and the dataset does not rely on a complementary external data source.

Marine Mammals

To estimate the total bycatch of marine mammals in the at-sea hake fleet, only tows that were monitored (on deck) for marine mammals were used. Once a bycatch rate was calculated from these monitored tows, it was expanded up to the entire fleet using total catch. Total catch of the at-sea hake fishery was aggregated into management areas based on fishing location. These areas were originally developed for the International North Pacific Fisheries Commission (INPFC from 1952-1992) and evolved into the current area definitions. The delineation of these management areas by latitudinal breaks are as follows:

Vancouver: Latitude > 47º 30 ' N lat.

Columbia: Latitude between 43° N lat. and 47º 30' N lat.

Eureka: Latitude between 40° 30' N lat. and 43° N lat.

Monterrey: Latitude between 36° N lat. and 40° 30' N lat.

Conception: Latitude < 36° N lat.

Bycatch estimates of marine mammal takes were calculated using the ratio estimator technique (Cochran 1977). The ratio estimator technique has also been applied to calculate marine mammal bycatch estimates in other fisheries such as Alaska (Perez 2006) and previously for the at-sea hake fleet (Perez 2003). As previously mentioned, observer sampling methods in the at-sea hake fishery are very similar to the methods used by observers in the Alaska groundfish trawl fisheries.

Ratio estimates (R*ij*) were calculated by management area *i* and year *j*:

$$R_{ij} = \frac{\sum_t y_{ijt}}{\sum_t x_{ijt}}$$

where:

y_{ijt} = the number of takes in management area *i* and year *j* in tow *t*,

x_{ijt} = lbs of total catch in management area *i* and year *j* in tow *t*.

The variance of R_{ij} is approximated by using the following equation (Cochran 1977):

$$Var(R_{ij}) = \frac{1-f}{n}\left(\frac{\bar{y}_{ij}}{\bar{x}_{ij}}\right)^2\left(\frac{s^2(y_{ij})}{\bar{y}^2_{ij}} + \frac{s^2(x_{ij})}{\bar{x}^2_{ij}} - 2\left(\frac{\sum_t (y_{ijt}-\bar{y}_{ij})(x_{ijt}-\bar{x}_{ij})}{\bar{y}_{ij}\bar{x}_{ij}}\right)\right)$$

where

$\bar{y}_{ij}$ and $\bar{x}_{ij}$ = the means of y_{ij} and x_{ij},

$s^2(y_{ij})$ and $s^2(x_{ij})$ = the variances of y_{ijt} and x_{ijt}.

$$f = \frac{d_{obs}}{d_{total}}$$

where:

d_{obs} = the total catch on all observed hauls that was monitored for marine mammals,

d_{total} = the total catch from the entire fishery.

Note that Var(R_{ij}) cannot be calculated when $\bar{x}_{ij} = 0$ or $\bar{y}_{ij} = 0$ for all tows/sets and should be used with extreme caution when R_{ij} is equal to one. One advantage in using this estimator is that it does not assume independence of the numerator and denominator.

The marine mammal bycatch was estimated by multiplying the bycatch ratio by the total fishery catch weight using the following formula:

$$B_{ij} = T_{ij}R_{ij}$$

where

B_{ij} = Bycatch in management area *i* in year *j*,

T_{ij} = Weight of total catch in management area *i* in year *j*.

The formula used to calculate the bycatch ratio variance is:

$$Var(B_{ij}) = T_{ij}^2 Var(R_{ij})$$

A lognormal approximation (Burnham et al. 1987) was used to calculate the confidence intervals using the following formulas:

$$C_{ij} = \exp(z_{\alpha/2}\sqrt{\ln(1 + (cv(B_{ij}))^2)})$$

$$L_{lowerij} = \frac{B_{ij}}{C_{ij}}$$

$$L_{upperij} = B_{ij}C_{ij}$$

where

$Z_{á/2}$= the quantile from the standard normal distribution corresponding to significance of *á*,

L = The lower and upper bounds of the confidence interval,

$CV(B_{ij})$ = Coefficient of variation of B_{ij}

The advantage in using this approximation is that it captures the skewed nature of the distribution and avoids calculating lower bounds less than zero.

For each species, the total takes in each year is calculated by summing the bycatch estimates across all of the groundfish management areas. The variance for each year is also calculated by summing the variance estimates across all of the groundfish management areas.

Seabirds

To estimate the total seabird bycatch in the at-sea hake fishery, all of the sampled tows were used as the seabirds were mixed in with the fish catch. Once the bycatch of seabirds is expanded to within all the sampled tows, the estimate is expanded up to the entire fleet. Approximately 99% of the tows in the fishery were sampled. This method for calculating seabird bycatch is the same as the method for calculating fish bycatch in the at-sea hake fishery.

The total number of takes of a seabird species in each tow was calculated using the following formula:

$$Y_{ts} = y_{ts} \cdot \frac{W_t}{w_t}$$

where

Y_{ts} = the total number of takes of species *s* in tow *t*,

y_{ts} = the number of observed takes of species *s* in tow *t*,

W_t = the weight of the total catch in tow *t*.

w_t = the weight of the subsample in tow *t*.

The total number of takes of seabird species in the fishery was calculated using the following formula:

$$B_s = \sum_t Y_{ts}\left(\frac{C_{Tot}}{C_{obs}}\right)$$

where

B_s = the bycatch estimate for species *s*,

C_{Tot} = the total catch from the fishery,

C_{Obs} = the catch from the observed fishery.

In regard to an estimate of uncertainty, with the data available, only the variation between tows could have been calculated. The data does not contain the necessary replicates for calculating within tow variation. Furthermore, as 99% of the tows were sampled, the between tow variation will be quite small.

West Coast Groundfish Observer Program

Selection Process

In the non-Pacific hake groundfish fisheries, permits are selected for observation by the WCGOP using random sampling without replacement. First, the WCGOP determines the amount of time (based on available resources) it will take to observe the entire fleet; this is termed the selection cycle. Next, the WCGOP aggregates locations along the US west coast into port groups. The permits/vessels in each fishery are assigned to a port group based upon the location of the previous year's landings. Within each port group, the permits/vessels are randomly selected for coverage. The limited-entry trawl, limited-entry non-sablefish-endorsed fixed-gear, and the Oregon-California state nearshore fisheries are selected for two-month periods, which coincide with two-month cumulative trip limit periods used in management. Limited-entry sablefish-endorsed fixed-gear permits are selected for the entire sablefish season (April 1 to October 31) until their quota is caught. This selection process is designed to produce a logistically feasible sampling plan with a distribution of observations throughout the entire geographic and temporal range of the fisheries. Once a permit/vessel has been selected for coverage, the WCGOP attempts to observe all trips and sample all tows/sets a vessel makes during the coverage time period.

Data Collection

Fisheries observers monitor and record catch data on commercial fishing vessels by following protocols in the WCGOP Manual. Observer sampling focuses on discarded catch and supplements existing fish ticket landing receipt data on retained catch. Observers generally sample 100% of tows/set on a trip. On trawlers, the observers focus their effort on discarded catch. The total weight of discarded catch is estimated, and the discarded catch is sampled for species composition. The species composition sample may be a census or a subsample of all discard. On fixed gear vessels (hook and line and pot gear), observers sample total catch (similar to at-sea hake observer sampling methodology) and sample anywhere from 30% to 100% of the catch from each

set. As marine mammals are large and unlikely to be missed, any takes during observed trawl tows are included when estimating bycatch. Since seabirds are smaller and blend more easily with fish catch, they may be fully accounted for only in the sampled portion of the catch. Therefore, if a seabird falls outside of the sampled portion of the set, that seabird is observed and noted; however, it is not included when calculating the estimates. WCGOP observers sample protected resources when the following occurs; a protected species is caught by the fishing gear, a marine mammal, seabird, or sea turtle interacts with the fishing vessel but does not get caught in the gear, or an ESA marine mammals seabird or sea turtle is sighted. Sightings of non-ESA listed marine mammals and seabirds (which are not interactions or takes) are only documented when time allows. As in the hake fishery, it should be recognized that some incidental marine mammal or seabird interactions could occur when gear is being set. These interactions would be missed as observers do not monitor the setting of gear as they are engaged in sampling the catch on-board.

Data Quality Control and Management

The WCGOP uses comprehensive quality control procedures. After entering the data, the observers are debriefed by WCGOP staff following every two-month cumulative trip limit period. The debriefing includes calculation checks, data form checks, sampling methodology checks, observer logbook review, an interview and a data entry check. Every six months, automated database quality control queries are run to detect data that fall outside specified ranges and identify other inconsistencies between data elements. Any inconsistencies found by the queries are reviewed and corrected as needed.

Data Processing and Analysis

The only available metric of total effort in the non-Pacific hake fisheries is retained/landed catch. Logbooks are only available in the bottom trawl fleet and only record retained catch, not total catch. Therefore, estimating bycatch of marine mammal and seabirds in these fisheries is a two-step process. First, bycatch is expanded within a tow/set. This provides an estimate of bycatch in the observed portion of each fishery. This observed rate is then expanded to the entire fleet using retained catch (fish tickets), by area.

After quality control, WCGOP data are processed. First, a tow/set-level expansion is needed to estimate the total retained and discarded weight for each species because of the sampling procedure that derives the species composition. If the species composition of a catch category is mixed, an observer may take a subsample from the catch category. Due to differences in data collection methods, the equations used for expanding a subsample to the tow/set level differ between trawl and fixed gear vessels.

For data from trawl trips, the following equation is used to calculate the weight of the subsample by summing across the observed weights of the individual species:

$$w_k = \sum_s x_{ks}$$

where

x_{ks} = observed weight of the species s in the subsample of catch category k,

w_k = weight of the subsample from catch category k.

The sampling ratio (R_k) used to scale the subsample weights to the amount in the catch category is calculated by dividing the weight of the subsample by the total weight of the catch category using the equation:

$$R_k = w_k / y_k$$

where

y_k = the total weight of catch category *k*.

The tow-level expanded weight of species *s* in category *k* is calculated by dividing the species weight in the subsample by the sampling ratio in the following equation:

$$X_{ks} = x_{ks} / R_k$$

where

X_{ks} = the weight of species *s* in catch category *k*.

Tallying the weight (X_{ks}) of the species *s* across all categories *k* within a tow provides the total weight of the species retained and/or discarded.

For data from fixed-gear (longline) trips, the following equation is used to calculate the weight of the retained and discarded catch of each species in a set:

$$X_s = x_s \frac{H}{h}$$

where

X_s= the calculated weight of species *s* in the set,

x_s = observed weight of the species *s* in the subsample,

H = the total number of hooks in a set,

h = the number of hooks sampled in a set.

After the data is expanded to the tow/set level, the data are adjusted so that the observed total trip pounds of retained fish in a catch category (as recorded by the observer) matches the total trip pounds on the fish ticket. Doing so ensures that the observed landings are comparable to unobserved landings when expanding bycatch estimates up to the entire fleet. To match the total trip pounds, the weights of each observer retained catch category are scaled up or down by the ratio of fish ticket and observer trip weights for that category, using the following equation to calculate the adjustment factor:

$$A_{mtk} = \frac{x_{mtk}}{\sum_k x_{mtk}}$$

where

x_{mtk} = observed lbs in catch category *k* in tow/set *t* in trip *m*

A_{mtk} = adjustment factor used for catch category *k* in tow/set *t* in trip *m*.

The equation used to adjust at-sea observer catch category weight is:

$$x'_{mtk} = A_{mtk} \cdot C_{mk}$$

where

x'_{mtk} = adjusted weight (lb) in catch category *k* in tow/set *t* in trip *m*,

C_{mk} = lb in catch category *k* for trip *m* recorded on the fish ticket.

When a catch category in the WCGOP data cannot be matched to a fish ticket species category, the WCGOP data are not adjusted and the original at-sea value is kept. Catch categories found only on the fish tickets were distributed across the tows/sets using the proportion of the observed catch per tow/set divided by the total observed catch per trip using the following equation:

$$B_{mt} = TotalWeightpertow/Totalweightpertrip = \left(\sum_k \sum_s x_{mtks}\right) / \left(\sum_t \sum_k \sum_s x_{mtks}\right)$$

$$C_{mtk} = B_{mt} \cdot C_{mk}$$

where

B_{mt} = the proportion of observed catch in tow/set *t* in trip *m*

C_{mtk} = lbs in catch category *k* for tow/set *t* in trip *m* recorded on the fish ticket.

For example, an observer monitors 1,400 hooks of a longline set of 2,812 hooks on a vessel. In the 1,400 hooks, the observer records the take of one Western gull. That one take is expanded to the entire set and total bycatch of gulls in this set is two. After landing their catch, the vessel receives a fish ticket. The fish ticket weight is considered more accurate than the measurement of retained catch while at sea. So the observer estimates of at-sea retained catch are adjusted on a per set basis to reflect any changes due to the total retained weight on the fish ticket. Once this within set expansion and retained weight adjustment is made, any bycatch on observed trips is expanded to the entire fishery in each management area using the total retained weights from fish tickets. Therefore, if this Western gull was caught in the Vancouver management area and a total of 20% of the retained weight in this fishery was observed there, the two gulls would be expanded to 10 total birds in that strata.

Several factors were considered in selecting and analyzing the available data in each fishery. For the limited-entry groundfish trawl fishery, the dataset analyzed included bottom trawl tows fished using both large and small footrope gear configurations. Danish/Scottish seine gear was excluded from this analysis because this gear type differs substantially from the other bottom trawl gear and is used by only one trawl vessel on the West Coast. For the limited-entry sablefish-endorsed fixed-gear fishery, the dataset analyzed included both longline and pot gear. However, no seabird or marine mammal takes were observed during sets using pot gear, so the analysis of this fishery focused on the longline data. The observed limited-entry non-sablefish-endorsed fixed-gear fishery data only included longline gear. In the Oregon and California nearshore fisheries, no marine

mammal or seabird takes were observed, and thus no analysis of the nearshore fishery was conducted.

Observations from WCGOP covered fisheries and landings made by these fisheries were aggregated into the groundfish management areas based on return port. Groundfish management areas are published in the bi-annual fishery specifications and management measures for the US west coast groundfish fisheries, contained in the Federal Register. These area delineations were originally developed for the International North Pacific Fisheries Commission (INPFC from 1952-1992) and evolved to the current area definitions. The delineation of these management areas by latitudinal breaks are as follows:

Vancouver: Latitude > 47º 30 ' N lat.

Columbia: Latitude between 43° N lat. and 47º 30' N lat.

Eureka: Latitude between 40° 30' N lat. and 43° N lat.

Monterey: Latitude between 36° N lat. and 40° 30' N lat.

Conception: Latitude < 36° N lat.

For marine mammal and seabird takes in the limited-entry trawl, limited-entry sablefish-endorsed fixed-gear, and limited-entry non-sablefish-endorsed fixed-gear fisheries, bycatch estimates were calculated using the ratio estimator (Cochran 1977). The ratio estimator has also been applied to calculate marine mammal bycatch estimates in other fisheries such as Alaska (Perez 2006). The ratio estimates (R*ij*) were calculated by management area *i* and year *j:*

$$R_{ij} = \frac{\sum_{m} y_{ijm}}{\sum_{m} x_{ijm}}$$

where

y_{ijm} = the number of takes in management area *i* and year *j* in trip *m*,

x_{ijm} = lb of target species in retained catch in management area *i* and year *j* in trip *m*.

The target used in the limited-entry bottom trawl fishery is the summary weight of those species listed in Table 2. The target is sablefish in both the limited-entry sablefish-endorsed and non-sablefish-endorsed fixed-gear fisheries.

The variance of R_{ij} is approximated by using the following equation (Cochran 1977):

$$Var(R_{ij}) = \frac{1-f}{n}\left(\frac{\bar{y}_{ij}}{\bar{x}_{ij}}\right)^2\left(\frac{s^2(y_{ij})}{\bar{y}^2_{ij}} + \frac{s^2(x_{ij})}{\bar{x}^2_{ij}} - 2\left(\frac{\sum_{t}(y_{ijm}-\bar{y}_{ij})(x_{ijm}-\bar{x}_{ij})}{\bar{y}_{ij}\bar{x}_{ij}}\right)\right)$$

where

$\bar{y}_{ij}$ and $\bar{x}_{ij}$ = the means of y_{ijm} and x_{ijm},

$s^2(y_{ij})$ and $s^2(x_{ij})$ = the standard errors of y_{ijm} and x_{ijm}.

$$f = \frac{d_{obs}}{d_{total}}$$

where

d_{obs} = the total retained catch on an observed trip that included groundfish species.

d_{total} = the total retained catch from fish ticket landing receipts.

Note that $Var(R_{ij})$ cannot be calculated when $\bar{x}_{ij} = 0$ or $\bar{y}_{ij} = 0$ for all tows/sets and should be used with extreme caution when R_{ij} is equal to one. One advantage in using this estimator is that it does not assume independence of the numerator and denominator.

The marine mammal and seabird takes were estimated by multiplying the bycatch ratio by the total of the target weight from fish ticket landing receipts using the following formula:

$$B_{ij} = T_{ij}R_{ij}$$

where

B_{ij} = Bycatch in management area *i* in year *j*,

T_{ij} = Total catch of target weight from fish tickets in management area *i* in year *j*.

The formula used to calculate the bycatch ratio is:

$$Var(B_{ij}) = T_{ij}^2 Var(R_{ij})$$

TABLE 2. Species classified as groundfish in the limited-entry trawl fishery for the calculation of bycatch rates.

Scientific Name	Common Name	Scientific Name	Common Name
Anoplopoma fimbria	Sablefish	Sebastes elongates	Greenstriped rockfish
Atheresthes evermanni	Kamchatka flounder	Sebastes emphaeus	Puget sound rockfish
Atheresthes stomias	Arrowtooth flounder	Sebastes ensifer	Swordspine rockfish
Citharichthys sordidus	Pacific sanddab	Sebastes entomelas	Widow rockfish
Citharichthys stigmaeus	Speckled sanddab	Sebastes eos	Pink rockfish
Citharichthys xanthostigma	Longfin Sanddab	Sebastes flavidus	Yellowtail rockfish
Eopsetta jordani	Petrale sole	Sebastes gilli	Bronzespotted rockfish
Errex zachirus	Res sole	Sebastes goodei	Chilipepper rockfish
Galeorhinus zyopterus	Soupfin shark	Sebastes helvomaculatus	Rosethorn rockfish
Hexagrammos decagrammus	Kelp greenling	Sebastes hopkinsi	Squarespot rockfish
Hippoglossoides elassodon	Flathead shole	Sebastes jordani	Shortbelly rockfish
Hydrolagus colliei	Spotted ratfish	Sebastes lentiginosus	Freckled rockfish

TABLE 2. Species classified as groundfish in the limited-entry trawl fishery for the calculation of bycatch rates.

Scientific Name	Common Name	Scientific Name	Common Name
Hypsopsetta guttulata	Diamond turbot	Sebastes levis	Cowcod rockfish
Merluccius productus	Pacific hake	Sebastes macdonaldi	Mexican rockfish
Microstomus pacificus	Dover sole	Sebastes maliger	Quillback rockfish
Ophiodon elongates	Lingcod	Sebastes melanops	Black rockfish
Platichthys stellatus	Starry flounder	Sebastes melanostomus	Blackgill rockfish
Pleuronectes asper	Yellowfin sole	Sebastes miniatus	Vermilion rockfish
Pleuronectes bilineatus	Rock sole	Sebastes mystinus	Blue rockfish
Pleuronectes isolepis	Butter sole	Sebastes nebulosus	China rockfish
Pleuronectes vetulus	English sole	Sebastes nigrocinctus	Tiger rockfish
Pleuronectes quadrituberculatus	Alaska plaice	Sebastes ovalis	Speckled rockfish
Pleuronichthys coenosus	C-O sole (C-O turbot)	Sebastes paucinspinis	Bocaccio rockfish
Pleuronichthys decurrens	Curlfin turbot	Sebastes phillipsi	Chameleon rockfish
Pleuronichthys verticalis	Horneyhead turbot	Sebastes pinniger	Canary rockfish
Psettichthys melanostictus	Sand sole	Sebastes polyspinis	Northern rockfish
Raja binoculata	Big skate	Sebastes proriger	Redstriped rockfish
Raja inornata	California skate	Sebastes rastrelliger	Grass rockfish
Raja rhina	Longnose skate	Sebastes reedi	Yellowmouth rockfish
Reinhardtius hippoglossoides	Greenland turbot	Sebastes rosaceus	Rosy rockfish
Scorpaena gutta	California scorpoinfish	Sebastes rosenblatti	Greenblotched rockfish
Scorpaenichthys marmoratus	Cabezon	Sebastes ruberrimus	Yelloweye rockfish
Sebastes aleutianus	Rougheye rockfish	Sebastes rubrivinctus	Flag rockfish
Sebastes alutus	Pacific Ocean Perch	Sebastes rufinanus	Dwarf-red rockfish
Sebastes atrovirens	Kelp rockfish	Sebastes rufus	Bank rockfish
Sebastes auriculatus	Aurora rockfish	Sebastes saxicola	Stripetail rockfish
Sebastes aurora	Aurora rockfish	Sebastes semicinctus	Halfbanded rockfish
Sebastes babcocki	Redbanded rockfish	Sebastes serranoides	Olive rockfish
Sebastes borealis	Shortraker rockfish	Sebastes serriceps	Treefish rockfish
Sebastes brevispinus	Silvergrey rockfish	Sebastes simulator	Pinkrose rockfish
Sebastes carnatus	Gopher rockfish	Sebastes umbrosus	Honeycomb rockfish
Sebastes caurinus	Copper rockfish	Sebastes variegatus	Harlequin rockfish
Sebastes chlorostictus	Greenspotted rockfish	Sebastes wilsoni	Pygmy rockfish
Sebastes chrysomelas	Black-and-Yellow rockfish	Sebastes zacentrus	Sharpchin rockfish
Sebastes ciliatus	Dusky rockfish	Sebastolobus alascanus	Shortspine thornyhead
Sebastes constellatus	Starry rockfish	Sebastolobus altivelis	Longspine thornyhead
Sebastes crameri	Darkblotched rockfish	Squalus acanthias	Spiny dogfish shark
Sebastes dalli	Calico rockfish	Triakis semifasciata	Leopard shark
Sebastes diploproa	Splitnose rockfish		

A lognormal approximation (Burnham et al. 1987) was used to calculate the confidence intervals using the following formulas:

$$C_{ij} = \exp(z_{\alpha/2}\sqrt{\ln(1 + (cv(B_{ij}))^2)})$$

$$L_{lowerij} = \frac{B_{ij}}{C_{ij}}$$

$$L_{upperij} = B_{ij}C_{ij}$$

where

$Z_{á/2}$= the quantile from the standard normal distribution corresponding to significance of á,

L = The lower and upper bounds of the confidence interval,

CV(B_{ij}) = Coefficient of variation of B_{ij}

The advantage in using this approximation is that it captures the skewed nature of the distribution and avoids calculating lower bounds less than zero.

For each species, the total takes in each year is calculated by summing the bycatch estimates across all of the groundfish management areas. The variance for each year is also calculated by summing the variance estimates across all of the groundfish management areas, assuming independence of bycatch estimates from different management areas.

Results and Discussion

Overall, six marine mammal species and eight seabird species were observed incidentally killed or injured in the at-sea hake fishery (2002-2006) and the observed groundfish fisheries (2002-2005), along with reported estimates for one marine mammal group and seven seabird groups which were not identified to the species level (see below). Of these species, the Brown Pelican and Stellar Sea Lion are listed under the ESA.

In the at-sea hake fishery observed by the A-SHOP, the estimated takes of marine mammals totaled 21 animals from 2002 to 2006 (Table 3). As each vessel in this fishery carries two observers, all trips are observed in this fishery. The number of trips taken each year, in each management area is provided. The total estimated takes were calculated for each year in each management area. The standard error, CV and ninety-five percent confidence intervals are provided. Ninety-five percent confidence intervals were used because the data were precise. In addition, the actual number of marine mammals observed from which the total estimate is calculated is also given.

Previous analysis of the at-sea hake fishery estimated takes and death of 44 marine mammals between 1990 and 2001 (Perez 2003). The species observed in this analysis are similar to the previous analysis done by Perez, which showed takes of California sea lion, Stellar sea lion, harbor seal, and northern elephant seal.

The estimated take of seabirds in the at-sea hake fishery totaled 50 animals from 2002 to 2006 (Table 4). An estimate of uncertainty was not calculated. Only the variation between tows could have been calculated with the available data, as the data does not contain the necessary replicates for calculating within tow variation. Furthermore, with 99% of the tows were sampled, the

between tow variation will be quite small. In general, the number of seabird takes was small; however, the exception is in 2004 when 21 northern fulmars were estimated to be taken.

In the non-Pacific hake groundfish fisheries observed by the WCGOP, only three fisheries had marine mammal or seabird takes; no marine mammal or seabird takes were observed in the Oregon and California state nearshore fisheries nor were there any observed on sets fishing pot gear.

The estimated marine mammal takes from 2002 to 2005 totaled 287 animals: 250 animals in the limited-entry bottom trawl fishery (Table 5), 29 in the sablefish endorsed fixed gear fishery (Table 7) and 8 in the non-sablefish endorsed fishery (Table 8). Of the total, 265 were California sea lions.

The estimated takes of seabirds totaled 575, 50% (289 birds) of which were common murre. Ninety percent confidence intervals were chosen because of the high relative precision of the estimate. For many estimates, the large coefficients of variation (CV) are characteristic of data that consists mostly of zeros with only one or two instances of takes. In these cases, the high CV is not a result of the estimator used, but of the variability in the data.

The estimated bycatch of common murre was driven by one observation of 33 murres caught in a single trawl set in 2003. The highest total bycatch of black-footed albatross occurred in 2005 and was estimated from only six animals observed within species composition samples. The estimated total bycatch of 36 brown pelicans occurred in 2005 due to the observation of one bird in a stratum with a low level of observer coverage (3%). We are currently expanding coverage in that fleet to help reduce the variability of future estimates.

To relate the amount of seabird bycatch to other fisheries, the number of seabird takes per 1,000 hooks is presented for the limited-entry sablefish-endorsed and non-sablefish-endorsed fixed-gear fisheries in Table 9 and Table 10. Only the birds observed on the hooks sampled were used to calculate takes per 1,000 hooks. In comparison to similar groundfish fisheries in Alaska, the rates for these two fisheries is lower. Over a period of four years, the combined average annual incidental catch rate (birds/1,000 hooks) was.01 and.002 for the West Coast sablefish and non-sablefish fleet, respectively. The incidental catch rate across all Alaskan demersal longline fisheries was.032 from 2000-2004 (NOAA Fisheries 2006).

Additional sources of marine mammal and seabird mortality beyond what is represented by observer samples could occur in these fleets. As previously noted, observers do not monitor gear setting or trawl warp wires for any interactions. In addition, in the case of demersal longline gear, animals caught during the set could fall off under water while the gear is being retrieved, out of view of the observer. Considering these unobservable potential sources of mortality, these estimates provided are conservative, but do provide an indication of groundfish fisheries interactions with marine mammal and seabird species.

References

Alaska Fisheries Science Center (AFSC). 2006. North Pacific groundfish observer manual. North Pacific Groundfish Observer Program. Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA. Available at http://www.afsc.noaa.gov/FMA/Manual_pages/MANUAL_pdfs/manual2007.pdf.

Burnham, K.P., Anderson, D.R., and G.C. White. 1987. Design and analysis methods for fish survival experiments based on release-recapture. American Fisheries Society Monograph 5. Bethesda, MD. 437 p.

Cochran, W.G. 1977. Sampling Techniques. John Wiley & Sons, New York. 155 p.

Northwest Fisheries Science Center (NWFSC). 2006. West coast groundfish observer training manual. NOAA, West Coast Groundfish Observer Program. Northwest Fisheries Science Center, 2725 Montlake Blvd E, Seattle, WA. Available at http://www.nwfsc.noaa.gov/research/divisions/fram/observer/observermanual/observermanual.cfm.

Northwest Fisheries Science Center (NWFSC). 2006. At-sea hake observer program sampling manual and information. NOAA, At-Sea Hake Observer Program. Northwest Fisheries Science Center, 2725 Montlake Blvd E, Seattle, WA. Available at http://www.nwfsc.noaa.gov/research/divisions/fram/observer/observermanual/hake_manual2007.pdf.

Perez, MA. 2003. Compilation of marine mammal incidental take data from the domestic and joint venture groundfish fisheries in the U.S. EEZ of the North Pacific, 1989-2001. NOAA Technical Memorandum NMFS-AFSC-138. Available at http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-138.pdf

Perez, M.A. 2006. Analysis of Marine Mammal Bycatch Data From the Trawl, Longline, and Pot Groundfish Fisheries of Alaska, 1998-2004, Defined by Geographic Area, Gear Type, and Catch Target Groundfish Species. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-167.

Informational Resources

West Coast Groundfish Observer Program

http://www.nwfsc.noaa.gov/research/divisions/fram/observer/index.cfm

At-Sea Hake Observer Program

http://www.nwfsc.noaa.gov/research/divisions/fram/observer/atseahake.cfm

Pacific Fisheries Management Council

http://www.pcouncil.org

NOAA Fisheries Groundfish Management Regulations and Public Notices

(Northwest Regional Office)

http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management

Marine Mammal Protection Act
http://www.nmfs.noaa.gov/pr/laws/mmpa/

Endangered Species Act
http://www.nmfs.noaa.gov/pr/laws/esa/

Migratory Bird Treaty Act
http://www.fws.gov/migratorybirds/intrnltr/mbta/mbtintro.html

Table 3. Bycatch estimates of marine mammal takes in the at-sea hake fishery from 2002 to 2006.

Year	Species	Management Area	Number of trips	Total Bycatch Estimate	Standard Error	CV	95% CI Lower	95% CI Upper	Number Observed[a]
2002	California Sea Lion	Vancouver	5	0					
		Columbia	301	0					
		Eureka	573	0					
		Total	879	0					
	Harbor Seal	Vancouver	5	0					
		Columbia	301	0					
		Eureka	573	0					
		Total	879	0					
	Northern Elephant Seal	Vancouver	5	0					
		Columbia	301	0					
		Eureka	573	0					
		Total	879	0					
	Stellar Sea Lion	Vancouver	5	0					
		Columbia	301	0					
		Eureka	573	1.2	0.4	0.37	0.6	2.3	1
		Total	879	1.2	0.4	0.37	0.6	2.3	1
2003	California Sea Lion	Vancouver	13	0	0.0				
		Columbia	1107	2.2	0.4	0.18	1.5	3.1	2
		Eureka	74	0					
		Total	1194	2.2	0.4	0.18	1.5	3.1	2
	Harbor Seal	Vancouver	13	0					
		Columbia	1107	0					
		Eureka	74	0					
		Total	1194	0					
	Northern Elephant Seal	Vancouver	13	0					
		Columbia	1107	0					
		Eureka	74	0					
		Total	1194	0					
	Stellar Sea Lion	Vancouver	13	0					
		Columbia	1107	1.1	0.3	0.25	0.7	1.8	1
		Eureka	74	0					
		Total	1194	1.1	0.3	0.25	0.7	1.8	1
2004	California Sea Lion	Vancouver	307	0					
		Columbia	1523	2.1	0.4	0.17	1.5	3.0	2
		Eureka	77	0					
		Total	1907	2.1	0.4	0.17	1.5	3.0	2
	Harbor Seal	Vancouver	307	0					
		Columbia	1523	0					
		Eureka	77	0					
		Total	1907	0					
	Northern Elephant Seal	Vancouver	307	1.2	0.5	0.43	0.5	2.8	1
		Columbia	1523	2.1	0.4	0.17	1.5	3.0	2
		Eureka	77	0					
		Total	1907	3.4	0.6	0.19	2.3	4.9	3
	Stellar Sea Lion	Vancouver	307	0					
		Columbia	1523	0					
		Eureka	77	0					
		Total	1907	0					

[a]This is the actual number of takes observed and recorded in the data.

Table 3 cont. Bycatch estimates of marine mammal takes in the at-sea hake fishery from 2002 to 2006.

Year	Species	Management Area	Number of trips	Total Bycatch Estimate	Standard Error	CV	95% CI Lower	95% CI Upper	Number Observed[a]
2005	California Sea Lion	Vancouver	251	0					
		Columbia	1557	0					
		Eureka	87	0					
		Total	1895	0					
	Harbor Seal	Vancouver	251	0					
		Columbia	1557	1.2	0.5	0.42	0.6	2.7	1
		Eureka	87	0					
		Total	1895	1.2	0.5	0.42	0.6	2.7	1
	Northern Elephant Seal	Vancouver	251	0					
		Columbia	1557	0					
		Eureka	87	0					
		Total	1895	0					
	Stellar Sea Lion	Vancouver	251	0					
		Columbia	1557	1.2	0.5	0.42	0.6	2.7	1
		Eureka	87	1.2	0.5	0.42	0.6	2.7	1
		Total	1895	2.4	0.7	0.30	1.4	4.3	2
2006	California Sea Lion	Vancouver	112	0					
		Columbia	1638	2.5	0.8	0.31	1.4	4.6	2
		Eureka	512	0					
		Total	2262	2.5	0.8	0.31	1.4	4.6	2
	Harbor Seal	Vancouver	112	0					
		Columbia	1638	1.3	0.6	0.44	0.6	2.9	1
		Eureka	512	0					
		Total	2262	1.3	0.6	0.44	0.6	2.9	1
	Northern Elephant Seal	Vancouver	112	0					
		Columbia	1638	0					
		Eureka	512	0					
		Total	2262	0					
	Stellar Sea Lion	Vancouver	112	0					
		Columbia	1638	1.3	0.6	0.44	0.6	2.9	1
		Eureka	512	2.4	0.6	0.27	1.4	4.0	2
		Total	2262	3.6	0.8	0.23	2.3	5.7	3

[a]This is the actual number of takes observed and recorded in the data.

Table 4. Bycatch estimates of seabird takes in the at-sea hake fishery from 2002 to 2006.

Year	Species	Management Area	Total Bycatch Estimate	Number Observed[a]
2003	Black Footed Albatross	Columbia	3.0	1
		Total	3.0	1
2004	Black Footed Albatross	Total		0
	Auklet/Murrelet Unid	Columbia	3.0	1
		Total	3.0	1
	Common Murre	Vancouver	3.0	1
		Total	3.0	1
	Northern Fulmar	Vancouver	18.0	5
		Columbia	3.0	1
		Total	21.0	6
	Shearwater Unid	Vancouver	2.0	1
		Columbia	6.0	2
		Total	8.0	3
2005	Black Footed Albatross	Columbia	2.0	1
		Total	2.0	1
	Common Murre	Columbia	2.0	1
		Total	2.0	1
	Northern Fulmar	Columbia	2.0	1
		Total	2.0	1
	Sea Birds Unid	Columbia	2.0	1
		Total	2.0	1
	Sooty Shearwater	Eureka	2.0	1
		Total	2.0	1
2006	Black Footed Albatross	Columbia	2.0	1
		Total	2.0	1

[a]This is the actual number of takes observed and recorded in the data.

Table 5. Bycatch estimates of marine mammals takes on limited-entry trawl vessels from 2002 to 2005.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2002	California Sea Lion	Vancouver	133	10%						
		Columbia	201	17%						
		Eureka	126	13%	7.8	7.3	0.94	2.1	28.8	1
		Monterey	120	14%	27.0	12.6	0.47	13.0	56.1	4
		Conception	23	22%						
		Total	603		34.8	14.6	0.42	17.9	67.5	5
	Harbor Porpoise	Vancouver	133	10%						
		Columbia	201	17%						
		Eureka	126	13%						
		Monterey	120	14%						
		Conception	23	22%						
		Total	603							
	Pacific White Sided Dolphin	Vancouver	133	10%						
		Columbia	201	17%						
		Eureka	126	13%						
		Monterey	120	14%						
		Conception	23	22%						
		Total	603							
	Sea Lion Unid	Vancouver	133	10%						
		Columbia	201	17%						
		Eureka	126	13%	7.8	7.3	0.94	2.1	28.8	1
		Monterey	120	14%						
		Conception	23	22%						
		Total	603		7.8	7.3	0.94	2.1	28.8	1
	Stellar Sea Lion	Vancouver	133	10%						
		Columbia	201	17%	11.5	7.4	0.64	4.4	30.3	2
		Eureka	126	13%						
		Monterey	120	14%						
		Conception	23	22%						
		Total	603		11.5	7.4	0.64	4.4	30.3	2

[a]This is the actual number of takes observed and recorded in the data.

Table 5 cont. Bycatch estimates of marine mammals takes on limited-entry trawl vessels from 2002 to 2005.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2003	California Sea Lion	Vancouver	48	5%	21.4	21.3	0.99	5.5	83.6	1
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%	141.7	41.3	0.29	88.6	226.7	19
		Conception	8	6%						
		Total	527		163.1	46.5	0.28	103.0	258.3	20
	Harbor Porpoise	Vancouver	48	5%						
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%						
		Conception	8	6%						
		Total	527							
	Pacific White Sided Dolphin	Vancouver	48	5%						
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%	7.5	6.9	0.93	2.0	27.4	1
		Conception	8	6%						
		Total	527		7.5	6.9	0.93	2.0	27.4	1
	Sea Lion Unid	Vancouver	48	5%						
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%						
		Conception	8	6%						
		Total	527							
	Stellar Sea Lion	Vancouver	48	5%						
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%						
		Conception	8	6%						
		Total	527							

[a]This is the actual number of takes observed and recorded in the data.

Table 5 cont. Bycatch estimates of marine mammals takes on limited-entry trawl vessels from 2002 to 2005.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2004	California Sea Lion	Vancouver	116	14%						
		Columbia	255	26%	3.9	3.3	0.86	1.1	13.2	1
		Eureka	79	28%						
		Monterey	186	33%	6.1	3.6	0.59	2.5	15.0	2
		Conception	21	21%						
		Total	657		10.0	4.9	0.49	4.6	21.4	3
	Harbor Porpoise	Vancouver	116	14%						
		Columbia	255	26%						
		Eureka	79	28%						
		Monterey	186	33%	3.1	2.5	0.83	0.9	10.0	1
		Conception	21	21%						
		Total	657		3.1	2.5	0.83	0.9	10.0	1
	Pacific White Sided Dolphin	Vancouver	116	14%						
		Columbia	255	26%						
		Eureka	79	28%						
		Monterey	186	33%						
		Conception	21	21%						
		Total	657							
	Sea Lion Unid	Vancouver	116	14%						
		Columbia	255	26%						
		Eureka	79	28%						
		Monterey	186	33%						
		Conception	21	21%						
		Total	657							
	Stellar Sea Lion	Vancouver	116	14%						
		Columbia	255	26%						
		Eureka	79	28%						
		Monterey	186	33%						
		Conception	21	21%						
		Total	657							

[a]This is the actual number of takes observed and recorded in the data.

Table 5 cont. Bycatch estimates of marine mammals takes on limited-entry trawl vessels from 2002 to 2005.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2005	California Sea Lion	Vancouver	87	20%						
		Columbia	247	27%						
		Eureka	64	18%	11.0	7.0	0.64	4.2	28.6	2
		Monterey	171	23%	8.7	5.5	0.63	3.4	22.4	2
		Conception	12	30%						
		Total	581		19.7	8.9	0.45	9.7	39.9	4
	Harbor Porpoise	Vancouver	87	20%						
		Columbia	247	27%						
		Eureka	64	18%						
		Monterey	171	23%						
		Conception	12	30%						
		Total	581							
	Pacific White Sided Dolphin	Vancouver	87	20%						
		Columbia	247	27%						
		Eureka	64	18%						
		Monterey	171	23%						
		Conception	12	30%						
		Total	581							
	Sea Lion Unid	Vancouver	87	20%						
		Columbia	247	27%						
		Eureka	64	18%						
		Monterey	171	23%						
		Conception	12	30%						
		Total	581							
	Stellar Sea Lion	Vancouver	87	20%						
		Columbia	247	27%						
		Eureka	64	18%						
		Monterey	171	23%						
		Conception	12	30%						
		Total	581							

[a]This is the actual number of takes observed and recorded in the data.

Table 6. Bycatch estimates of seabird takes on limited-entry trawl vessels from 2002 to 2005.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2002	Brandts Cormorant	Vancouver	133	10%						
		Columbia	201	17%						
		Eureka	126	13%						
		Monterey	120	14%						
		Conception	23	22%						
		Total	603							
	Common Murre	Vancouver	133	10%						
		Columbia	201	17%						
		Eureka	126	13%						
		Monterey	120	14%						
		Conception	23	22%						
		Total	603							
	Cormorant Unid	Vancouver	133	10%						
		Columbia	201	17%						
		Eureka	126	13%						
		Monterey	120	14%						
		Conception	23	22%						
		Total	603							
	Gull Unid	Vancouver	133	10%						
		Columbia	201	17%						
		Eureka	126	13%						
		Monterey	120	14%						
		Conception	23	22%						
		Total	603							
	Leachs Storm Petrel	Vancouver	133	10%						
		Columbia	201	17%						
		Eureka	126	13%	50.7	47.1	0.93	13.9	185.6	1
		Monterey	120	14%						
		Conception	23	22%						
		Total	603		50.7	47.1	0.93	13.9	185.6	1
	Northern Fulmar	Vancouver	133	10%	9.8	9.3	0.94	2.6	36.5	1
		Columbia	201	17%						
		Eureka	126	13%						
		Monterey	120	14%						
		Conception	23	22%						
		Total	603		9.8	9.3	0.94	2.6	36.5	1
	Storm Petral Unid	Vancouver	133	10%						
		Columbia	201	17%						
		Eureka	126	13%						
		Monterey	120	14%						
		Conception	23	22%						
		Total	603							

[a]This is the actual number of takes observed and recorded in the data.

Table 6 cont. Bycatch estimates of seabird takes on limited-entry trawl vessels from 2002 to 2005.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2003	Brandts Cormorant	Vancouver	48	5%						
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%	7.5	7.0	0.94	2.0	27.6	1
		Conception	8	6%						
		Total	527		7.5	7.0	0.94	2.0	27.6	1
	Common Murre	Vancouver	48	5%						
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%	268.5	232.2	0.86	78.6	917.9	36
		Conception	8	6%						
		Total	527		268.5	232.2	0.86	78.6	917.9	36
	Cormorant Unid	Vancouver	48	5%						
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%	14.9	10.0	0.67	5.5	40.6	2
		Conception	8	6%						
		Total	527		14.9	10.0	0.67	5.5	40.6	2
	Gull Unid	Vancouver	48	5%						
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%						
		Conception	8	6%						
		Total	527							
	Leachs Storm Petrel	Vancouver	48	5%						
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%						
		Conception	8	6%						
		Total	527							
	Northern Fulmar	Vancouver	48	5%						
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%						
		Conception	8	6%						
		Total	527							
	Storm Petral Unid	Vancouver	48	5%						
		Columbia	160	15%						
		Eureka	123	18%						
		Monterey	188	13%						
		Conception	8	6%						
		Total	527							

[a]This is the actual number of takes observed and recorded in the data.

Table 6 cont. Bycatch estimates of seabird takes on limited-entry trawl vessels from 2002 to 2005.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2004	Brandts Cormorant	Vancouver	115	13%						
		Columbia	254	24%						
		Eureka	78	26%						
		Monterey	184	31%						
		Conception	21	20%						
		Total	652							
	Common Murre	Vancouver	115	13%						
		Columbia	254	24%	4.1	3.6	0.87	1.2	14.3	1
		Eureka	78	26%						
		Monterey	184	31%	15.9	8.0	0.51	7.3	34.9	5
		Conception	21	20%						
		Total	652		20.0	8.8	0.44	10.0	40.1	6
	Cormorant Unid	Vancouver	115	13%						
		Columbia	254	24%						
		Eureka	78	26%						
		Monterey	184	31%	6.4	3.8	0.59	2.6	15.7	2
		Conception	21	20%						
		Total	652		6.4	3.8	0.59	2.6	15.7	2
	Gull Unid	Vancouver	115	13%						
		Columbia	254	24%						
		Eureka	78	26%						
		Monterey	184	31%						
		Conception	21	20%						
		Total	652							
	Leachs Storm Petrel	Vancouver	115	13%						
		Columbia	254	24%						
		Eureka	78	26%						
		Monterey	184	31%						
		Conception	21	20%						
		Total	652							
	Northern Fulmar	Vancouver	115	13%						
		Columbia	254	24%						
		Eureka	78	26%						
		Monterey	184	31%						
		Conception	21	20%						
		Total	652							
	Storm Petral Unid	Vancouver	115	13%						
		Columbia	254	24%	4.1	3.6	0.87	1.2	14.3	1
		Eureka	78	26%						
		Monterey	184	31%						
		Conception	21	20%						
		Total	652		4.1	3.6	0.87	1.2	14.3	1

[a]This is the actual number of takes observed and recorded in the data.

Table 6 cont. Bycatch estimates of seabird takes on limited-entry trawl vessels from 2002 to 2005.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2005	Brandts Cormorant	Vancouver	87	20%						
		Columbia	247	26%						
		Eureka	63	17%						
		Monterey	171	22%						
		Conception	12	29%						
		Total	580							
	Common Murre	Vancouver	87	20%						
		Columbia	247	26%						
		Eureka	63	17%						
		Monterey	171	22%						
		Conception	12	29%						
		Total	580							
	Cormorant Unid	Vancouver	87	20%						
		Columbia	247	26%						
		Eureka	63	17%						
		Monterey	171	22%						
		Conception	12	29%						
		Total	580							
	Gull Unid	Vancouver	87	20%						
		Columbia	247	26%	3.8	3.3	0.86	1.1	13.1	1
		Eureka	63	17%						
		Monterey	171	22%						
		Conception	12	29%						
		Total	580		3.8	3.3	0.86	1.1	13.1	1
	Leachs Storm Petrel	Vancouver	87	20%						
		Columbia	247	26%						
		Eureka	63	17%						
		Monterey	171	22%						
		Conception	12	29%						
		Total	580							
	Northern Fulmar	Vancouver	87	20%						
		Columbia	247	26%						
		Eureka	63	17%						
		Monterey	171	22%						
		Conception	12	29%						
		Total	580							
	Storm Petral Unid	Vancouver	87	20%						
		Columbia	247	26%						
		Eureka	63	17%						
		Monterey	171	22%						
		Conception	12	29%						
		Total	580							

[a]This is the actual number of takes observed and recorded in the data.

Table 7. Bycatch estimates of marine mammal and seabird takes on limited-entry sablefish-endorsed vessels from 2002 to 2005.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2002	California Sea Lion	Vancouver	20	27%						
		Columbia	16	21%						
		Eureka	23	30%						
		Monterey	2	10%						
		Total	61							
	Bird Unid	Vancouver	20	27%						
		Columbia	16	21%						
		Eureka	23	30%						
		Monterey	2	10%						
		Total	61							
	Black Foot Albatross	Vancouver	20	27%						
		Columbia	16	21%						
		Eureka	23	30%	3.4	3.0	0.87	1.0	11.8	1
		Monterey	2	10%						
		Total	61		3.4	3.0	0.87	1.0	11.8	1
	Cormorant Unid	Vancouver	20	27%						
		Columbia	16	21%						
		Eureka	23	30%						
		Monterey	2	10%	10.9	6.0	0.55	4.7	25.4	1
		Total	61		10.9	6.0	0.55	4.7	25.4	1
	Western Gull	Vancouver	20	27%						
		Columbia	16	21%						
		Eureka	23	30%						
		Monterey	2	10%	10.9	6.0	0.55	4.7	25.4	4
		Total	61		10.9	6.0	0.55	4.7	25.4	4
2003	California Sea Lion	Vancouver	11	26%						
		Columbia	22	28%	4.0	3.6	0.89	1.1	14.1	1
		Eureka	5	4%						
		Monterey	4	23%						
		Total	42		4.0	3.6	0.89	1.1	14.1	1
	Bird Unid	Vancouver	11	26%						
		Columbia	22	28%	4.0	3.7	0.91	1.1	14.5	1
		Eureka	5	4%						
		Monterey	4	23%						
		Total	42		4.0	3.7	0.91	1.1	14.5	1
	Black Foot Albatross	Vancouver	11	26%	9.1	5.8	0.64	3.5	23.7	2
		Columbia	22	28%	8.0	7.3	0.91	2.2	28.9	2
		Eureka	5	4%						
		Monterey	4	23%						
		Total	42		17.1	9.3	0.55	7.4	39.7	4
	Cormorant Unid	Vancouver	11	26%						
		Columbia	22	28%						
		Eureka	5	4%						
		Monterey	4	23%						
		Total	42							
	Western Gull	Vancouver	11	26%						
		Columbia	22	28%						
		Eureka	5	4%						
		Monterey	4	23%						
		Total	42							

[a]This is the actual number of takes observed and recorded in the data.

Table 7 cont. Bycatch estimates of marine mammal and seabird takes on limited-entry sablefish-endorsed vessels.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2004	California Sea Lion	Vancouver	12	9%						
		Columbia	18	9%	11.1	11.1	1.00	2.8	43.5	1
		Eureka	2	2%						
		Monterey	8	8%						
		Total	40		11.1	11.1	1.00	2.8	43.5	1
	Bird Unid	Vancouver	12	9%						
		Columbia	18	9%						
		Eureka	2	2%						
		Monterey	8	8%						
		Total	40							
	Black Foot Albatross	Vancouver	12	9%	21.1	14.9	0.70	7.4	60.1	2
		Columbia	18	9%	11.1	10.9	0.99	2.8	42.9	1
		Eureka	2	2%						
		Monterey	8	8%						
		Total	40		32.2	18.5	0.57	13.4	77.4	3
	Cormorant Unid	Vancouver	12	9%						
		Columbia	18	9%						
		Eureka	2	2%						
		Monterey	8	8%						
		Total	40							
	Western Gull	Vancouver	12	9%						
		Columbia	18	9%						
		Eureka	2	2%						
		Monterey	8	8%						
		Total	40							
2005	California Sea Lion	Vancouver	18	32%						
		Columbia	35	36%	14.0	5.7	0.41	7.3	26.8	5
		Eureka	29	36%						
		Monterey	13	47%						
		Total	95		14.0	5.7	0.41	7.3	26.8	5
	Bird Unid	Vancouver	18	32%						
		Columbia	35	36%						
		Eureka	29	36%						
		Monterey	13	47%						
		Total	95							
	Black Foot Albatross	Vancouver	18	32%	6.3	3.8	0.61	2.5	15.9	2
		Columbia	35	36%	42.1	21.6	0.51	19.0	93.2	7[a]
		Eureka	29	36%	8.4	4.8	0.57	3.5	20.1	3
		Monterey	13	47%						
		Total	95		56.8	22.4	0.40	30.3	106.3	12
	Cormorant Unid	Vancouver	18	32%						
		Columbia	35	36%						
		Eureka	29	36%						
		Monterey	13	47%						
		Total	95							
	Western Gull	Vancouver	18	32%						
		Columbia	35	36%						
		Eureka	29	36%						
		Monterey	13	47%						
		Total	95							

[a]This is the actual number of takes observed and recorded in the data and includes one bird that was observed outside of the sampled catch.

Table 8. Bycatch estimates of marine mammal and seabird takes on non-sablefish-endorsed limited-entry fixed-gear vessels from 2002 to 2005.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2002	Brown Pelican	Columbia	0							
		Monterey	2	2%						
		Conception	10	1%						
			12							
	California Sea Lion	Columbia	0							
		Monterey	2	2%						
		Conception	10	1%						
			12							
	Cormorant Unid	Columbia	0							
		Monterey	2	2%						
		Conception	10	1%						
			12							
	Western Gull	Columbia	0							
		Monterey	2	2%						
		Conception	10	1%						
			12							
2003	Brown Pelican	Columbia	3	32%						
		Monterey	6	6%						
		Conception	122	11%						
			131							
	California Sea Lion	Columbia	3	32%						
		Monterey	6	6%						
		Conception	122	11%						
			131							
	Cormorant Unid	Columbia	3	32%						
		Monterey	6	6%						
		Conception	122	11%	9.3	8.9	0.95	2.5	34.9	1
			131		9.3	8.9	0.95	2.5	34.9	1
	Western Gull	Columbia	3	32%						
		Monterey	6	6%						
		Conception	122	11%	9.3	8.9	0.95	2.5	34.9	1
	Western Gull Total		131		9.3	8.9	0.95	2.5	34.9	1

[a]This is the actual number of takes observed and recorded in the data.

Table 8 cont. Bycatch estimates of marine mammal and seabird takes on non-sablefish-endorsed limited-entry fixed-gear vessels from 2002 to 2005.

Year	Species	Management Area	Number of observed trips	% observer coverage	Total Bycatch Estimate	Standard Error	CV	90% CI Lower	90% CI Upper	Number Observed[a]
2004	Brown Pelican	Columbia	0							
		Monterey	3	7%						
		Conception	53	12%						
	Brown Pelican Total		56							
	California Sea Lion	Columbia	0							
		Monterey	3	7%						
		Conception	53	12%	8.2	7.7	0.95	2.2	30.5	1
	California Sea Lion Total		56		8.2	7.7	0.95	2.2	30.5	1
	Cormorant Unid	Columbia	0							
		Monterey	3	7%						
		Conception	53	12%						
	Cormorant Unid Total		56							
	Western Gull	Columbia	0							
		Monterey	3	7%						
		Conception	53	12%						
	Western Gull Total		56							
2005	Brown Pelican	Columbia	0							
		Monterey	4	11%						
		Conception	34	3%	35.6	35.5	1.00	9.1	139.7	1
	Brown Pelican Total		38		35.6	35.5	1.00	9.1	139.7	1
	California Sea Lion	Columbia	0							
		Monterey	4	11%						
		Conception	34	3%						
	California Sea Lion Total		38							
	Cormorant Unid	Columbia	0							
		Monterey	4	11%						
		Conception	34	3%						
	Cormorant Unid Total		38							
	Western Gull	Columbia	0							
		Monterey	4	11%						
		Conception	34	3%						
	Western Gull Total		38							

[a]This is the actual number of takes observed and recorded in the data.

Table 9. The number of takes observed per hooks observed on sablefish-endorsed limited-entry fixed-gear vessels from 2002 to 2005.

Year	Number of Trips Observed	Number of Sets Observed	Number Observed[a]	Number observed per 1,000 hooks
2002	61	369	6	0.0092
2003	42	334	5	0.0116
2004	40	272	3	0.0105
2005	95	649	11[a]	0.0100

[a]The number of observed only includes the birds within the sampled catch. The Blackfooted albatross observed outside the sampled catch was not included so that the number of birds observed would correspond to the number of hooks sampled.

Table 10. The number of takes observed per hooks observed on non-sablefish-endorsed limited-entry fixed-gear vessels from 2002 to 2005.

Year	Number of Trips	Number of Sets	Number Observed[a]	Number observed per 1,000 hooks
2002	12	23	0	0.0000
2003	131	220	2	0.0010
2004	56	123	1	0.0008
2005	38	68	1	0.0047

[a]The number of observed only includes the birds within the sampled catch.