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North Pacific Marine Mammal Bycatch Estimation Methodology and Results, 2007-2011

by
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ABSTRACT

Analyses of North Pacific marine mammal bycatch data for the period 1989-2006 have been made by Perez (2003, 2006, Unpubl.) based on Structured Query Language scripts. A change in the structure of the Oracle database maintained by the Fisheries Monitoring and Analysis (FMA) Division of the Alaska Fisheries Science Center in 2008 required that analysis programs be rewritten. The present analysis, for the period 2007-2011, was undertaken using the R programming language (R Core Team 2012). Bycatch estimates were calculated for each of 23 groundfish trawl, longline, and pot fisheries in Alaska using the FMA observer data and the total fishery data from the Catch Accounting System of the Alaska Regional Office of the National Marine Fisheries Service. Fisheries were determined by the target species, gear type, and area. The weight of all groundfish caught in a haul was used as a measure of effort. The total number of hauls was unknown for each fishery. The ratio of sampled groundfish weight to number of sampled hauls was assumed to be equal to the ratio of total groundfish weight for the fishery to the total number of hauls in the fishery. The observed bycatch of all marine mammal species for the years 2007-2011 was 16, 38, 20, 23 and 32, respectively. An additional 12 marine mammal mortalities were observed but were not used to estimate total marine mammal mortality because they occurred in hauls with unknown effort. The estimated bycatch of all marine mammals for these years was 31.8, 42.9, 21.1, 28.6 and 38.4, respectively. The following marine mammal species were bycaught during 2007-2011: bearded seal, harbor seal, northern elephant seal, northern fur seal, Steller (northern) sea lion, ribbon seal, ringed seal, spotted seal (larga seal), unidentified pinniped, walrus, Dall's porpoise, gray whale, harbor porpoise, humpback whale, killer whale and sperm whale. Annual bycatch (killed or seriously injured) estimates were calculated for each marine mammal stock in each fishery for the 5 year period. These estimates are used to assess and manage marine mammal stocks and for classification of commercial fisheries.

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INTRODUCTION

Information collected by fisheries observers on marine mammal interactions with groundfish fisheries in the North Pacific Ocean (Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA)) has been compiled and analyzed by the National Marine Mammal Laboratory (NMML) and the North Pacific Groundfish and Halibut Observer Program (Observer Program) at the Alaska Fisheries Science Center (AFSC) since the early 1970s (Perez 2003). The observer program based at the AFSC is a largely industry-funded, on-board observer monitoring system implemented in early 1990. During this data collection period (2007 – 2011), all vessels fishing for groundfish in federal waters were required to carry observers for at least a portion of their fishing time, except halibut vessels and vessels less than 60 feet. Observers were placed on vessels to collect fishery data as well as data on interactions with seabirds and marine mammals. Observer trips occurred on either pot, longline or trawl vessels. Vessels between 60 and 125 feet and all vessels fishing pot gear were required to have observers on board for 30% of their fishing days (30% coverage strata), while vessels over 125 feet were required to have at least one observer on board for all fishing days (100% and 200% coverage strata; 200% coverage means that there were two observers and all trips and hauls or sets were sampled) as were vessels participating in some limited access fisheries (GOA rockfish, American Fisheries Act (AFA) pollock). On trips with less than 200% coverage (single observer on board), hauls were randomly selected to be sampled for species composition and collection of biological samples, unless the observer was able to sample all hauls. Vessels were responsible for obtaining observers and determining when they would be on board. The Fisheries Monitoring and Analysis (FMA) division of the AFSC monitors groundfish fishing activities in the U.S. Exclusive Economic Zone (EEZ) off Alaska and conducts research associated with sampling commercial fishery catches[1]. The commercial catch data and marine mammal interaction data, including marine mammal serious injury and mortality that occurs incidental to the fishery, are maintained by the FMA in an Oracle database. Further mention of marine mammal bycatch refers to serious injury and/or mortality.

Although the basic statistical methodology for calculating marine mammal bycatch estimates is much the same as used previously (e.g., Perez 2006), the manner in which the data are organized and processed for the bycatch analyses has changed since 2006. Earlier analyses were almost entirely based on SQL[2] (Structured Query Language)

[1] In 2013 the observer deployment plan changed (NMFS 2013).
[2] SQL is a language for querying and managing data in databases (see http://en.wikipedia.org/wiki/SQL).

queries and scripts to access the Observer Program and National Marine Fisheries Service (NMFS) Alaska Regional Office Catch Accounting System (CAS) Oracle databases to summarize and analyze marine mammal bycatch. The previous SQL scripts were updated to accommodate changes made to the Observer Program Oracle database structure in 2008. Current methods are based on analyzing the results of Oracle SQL queries of the Observer Program and CAS databases using the R programming environment (R Development Core Team 2012). Oracle tables and views are queried from within R; bycatch estimation and other analyses are then carried out using the data in the R data frames.

Information recorded by the Observer Program observers includes: haul date, NMFS statistical area, latitude, longitude, cruise, vessel code, vessel type, gear type, etc. If there are any marine mammal interactions, which may include incidental mortality, injury, or deterrence, further data are collected: including marine mammal interaction type, species name, condition, number of animals, probable cause of any mortalities, specimen type (e.g., photo taken, tooth extracted). Multiple animals and/or species may be involved in an interaction.

Estimation of total marine mammal bycatch is carried out for each fishery in the NMFS List of Fisheries (LOF). Currently there are 23 fisheries for which bycatch must be estimated (Appendix 1; the NMFS publishes the LOF annually in the Federal Register; see http://www.nmfs.noaa.gov/pr/interactions/lof/index.htm). Bycatch data are analyzed by post-stratifying the data with post-strata defined by year, fishery (based on target species, gear type, and NMFS statistical area), marine mammal species involved in an interaction (resulting in a mortality or serious injury), NMFS statistical area, time period, and vessel class (based on vessel length) (Fig. 1).

Information on trip target species for a particular haul is obtained from querying the CAS database, which contains information on target species and total groundfish weight. The target species is determined using an algorithm developed by the NMFS Alaska Regional Office. The parameters used for calculating the target fishery are different for catcher/processors (CPs) and catcher vessels (CVs), the amount of observer coverage, and whether delivery is made to a mothership or to a shoreside facility (Cahalan et al. 2010, p. 22). It should be noted that the target species may not necessarily correspond to the predominant species caught in a particular haul. An earlier version of this document used target species weights as a measure of effort. In the current analysis, effort has been defined as the estimated weight of all groundfish caught.

Groundfish catch weights are determined by the NMFS Alaska Regional Office (AKR) and are available from the FMA Oracle views of AKR data (Appendices 2, 8 and 9), created by Douglas Turnbull of AFSC/FMA. Groundfish weights are based on sampling the catch (haul/set). In cases where it was not possible for observers to sample the catch then no groundfish weight for the haul is given although marine mammal bycatch may have been documented by the observer. The AKR does impute (the substitution of some value for missing data) weights for these "missed" hauls based on species composition data from hauls near in time but these imputed weights have not been used in bycatch estimation; their use would introduce a further source of error that would not be quantifiable.

The species, gear, and other codes used by the AFSC and AKR Oracle tables were converted to a common format, usually numeric. For example, the AFSC gear codes are numeric while the CAS gear codes are character codes. The various codes and their definitions are given in Appendices 2-5.

Data Sources

North Pacific Groundfish and Halibut Observer Program Data

The Observer Program Oracle database contains haul records that are uniquely identified by a 20-digit identifier (haul_join: since 2008; a 6 or 7 digit number prior to 2008). A fishery number (currently 1 through 23, corresponding to the number of fisheries in the LOF) is assigned to each haul or set based on the NMFS statistical area, gear type and target species code – see Appendix 1). Each Observer Program haul record is assigned a number corresponding to each week period (1 to 53) based on the week-ending dates from the CAS database. After which, the data contain codes for identifying fishery, area, marine mammal species, marine mammal interaction type, target species, target species weight, week period, etc. For a given post-stratum, the total weight of the target species is obtained from the CAS data. The primary table (view) used to obtain bycatch data summarizes much of the marine mammal interaction data by haul or set (Appendix 7). The statistical methodology used to estimate bycatch and its variance are given below.

Catch Accounting System (CAS) Data

The CAS contains data for the entire fishery (observed and unobserved) for each trip and week-ending date (Saturday). These data contain groundfish weight as well as trip target codes, gear type and NMFS area from which a fishery (Appendix 1) can be assigned to a post-stratum. Descriptions of the observer haul data and the trip data are given in Appendices 8-9). The input data are updated periodically (materialized views) by a database administrator and in near-real time each time they are accessed (views).

The same procedure was used to determine the fishery for both the Observer Program data and the CAS data: a fishery is defined by gear type, statistical area, and target species.

Bycatch Estimation Method

Bycatch estimates have been carried out previously using either design-based estimators (Pikitch et al. 1998) or model-based estimators (Perkins and Edwards 1996). The ratio-estimation method used here is a simplified form of a model-based estimator within a sampling design (Wigley et al. 2007). The ratio method consists of multiplying a bycatch ratio, defined for a stratum as the number of animals bycaught divided by some measure of fishing effort, times the total fishing effort in the stratum. For this study, the metric tons (t) of all groundfish caught has been used as a measure of effort (i.e., not just catch (t) of target species). This approach recognizes that, in the event that a haul takes groundfish that are not the target species for that fishery, NMFS statistical area, week and vessel class, the process of catching the non-target groundfish required that the haul be fishing for some period of time and so the effort should be included in the calculations.

Bycatch of marine mammals was occasionally observed in hauls that were not sampled for fish composition. These bycatches were not used in estimating bycatch since effort (groundfish weight of the haul or set) was unknown. The corresponding coefficient of variation (CV) refers only to the estimated bycatch and does not take into account bycatches from unsampled hauls or sets.

The variance of the simple ratio estimate requires that the total number of hauls in the strata is known. Since this is unknown, the assumption has been made that the sampling fraction based on the number of hauls sampled (n/N) is approximately the same as the sample fraction defined in terms of weight of groundfish (w/W) for the stratum ($n/N \approx$

w/W where *n* is the number of hauls sampled, *N* is the total number of hauls, *w* is the groundfish weight of sampled hauls, and *W* is the total groundfish weight); hence $N \approx n \cdot W/w$.

The number of hauls sampled in a single year is on the order of 40,000 while the observed bycatch (of all marine mammal species) is usually not more than 30-40 animals. The data are thus too sparse to establish how (or even if) the observed bycatch is related to the groundfish catch (in t), especially by marine mammal species. However, in order to estimate bycatch and an approximate variance, the above assumption has been made (as was done for earlier bycatch estimates).

From a query of this view the observed bycatch can be determined (except for marine mammal injuries which, upon examination of observer comments and photos, etc., are determined to be a serious injury as defined by NMFS Policy Directive PD 02-038). The data on effort, the metric tons of groundfish caught in marine mammal bycatch hauls, is obtained from AFFSC Oracle views that are based on AKR Oracle data (Appendices 8-9).

Vessel class, defined by vessel length) was used as a post-stratum: vessel class 1 = vessel lengths ≥ 125 feet, vessel class 2 = vessel lengths from 60 – 124 feet, and vessel class 3 = vessel lengths < 60 feet. Vessel class 3 was not used since only vessels ≥ 60 feet carried observers. Preliminary analyses indicated that observed bycatches were noticeably larger for vessels ≥ 125 feet. This is not unexpected since these vessels have 100% observer coverage while vessels ≥ 60 feet and < 125 feet have partial coverage. The present analysis post-stratifies data into three time periods: weeks 1-18, weeks 19-36 and weeks > 36. This was done in order to reduce the number of strata that have few or no data. Previous analyses (Perez 2006) used 4-week time periods. In addition, the present analyses discontinued use of the analyst's judgment at certain steps in the analytical procedures. Since, the present procedure is based on the execution of a series of R functions that query the various Oracle tables or views, and barring that the Oracle data has not changed, the results are reproducible.

Statistical Formulas

Analytical methods are based on Perez (2006; see also Manly (2009) and Cochran (1977, p. 155, Equation 6.13)). Bycatches are estimated for each species by year, fishery and marine mammal species. Post-stratified estimates by NMFS statistical area (about 20 areas comprise the Bering Sea-Aleutian Islands and the Gulf of Alaska), time period (weeks 1-18, 19-36 and > 36) and vessel class (generally, two classes; see above) are also provided.

For a given marine mammal post-stratum *s* (defined by year and fishery), let $y_{s,a,t,v}$ be the observed number of marine mammals bycaught (including animals seriously injured) in the observed hauls or sets in NMFS statistical area *a,* time period *t*, and vessel class *v*. Furthermore, let $w_{s,a,t,v}$ be the metric tons of groundfish caught in observed hauls or sets in post-strata *a, t, v* of *s* and $W_{s,a,t,v}$ be the corresponding total (observed and unobserved) metric tons of groundfish caught. Then the estimated bycatch rate, $\hat{r}_{s,a,t,v}$, is given by

$$\hat{r}_{s,a,t,v} = \frac{y_{s,a,t,v}}{w_{s,a,t,v}}.$$

The estimate of total bycatch in stratum *s* is

$$\hat{Y}_s = \sum_{a,t,v} \hat{r}_{s,a,t,v} \cdot W_{s,a,t,v},$$

and the variance is

$$\mathrm{var}\left(\hat{Y}_s\right) = \sum_{a,t,v} \mathrm{var}\left(\hat{r}_{s,a,t,v}\right) W^2_{s,a,t,v}.$$

The estimated variance of $\hat{r}_{s,a,t,v}$ is given by

$$\mathrm{var}(\hat{r}_{s,a,t,v}) = \frac{\sum_{i=1}^{n}\left(y_i - \hat{r}_{s,a,t,v} \cdot w_i\right)^2}{n-1} \frac{\left(1-n/N\right)}{n\bar{w}^2}$$

where the summation takes place over the number of hauls or sets within the post-stratum *a, t, v* and $\bar{w}$ is the mean observed effort (metric tons of groundfish caught) in the post-stratum. Since N, the total number of hauls or sets in the post-stratum, is unknown (data for the total fishery is in metric tons of groundfish species caught by week), the ratio n/N is approximated by the ratio of groundfish species weights, w/W. It is assumed that the total weight of the groundfish species caught in the post-stratum is known with little or no error. Since this is unlikely to be the case, and since additional variance arising from the post-stratification of hauls is not included, the variance estimates may underestimate the true variance.

If we consider the post-strata to be independent, the variance of the sum of post-strata estimates is the sum of the post-strata variances. The estimation method described above can be generalized by computing a weighed bycatch ratio for post-stratum *s*:

$$\hat{r}_s = \sum_{a,t,v} \alpha_{s,a,t,v} \hat{r}_{s,a,t,v}$$

where the summation takes place over the strata of *s* and $\sum_{a,t,v} \alpha_{s,a,t,v} = 1$. The estimated bycatch is then

$$\hat{Y}_s = \hat{r}_s W_s$$

where $W_s = \sum_{a,t,v} W_{s,a,t,v}$. If $\alpha_{s,a,t,v}$ is equal to $W_{s,a,t,v}/W_s$ then $\hat{Y}_s$ is the simple ratio estimate. Another possible weight would be the relative observed effort in each substratum, $w_{s,a,t,v} \Big/ \sum_{a,t,v} w_{s,a,t,v}$. By computing a bycatch ratio for each post-stratum and adding the estimates by stratum, equal weights are given to each bycatch ratio whereas computing a single weighted bycatch ratio (with statistical weights proportional to the observed effort) for the post-strata will yield a bycatch ratio that gives more weight to post-strata with higher fractions of total effort that are observed. The simple ratio estimate has been used here despite that observed bycatches in strata with low effort could lead to relatively larger estimates of bycatch. However, using a single weighted bycatch ratio estimate (other than with weights equal to the relative total effort in the strata), could "hide" an important issue that should be addressed in the fishery.

Confidence intervals (CI) are based on the lognormal distribution (Burnham et al. 1987, p. 212). Because most of the hauls (usually > 99%) have zero bycatch, standard (based on normal distribution assumptions) confidence intervals (estimate ± 2 S.E.) can result in negative lower confidence intervals. An obvious fix is to use the observed catch for the lower confidence bound. The lognormal distribution, however, has the advantage that the resulting confidence bound is positive (though this assumes that the positive data are log-normally distributed).

If the CV (coefficient of variation) is not small, Burnham et al. (1987) recommend computing confidence intervals based on the log-transform with

$$\hat{\text{var}}\left[\log\left(\hat{r}\right)\right] = \log\left(1 + \left[cv\left(\hat{r}\right)\right]^2\right).$$

For an approximate (1-α)100% CI, the lower and upper bounds, $\hat{r}_L$ and $\hat{r}_U$, are given by

$\hat{r}_L = \hat{r}/C$ and $\hat{r}_U = \hat{r} \cdot C$, where $C = \exp\left(z_{\alpha/2} \sqrt{\log\left(1 + \left[cv(\hat{r})\right]^2\right)} \right)$. For bycatch analyses, $z_{\alpha/2}$ = 2 has been used, yielding approximate 95% confidence intervals. Thus, lower and upper confidence intervals for $\widehat{Y}_s$ are given by:

$$\hat{W}_s \cdot \hat{r}_s / C \text{ and } \hat{W}_s \cdot \hat{r}_s \cdot C .$$

If the groundfish species weight is missing for a stratum then the bycatch ratio and standard error for that stratum cannot be calculated. This can occur if species sub-sampling did not take place. A confidence interval computed using the above procedure could be used but it would only apply to the strata with no missing values.

When bycatch ratio in a stratum, y_s/w_s, is small, which is the case, the ratio estimate is equivalent to assuming a Poisson distribution for the bycatch ratio: probability (bycatch = 0) = $\exp(-y_s/w_s) \approx 1 - y_s/w_s$. If the probability is small that > 1 animals are bycaught in a stratum, then probability (bycatch = 1) ≈ 1 – prob. (bycatch = 0) = y_s/w_s and the estimated bycatch is $W_s y_s/w_s$, which is equivalent to the ratio estimate.

Potential Sources of Error

- As indicated above, N_s, the number of hauls or sets in a strata is generally unknown and must be estimated based on the assumption that the ratio of observed to total hauls or sets is equal to the ratio of groundfish weight from observed hauls or sets to the total groundfish weight in the post-strata. Both the observed and total groundfish weights are estimates based on sampling the catch. The ratio of these groundfish weights is used to prorate the observed bycatch in a stratum to the total bycatch in a stratum and is also used in the variance formula, where it is assumed to be the ratio of known integers. It is not possible to account for the potential error in the estimated CV of the bycatch due this assumption (the ratio of these random variables are equivalent to the sample fraction). Using the ratio of groundfish weights could result in either an under- or over-estimate of the total bycatch because it is not known in which direction the ratio deviates from the true ratio (n_s/N_s). Treating the ratio as a fixed quantity though will lead to an underestimate of the CV.

- The error incurred in the estimating species composition and weight is also unknown. Bycatch rates are estimated by summing over all observed hauls in the strata so they will be biased towards bycatch rates from larger vessels, which have greater observer coverage. The combination of data from different sample strata,

having different coverage rates, may introduce a bias in the bycatch rates (Cahalan et al. 2010). In addition, the number of hauls in a stratum is a random variable and treating it as a known constant will underestimate the variance for the stratum.

- A part of groundfish catch on longline gear may be lost to predation by marine mammals or sharks prior to retrieval (Perez 2003). There is no way to determine the weight of groundfish lost but it would affect both the observed and total sets in a stratum so the bias may be negligible.

- There may also be uncertainty in determining a single target species to assign to an observed haul or a trip. However, the algorithm employed by the CAS has been used throughout. In almost all cases a target species is assigned by the CAS.

For most sources of error it is not possible to determine how they will likely impact the bycatch estimates. However, most sources of error that are not possible to quantify will result in underestimating the standard error (and thus, CV) of the estimated bycatch.

Observer Coverage

Observer coverage, the percentage of a fishery observed by the observers, as with other bycatch analyses, is based on groundfish weight instead of the proportion of hauls or sets sampled. Since observers are placed on vessels ≥ 60 feet the coverage can only be estimated for vessels ≥ 60 feet. The total groundfish weight for a fishery (from landings data) will contain some data from vessels < 60 feet. These are filtered out using an Oracle table that gives the length of each vessel (using vessel ID). The observer coverage for a fishery is calculated as the groundfish weight from observed hauls or sets divided by the total groundfish weight for vessels greater than 60 feet. A CAS code indicates where (jurisdictional waters) the harvest took place: S = state waters, F = federal waters, and NULL indicates a groundfish discard estimate generated from a landing report and thus cannot be attributed to either state or federal waters. A further code, the state fishery flag, indicates whether or not the catch contributed to a state fishery (Y) or not (N).

A small bias is introduced by only extracting total groundfish catch (t) records with the state fishery flag = F and ignoring groundfish discard estimates. This resulted in lower a groundfish catch (t) of about 0.8% and results in very

slightly smaller bycatch estimates (since the ratio of total groundfish catch (t) to observed groundfish catch (t) is smaller).

R Analysis and Functions

Analytical methods are based on Perez (2006; see also Manly 2009). However, the methods for obtaining the necessary data are different, especially since the design of the Oracle tables and view changed in 2008. All the Oracle tables and views are read by R as data frames and subsequent data manipulations and computations are carried out in R (R Development Core Team 2012). A simplified description of the approach is as follows:

1. Bycatch data, including unique identifying haul numbers (haul_join) are obtained by strata from the OBSINT.DEBRIEFED_MAMMAL table (Appendix 2). Strata are year, fishery, marine mammal species, NMFS statistical area, time period and vessel class.
2. The above data do not contain groundfish weight by haul or set so the hauls are matched with those in the NORPAC.AKR_OBS_HAUL_MV (matching on haul_join, Appendix 2) materialized view which contains the groundfish weights for observed all hauls or sets. Vessel class, fishery, time period and other variables are then computed.
3. The bycatch ratios, *r*, are then computed for the area, time period and vessel class post-strata for each year, fishery and marine mammal species (where there are data) and the variances of the bycatch ratios are computed. The estimated bycatch for the strata are obtained adding the estimates for each post-stratum (area, time-period, vessel class strata).
4. Total groundfish weights (observed and unobserved) for these strata are obtained from the NORPAC.AKR_CA_PRIMARY_TXN_MV materialized view (Appendices 2, 9). Vessel class, fishery, time period and other variables are also computed for the records in this table.

A. Observed bycatch

The observed bycatch is based on the Observer Program data for a given year. Marine mammal interactions "killed by gear", "killed by propeller", and "lethal removal" are automatically considered bycatch mortalities (Appendix 3). Each marine mammal interaction "entangled in gear" is reviewed separately to assess whether the entanglement caused a serious injury. The data table is first filtered to include only bycatch records (hauls) and these are sorted by fishery, gear type, marine mammal species, NMFS area, the time period (weeks 1-18 = 1, 19-36 = 2 and weeks > 36

= 3). In some cases, where there may be more than one marine mammal interaction per haul, multiple records exists for a single haul and these must be accounted for (the groundfish weight will be the same for each record).

B. Estimated bycatch

The estimated bycatch is based on computing the bycatch rate in each stratum (as defined above) and the sum of the groundfish weights for that stratum (from the Observer Program data). The total groundfish weight is obtained from the CAS data for the stratum. The CAS data is based on trips and week periods. The estimated bycatch is the observed bycatch per groundfish weight (for a stratum) times the total groundfish weight (observed and unobserved data) for the stratum from the CAS data.

RESULTS and DISCUSSION

Estimated bycatches of all marine mammal species for 2007-2011, based on time periods of 4, 8, 10 and 18 weeks (used in this study) were 177, 182, 162 and 171, respectively. The number of observed hauls with marine mammal interactions, by interaction code (see Appendix 3) and year are given in Table 1. Mortalities are shown in gray (codes 4 and 5). These interactions resulted in the number of animals by interaction code and year shown in Table 2. Table 3 gives the estimated observer coverage by fishery, vessel class and year, based on metric tons of groundfish caught (effort). Coverage for vessel class 1 can be seen to be almost always greater than for vessel class 2 for each fishery. Table 4 shows the number of hauls or sets sampled by fishery and gear type for each year. The estimated bycatch by year, fishery and marine mammal species is shown in Table 5. It should be noted that the observed and estimated bycatches have been summed over the substrata NMFS statistical area, vessel class and time period. The observer coverage is for the entire fishery for the year, based on groundfish weights, and ignores vessel class. The annual observer coverage in Table 5 is not used in estimating bycatch. The observer coverage in the strata NMFS statistical area, vessel class and time period are used and these can be often quite different from the annual observer coverage. Table 6 presents the information in Table 5 for formatted in the manner used for Alaska Marine Mammal Stock Assessments (Allen and Angliss 2011). The mean annual mortality (MAM) of a marine mammal species is the arithmetic average of the estimated mortality for 2007-2011 by species and fishery. Similarly, the mean total annual mortality (MTAM) is the sum of the MAMs by fishery for a marine mammal species (see Allen and Angliss 2011). The various database codes and definitions are given in Appendices 1-10.

Marine mammal bycatch estimates in commercial fisheries are reported in the annual marine mammal stock assessment reports (e.g., Allen and Angliss 2011) and used to classify commercial fisheries in the NMFS List of Fisheries as required under Section 118 of the Marine Mammal Protection Act. These data are also used in management regimes for marine mammal stocks.

Some of the decisions made in the course of the analysis that affected the number of observed marine mammals used in the bycatch calculation include:

- Marine mammal bycatch events seen by an observer were used and not marine mammal events that were reported by the captain or crew but not seen by an observer
- Effort for which a fisheries could not be assigned (trip target species not given) was not used
- If a bycatch was recorded but a groundfish weight of zero was given for the haul the bycatch was used in the analysis and a zero weight was used for effort (there may be hundreds of hauls in the strata so this would introduce a very small error).

Vessels less than 60 feet (vessel class 3) were not considered in the analysis since there were no observers placed on these vessels and hence no information available on bycatches for these vessels. They make up, however, a small portion, by weight of catch, of the overall effort in the LOF fisheries. Vessel class 1 ($\geq$ 125 feet) substrata have higher observer coverage than vessel class 2 (> 60 feet and < 125 feet) and hence the bycatch estimates are more reliable.

Only one marine mammal species, northern fur seal, in the 2007 BSAI pollock fishery, resulted in much larger estimated bycatch (14.6) than was observed (3). This was due to a stratum with low observer coverage so that the bycatch ratio was scaled up by a factor of about 5. Other estimated bycatches do not differ greatly from the observed bycatches because the observer coverage was relatively high. Estimated CVs show large variations, from 0.01 to 0.88 and the larger CVs generally correspond to lower observer coverage for the strata. The CVs are likely underestimates for the reasons indicated previously.

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CITATIONS

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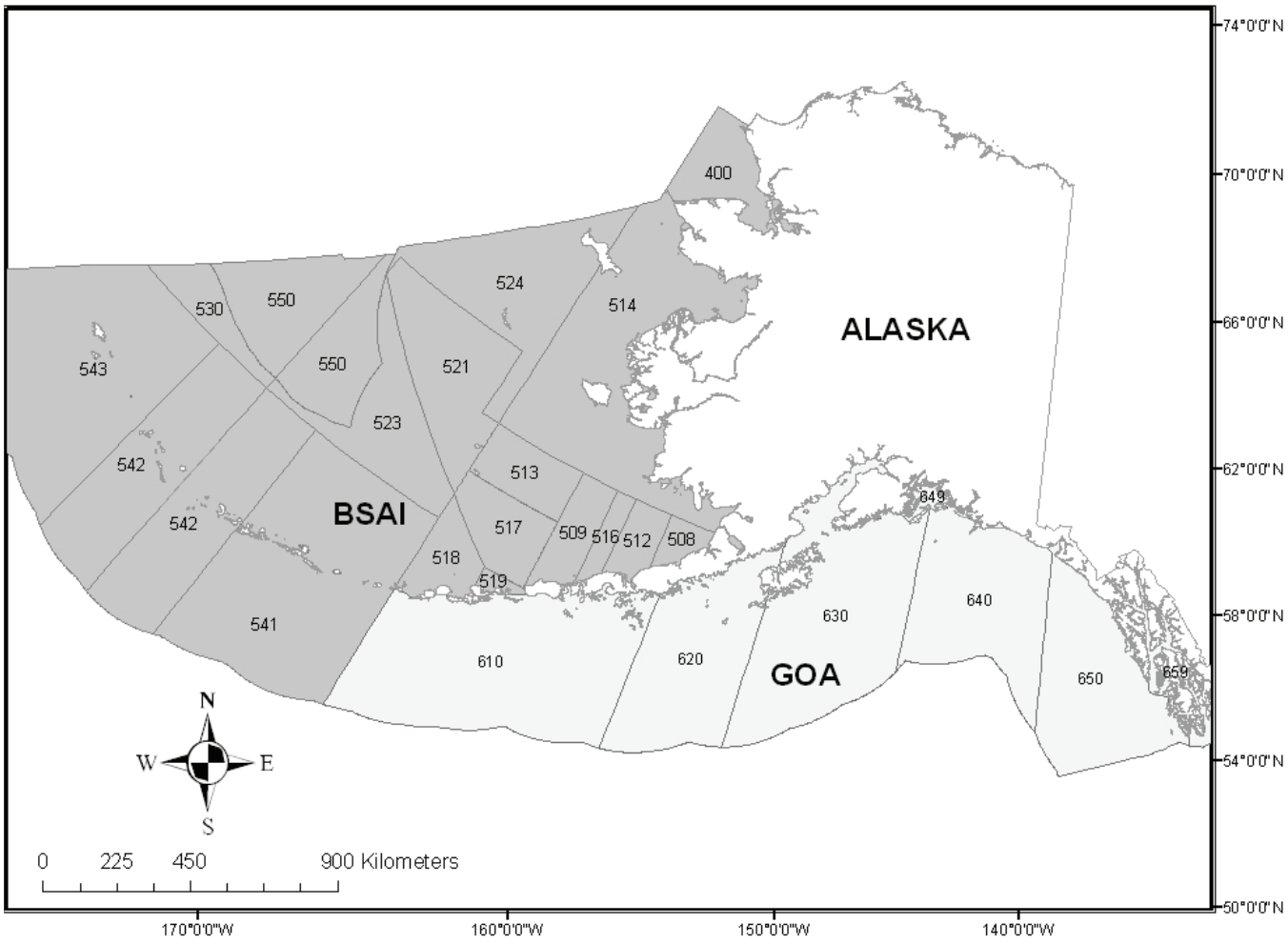

Fig. 1.-- National Marine Fisheries Service statistical areas (Federal reporting areas) and fisheries management plan regions in Alaska. The Bering Sea and Aleutian Island (BSAI) region is shaded dark grey; the Gulf of Alaska (GOA) is shaded in light grey; and NMFS statistical areas are identified with numbers (from Cahalan et al. 2010).

Table 1. -- Number of sampled hauls by year and marine mammal interaction.

	Interaction codes[1]											
Year	**1**	**2**	**3**	**4**	**5**	**6**	**9**	**10**	**12**	**13**	**14**	**Sum**
2007	7	1	1	20	0	54	8	237	12	3	0	343
2008	5	0	0	38	1	65	6	158	1	2	115	391
2009	34	0	0	18	2	28	0	188	4	3	52	329
2010	34	0	0	26	1	7	0	195	11	7	62	363
2011	34	0	0	33	0	34	5	197	7	2	48	360
Sum	114	1	1	135	4	208	19	975	35	17	277	1786

[1] Interaction codes 4 and 5 are mortalities: killed by gear and killed by propeller. Any seriously injured animals were included in either interaction codes 4 or 5. Other interaction codes and definitions are given in Appendix 3

Table 2. -- Number of animals by year and marine mammal interaction code (based on hauls in Table 1).

	Interaction codes											
Year	**1**	**2**	**3**	**4**	**5**	**6**	**9**	**10**	**12**	**13**	**14**	**Sum**
2007	20	1	1	20	0	55	11	1155	39	4	0	1306
2008	17	0	0	38	1	65	6	385	1	3	1318	1834
2009	182	0	0	19	2	28	0	747	10	3	144	1135
2010	140	0	0	26	1	27	0	633	27	26	154	1034
2011	126	0	0	33	0	34	5	529	10	2	228	967
Sum	485	1	1	136	4	209	22	3449	87	38	1844	6276

Table 3. -- Observer coverage (fractions) by year, fishery and vessel class (based on groundfish weights; '-' indicates incomplete or no data)[1].

		Year				
Fishery	**Vessel class**	**2007**	**2008**	**2009**	**2010**	**2011**
AK BSAI Atka mackerel trawl	1	0.95	1.00	0.99	1.00	1.00
	2	0.56	0.89	1.00	-	0.98
BSAI flatfish trawl	1	0.78	1.00	1.00	1.00	1.00
	2	0.36	0.99	0.99	1.00	1.00
BSAI Pacific cod trawl	1	0.77	1.00	1.00	1.00	1.00
	2	0.32	0.36	0.41	0.44	0.42
BSAI pollock trawl	1	0.97	0.97	0.98	0.98	0.98
	2	0.31	0.33	0.34	0.37	0.97
BSAI rockfish trawl	1	0.88	1.00	0.99	1.00	1.00
	2	0.10	0.19	1.00	1.00	1.00
GOA flatfish trawl	1	0.88	0.51	0.56	0.55	0.67
	2	0.21	0.26	0.19	0.23	0.20
GOA Pacific cod trawl	1	-	0.97	1.00	-	1.00
	2	0.25	0.23	0.38	0.36	0.44
GOA pollock trawl	2	0.27	0.34	0.43	0.29	0.32
GOA rockfish trawl	1	0.98	0.98	0.97	0.94	0.97
	2	0.75	0.71	0.81	0.90	0.82
BSAI Greenland turbot longline	1	0.62	0.75	0.77	0.60	0.66
	2	0.84	0.67	0.51	0.56	0.39
BSAI Pacific cod longline	1	0.66	0.65	0.62	0.66	0.62
	2	0.52	0.56	0.56	0.58	0.43
BSAI rockfish longline	1	0.88	-	1.00	0.63	-
BSAI sablefish longline	1	0.57	0.51	0.88	0.65	0.85
	2	0.48	0.53	0.42	0.56	0.50
GOA Pacific cod longline	1	0.64	0.56	0.62	0.68	0.58
	2	0.34	0.21	0.38	0.34	0.48
GOA Pacific halibut longline	1	0.48	0.68	0.55	0.52	0.49
	2	0.10	0.01	0.11	0.08	0.09
GOA rockfish longline	1	-	-	0.80	-	-
	2	-	-	2.40	0.15	-
GOA sablefish longline	1	0.64	0.53	0.69	0.68	0.60
	2	0.34	0.31	0.35	0.34	0.32
BSAI Pacific cod pot	1	0.37	0.41	0.46	0.33	0.38
	2	0.28	0.18	0.23	0.26	0.24
BS sablefish pot	1	-	-	0.37	0.34	0.42
	2	0.35	0.37	0.44	0.34	0.37
AI sablefish pot	1	-	-	-	-	0.78
	2	0.39	-	0.28	0.11	0.57
GOA Pacific cod pot	1	-	0.58	0.82	-	-
	2	0.16	0.25	0.16	0.14	0.22

[1] Alaska Pacific halibut longline fisheries and Gulf of Alaska longline flatfish fishery are not shown; only partial data available

Table 4. -- Number of hauls/sets sampled by fishery, year, and gear type (dot indicates no data).

	2007 Gear type					2008 Gear type				
Fishery	**NPT**	**PTR**	**POT**	**HAL**	**Sum**	**NPT**	**PTR**	**POT**	**HAL**	**Sum**
AK BSAI Atka mackerel trawl	1366	.	.	.	1366	1061	.	.	.	1061
AK BSAI flatfish trawl	7908	.	.	.	7908	13118	.	.	.	13118
AK BSAI Pacific cod trawl	4196	9	.	.	4205	1678	9	.	.	1687
AK BSAI pollock trawl	40	16006	.	.	16046	212	12769	.	.	12981
AK BSAI rockfish trawl	275	.	.	.	275	366	1	.	.	367
AK GOA flatfish trawl	1404	10	.	.	1414	1670	3	.	.	1673
AK GOA Pacific cod trawl	378	12	.	.	390	379	34	.	.	413
AK GOA pollock trawl	19	424	.	.	443	91	425	.	.	516
AK GOA rockfish trawl	944	285	.	.	1229	1014	167	.	.	1181
AK BSAI Greenland turbot longline	.	.	.	580	580	.	.	.	307	307
AK BSAI Pacific cod longline	.	.	.	8942	8942	.	.	.	12395	12395
AK BSAI Pacific halibut longline	.	.	.	72	72	.	.	.	83	83
AK BSAI rockfish longline	.	.	.	14	14	.	.	.	.	0
AK BSAI sablefish longline	.	.	.	352	352	.	.	.	356	356
AK GOA Pacific cod longline	.	.	.	662	662	.	.	.	676	676
AK GOA Pacific halibut longline	.	.	.	88	88	.	.	.	147	147
AK GOA rockfish longline	.	.	.	0	0	.	.	.	.	.
AK GOA sablefish longline	.	.	.	1549	1549	.	.	.	1214	1214
AK GOA Pacific cod pot	.	.	466	.	466	.	.	352	.	352
AK BSAI Pacific cod pot	.	.	836	.	836	.	.	795	.	795
Unknown (non-LOF)	442	105	801	453	1801	216	164	651	636	1590
Sum	16972	16851	2103	12712	**48638**	19805	13495	1798	15814	**50912**

Gear types:
NPT = Non-pelagic trawl
PTR = Pelagic trawl
POT = Pot
HAL = Hook and line

Table 4. -- Cont.

	2009 Gear type					2010 Gear type				
Fishery	**NPT**	**PTR**	**POT**	**HAL**	**Sum**	**NPT**	**PTR**	**POT**	**HAL**	
AK BSAI Atka mackerel trawl	1393	0	.	.	1393	1421	.	.	.	1421
AK BSAI flatfish trawl	10818	2	.	.	10820	11473	.	.	.	11473
AK BSAI Pacific cod trawl	1246	34	.	.	1280	1249	11	.	.	1260
AK BSAI pollock trawl	285	10030	.	.	10315	337	9130	.	.	9467
AK BSAI rockfish trawl	344	.	.	.	344	411	1	.	.	412
AK GOA flatfish trawl	1549	3	.	.	1552	1391	.	.	.	1391
AK GOA Pacific cod trawl	308	8	.	.	316	452	6	.	.	458
AK GOA pollock trawl	35	371	.	.	406	31	416	.	.	447
AK GOA rockfish trawl	1192	195	.	.	1387	1148	167	.	.	1315
AK BSAI Greenland turbot longline	.	.	.	544	544	.	.	.	784	784
AK BSAI Pacific cod longline	.	.	.	12000	12000	.	.	.	10898	10898
AK BSAI Pacific halibut longline	.	.	.	91	91	.	.	.	179	179
AK BSAI rockfish longline	.	.	.	23	23	.	.	.	12	12
AK BSAI sablefish longline	.	.	.	673	673	.	.	.	553	553
AK GOA Pacific cod longline	.	.	.	823	823	.	.	.	1462	1462
AK GOA Pacific halibut longline	.	.	.	285	285	.	.	.	130	130
AK GOA rockfish longline	.	.	.	46	46	.	.	.	4	4
AK GOA sablefish longline	.	.	.	1140	1140	.	.	.	1051	1051
AK GOA Pacific cod pot	.	.	187	.	187	.	.	168	.	168
AK BSAI Pacific cod pot	.	.	726	.	726	.	.	1198	.	1198
Unknown (non-LOF)	163	49	646	501	1359	110	32	605	427	1264*
Sum	17333	10692	1559	16126	**45710**	18023	9763	1971	15500	**45302**

* Includes 45 unknown gear codes

Table 4. -- Cont.

	2011 Gear type				
Fishery	**NPT**	**PTR**	**POT**	**HAL**	**Sum**
AK BSAI Atka mackerel trawl	1113	5	.	.	1118
AK BSAI flatfish trawl	11091	.	.	.	11091
AK BSAI Pacific cod trawl	1596	9	.	.	1605
AK BSAI pollock trawl	249	17285	.	.	17534
AK BSAI rockfish trawl	635	.	.	.	635
AK GOA flatfish trawl	1162	.	.	.	1162
AK GOA Pacific cod trawl	553	1	.	.	554
AK GOA pollock trawl	83	417	.	.	500
AK GOA rockfish trawl	1030	105	.	.	1135
AK BSAI Greenland turbot longline	.	.	.	623	623
AK BSAI Pacific cod longline	.	.	.	12804	12804
AK BSAI Pacific halibut longline	.	.	.	105	105
AK BSAI rockfish longline	.	.	.	2	2
AK BSAI sablefish longline	.	.	.	600	600
AK GOA Pacific cod longline	.	.	.	1707	1707
AK GOA Pacific halibut longline	.	.	.	114	114
AK GOA rockfish longline	.	.	.	.	.
AK GOA sablefish longline	.	.	.	1135	1135
AK GOA Pacific cod pot	.	.	477	.	477
AK BSAI Pacific cod pot	.	.	1242	.	1242
Unknown (non-LOF)	577	151	813	350	1891
Sum	18089	17973	2532	17440	**56034**

Gear types:
NPT = Non-pelagic trawl
PTR = Pelagic trawl
POT = Pot
HAL = Hook and line

Table 5. -- Observed and estimated bycatch by year, fishery and marine mammal species, including estimated fraction of the fishery observed, observed bycatch, estimated bycatch and CV of the estimated bycatch. Numbers in parentheses are observed bycatches in unsampled hauls are not used to estimate bycatch and the CV.

Year	Fishery	Observed coverage	Marine mammal species	Observed Bycatch	Estimated bycatch	CV
2007	AK BSAI Atka mackerel trawl	0.940	Ribbon seal	1	1.0	0.22
	BSAI flatfish trawl	0.718	Steller (northern) sea lion	3 (1)[1]	3.7	0.25
			Walrus	2	3.8	0.54
			Harbor porpoise	1	1.8	0.67
			Harbor seal	(1)		
	BSAI Pacific cod trawl	0.534	Steller (northern) sea lion	1 (2)	1.0	0.15
	BSAI pollock trawl	0.848	Northern fur seal	3	14.6	0.88
			Bearded seal	1	1.0	0.00
			Steller (northern) sea lion	2	2.0	0.04
	BSAI Greenland turbot longline	0.639	Killer whale	1	1.5	0.61
	GOA sablefish longline	0.167	Sperm whale	1	1.4	0.57
				16 (4)	31.8	0.41
2008	BSAI flatfish trawl	0.996	Northern fur seal	2	2.1	0.17
			Bearded seal	1	1.0	0.04
			Steller (northern) sea lion	11	11.0	0.01
			Killer whale	1	1.0	0.03
			Walrus	1	1.0	0.00
			Ringed seal	2	2.0	0.02
			Spotted seal (Larga seal)	2	2.0	0.02
	BSAI pollock trawl	0.854	Northern fur seal	1	1.0	0.12
			Bearded seal	4	4.1	0.08
			Steller (northern) sea lion	8	10.1	0.24
			Ribbon seal	2	2.1	0.14
			Ringed seal	1	1.0	0.15
			Harbor seal	1	2.9	0.82
	GOA Pacific cod longline	0.146	Steller (northern) sea lion	1	1.6	0.61
				38(1)[2]	42.9	0.08
2009	AK BSAI Atka mackerel trawl	0.990	Ribbon seal	1	1.0	0.01
	BSAI flatfish trawl	0.998	Northern fur seal	1	1.0	0.02
			Steller (northern) sea lion	3	3.0	0.06
			Killer whale	2	2.0	0.02
			Ringed seal	1	1.0	0.01
			Spotted seal (Larga seal)	1	1.0	0.00
	BSAI pollock trawl	0.855	Bearded seal	1	1.0	0.22
			Steller (northern) sea lion	6	6.2	0.09
			Ribbon seal	1	1.0	0.11
			Ringed seal	1	1.0	0.11
			Dall's porpoise	1	1.0	0.20
	GOA flatfish trawl	0.213	Northern elephant seal	1	1.9	0.67
	BSAI Pacific cod longline	0.604	Dall's porpoise	(1)		
				20(1)	21.1	0.07

Table 5.-- Cont.

2010	AK BSAI Atka mackerel trawl	0.999	Steller (northern) sea lion	1	1.0	0.05
	BSAI flatfish trawl	0.999	Northern fur seal	(1)		
			Steller (northern) sea lion	4 (1)	4.0	0.01
			Gray whale	1	1.0	0.01
			Humpback whale	(1)		
			Walrus	2	2.0	0.01
	BSAI Pacific cod trawl	0.659	Steller (northern) sea lion	1	1.0	0.00
	BSAI pollock trawl	0.862	Northern fur seal	2	2.0	0.07
			Bearded seal	(1)		
			Steller (northern) sea lion	5	8.2	0.35
			Humpback whale	1	1.0	0.08
			Spotted seal (Larga seal)	1	1.0	0.11
	BSAI rockfish trawl	1.000	Killer whale	1	1.0	0.00
	GOA Pacific cod trawl	0.314	Harbor seal	1	2.8	0.82
	BSAI Pacific cod longline	0.641	Northern fur seal	1	1.4	0.51
			Unident. pinniped	1	1.1	0.34
	GOA Pacific cod longline	0.284	Steller (northern) sea lion	1	1.1	0.32
				23(4)	28.6	0.13
2011	BSAI flatfish trawl	0.999	Bearded seal	1	1.0	0.06
			Steller (northern) sea lion	7	7.0	0.01
			Ringed seal	6(1)	6.0	0.02
			Harbor seal	1	1.0	0.04
	BSAI Pacific cod trawl	0.595	Steller (northern) sea lion	1	1.0	0.12
			Ringed seal	1	1.0	0.00
	BSAI pollock trawl	0.979	Steller (northern) sea lion	9	9.3	0.06
			Ringed seal	3	3.0	0.03
	GOA flatfish trawl	0.307	Harbor seal	1	1.9	0.68
	BSAI Pacific cod longline	0.573	Ringed seal	1	1.6	0.60
			Spotted seal (Larga seal)	1	1.6	0.60
				32(2)[3]	38.4	0.06

[1] Numbers in parentheses are observed bycatches in unsampled hauls and were not used in estimating bycatch and its CV

[2] A Steller (northern) sea lion was observed in an offload operation in 2008. The animal was included in the sum of observed bycatches in unsampled hauls for 2008 (1).

[3] A spotted seal (Larga seal) and a bearded seal morality were observed in offload operations in 2011 and could be traced to the pollock fishery in NMFS area 521. This animal was treated as in footnote 2.

Table 6.-- Data from Table 5, formatted as in Alaska Marine Mammal Stock Assessments reports. See foot note 1 for heading abbreviations. MAM, cv MAM, MTAM, and cv MTAM are listed on the first line for each species and fishery and refer to the 5 years 2007-2011.

Marine Mammal Species	Fishery	Year	Obs cov.	Obs bycatch (samp.)	Obs bycatch (unsamp.)	Estimated bycatch	cv	MAM	cv MAM	MTAM	cv MTAM
Northern fur seal	BSAI flatfish trawl	2007	0.718					0.62	0.11	4.42	0.58
		2008	0.996	2		2.1	0.17				
		2009	0.998	1		1.0	0.02				
		2010	0.999		1						
		2011	0.999								
	BSAI pollock trawl	2007	0.848	3		14.6	0.88	3.52	0.73		
		2008	0.854	1		1.0	0.12				
		2009	0.855								
		2010	0.862	2		2.0	0.07				
		2011	0.979								
	BSAI Pacific cod longline	2007	0.626								
		2008	0.626								
		2009	0.604								
		2010	0.641	1		1.4	0.52	0.28	0.51		
		2011	0.573								
Bearded seal	BSAI flatfish trawl	2007	0.718					0.4	0.03	1.62	0.05
		2008	0.996	1		1.0	0.04				
		2009	0.998								
		2010	0.999								
		2011	0.999	1		1.0	0.06				
	BSAI pollock trawl	2007	0.848	1		1.0	0	1.22	0.06		
		2008	0.854	4		4.1	0.08				
		2009	0.855	1		1.0	0.21				
		2010	0.862		1						
		2011	0.979								
Steller (northern) sea lion	AK BSAI Atka mackerel trawl	2007	0.940					0.2	0.05	14.24	0.06
		2008	0.999								
		2009	0.990								
		2010	0.999	1		1.0	0.05				
		2011	0.999								
	BSAI flatfish trawl	2007	0.718	3	1	3.7	0.25	5.74	0.03		
		2008	0.996	11		11.0	0.01				
		2009	0.998	3		3.0	0.06				
		2010	0.999	4	1	4.0	0.01				
		2011	0.999	7		7.0	0.01				

Table 6. -- Cont.

	BSAI Pacific cod trawl	2007	0.534	1	2	1.0	0.15	0.6	0.07		
		2008	0.586								
		2009	0.634								
		2010	0.659	1		1.0	0				
		2011	0.595	1		1.0	0.12				
	BSAI pollock trawl	2007	0.848	2		2.0	0.04	7.16	0.11		
		2008	0.854	8		10.1	0.24				
		2009	0.855	6		6.2	0.09				
		2010	0.862	5		8.2	0.35				
		2011	0.979	9		9.3	0.06				
	GOA Pacific cod longline	2007	0.202					0.54	0.39		
		2008	0.146	1		1.6	0.61				
		2009	0.209								
		2010	0.284	1		1.1	0.32				
		2011	0.303								
Gray whale	BSAI flatfish trawl	2007	0.718					0.2	0.01	0.2	0.01
		2008	0.996								
		2009	0.998								
		2010	0.999	1		1.0	0.01				
		2011	0.999								
Northern elephant seal	GOA flatfish trawl	2007	0.31					0.38	0.67	0.38	0.67
		2008	0.274								
		2009	0.213	1		1.9	0.68				
		2010	0.263								
		2011	0.307								
Humpback whale	BSAI pollock trawl	2007	0.848					0.2	0.08	0.2	0.08
		2008	0.854								
		2009	0.855								
		2010	0.862	1		1.0	0.08				
		2011	0.979								
	BSAI flatfish trawl	2007	0.718								
		2008	0.996								
		2009	0.998								
		2010	0.999		1						
		2011	0.999								
		2008	0.996	1		1.0	0.03				
		2009	0.998	2		2.0	0.02				
		2010	0.999								
		2011	0.999								

Table 6. -- Cont.

	BSAI rockfish trawl	2007	0.876					0.2	0		
		2008	0.984								
		2009	0.994								
		2010	1.000	1		1.0	0				
		2011	0.998								
	BSAI Greenland turbot longline	2007	0.639	1		1.5	0.59	0.3	0.61		
		2008	0.738								
		2009	0.737								
		2010	0.592								
		2011	0.589								
Walrus	BSAI flatfish trawl	2007	0.718	2		3.8	0.54	1.36	0.3	1.36	0.3
		2008	0.996	1		1.0	0				
		2009	0.998								
		2010	0.999	2		2.0	0.01				
		2011	0.999								
Ribbon seal	AK BSAI Atka mackerel trawl	2007	0.940	1		1.0	0.21	0.4	0.11	1.02	0.08
		2008	0.999								
		2009	0.990	1		1.0	0.01				
		2010	0.999								
		2011	0.999								
	BSAI pollock trawl	2007	0.848					0.62	0.1		
		2008	0.854	2		2.1	0.14				
		2009	0.855	1		1.0	0.11				
		2010	0.862								
		2011	0.979								
Ringed seal	BSAI flatfish trawl	2007	0.718					1.8	0.02	3.32	0.06
		2008	0.996	2		2.0	0.02				
		2009	0.998	1		1.0	0.01				
		2010	0.999								
		2011	0.999	6	1	6.0	0.02				
	BSAI Pacific cod trawl	2007	0.534					0.2	0		
		2008	0.586								
		2009	0.634								
		2010	0.659								
		2011	0.595	1		1.0	0				
	BSAI pollock trawl	2007	0.848					1	0.04		
		2008	0.854	1		1.0	0.15				
		2009	0.855	1		1.0	0.11				
		2010	0.862								
		2011	0.979	3		3.0	0.03				

Table 6. -- Cont.

	BSAI Pacific cod longline	2007	0.626					0.32	0.6		
		2008	0.626								
		2009	0.604								
		2010	0.641								
		2011	0.573	1		1.6	0.61				
Spotted seal (Larga seal)	BSAI flatfish trawl	2007	0.718					0.6	0.02	1.12	0.17
		2008	0.996	2		2.0	0.02				
		2009	0.998	1		1.0	0				
		2010	0.999								
		2011	0.999								
	BSAI pollock trawl	2007	0.848					0.2	0.11		
		2008	0.854								
		2009	0.855								
		2010	0.862	1		1.0	0.11				
		2011	0.979								
	BSAI Pacific cod longline	2007	0.626					0.32	0.6		
		2008	0.626								
		2009	0.604								
		2010	0.641								
		2011	0.573	1		1.6	0.61				
Sperm whale	GOA sablefish longline	2007	0.167	1		1.4	0.56	0.28	0.57	0.28	0.57
		2008	0.156								
		2009	0.162								
		2010	0.152								
		2011	0.141								
Harbor porpoise	BSAI flatfish trawl	2007	0.718	1		1.8	0.67	0.36	0.67	0.36	0.67
		2008	0.996								
		2009	0.998								
		2010	0.999								
		2011	0.999								
Harbor seal	BSAI flatfish trawl	2007	0.718		1			0.2	0.04	1.72	0.41
		2008	0.996								
		2009	0.998								
		2010	0.999								
		2011	0.999	1		1.0	0.04				
	BSAI pollock trawl	2007	0.848					0.58	0.82		
		2008	0.854	1		2.9	0.81				
		2009	0.855								
		2010	0.862								
		2011	0.979								

Table 6. -- Cont.

	GOA flatfish trawl	2007	0.310					0.38	0.68		
		2008	0.274								
		2009	0.213								
		2010	0.263								
		2011	0.307	1		1.9	0.68				
	GOA Pacific cod trawl	2007	0.174					0.56	0.82		
		2008	0.153								
		2009	0.294								
		2010	0.314	1		2.8	0.81				
		2011	0.410								
Dall's porpoise	BSAI pollock trawl	2007	0.848					0.20	0.20	0.20	0.20
		2008	0.854								
		2009	0.855	1		1.0	0.20				
		2010	0.862								
		2011	0.979								
	BSAI Pacific cod longline	2007	0.626								
		2008	0.626								
		2009	0.604		1						
		2010	0.641								
		2011	0.573								
Unident. pinniped	BSAI Pacific cod longline	2007	0.626					0.22	0.34	0.22	0.34
		2008	0.626								
		2009	0.604								
		2010	0.641	1		1.1	0.33				
		2011	0.573								
				129	10	158.5		31.76		31.76	

[1] Heading abbreviations: Obs. Cov.: observer coverage, Obs. Bycatch (samp.): observed bycatch in sampled hauls, Obs. Bycatch (unsamp.): observed bycatch in unsampled hauls, cv: coefficient of variation of estimated bycatch, MAM: mean annual mortality, cv MAM: cv of MAM, MTAM: mean total annual mortality, cv MTAM: cv of MTAM.

APPENDICES

Appendix 1. -- National Marine Fisheries Service list of fisheries (LOF) for which bycatch estimates must be made.

	Fishery	Target species	CAS species group
AK BSAI groundfish trawl fishery			
1	AK BSAI Atka mackerel trawl fishery	A	AMCK
2	AK BSAI flatfish, trawl fishery	Y + R + L + F + E + W + T	AKPL, ARTH, FLO5, FSOL, GRTB, RSOL, YSOL
3	AK BSAI Pacific cod trawl fishery	C	PCOD
4	AK BSAI pollock trawl fishery	B + P	PLCK
5	AK BSAI rockfish trawl fishery	K	NORK, REYE, ROCK, SRKR
AK GOA groundfish trawl fishery			
6	AK GOA flatfish trawl fishery	D + H + W + X + L	ARTH, DFL4, FLO5, FSOL, REXS, SFL1
7	AK GOA Pacific cod trawl fishery	C	PCOD
8	AK GOA pollock trawl fishery	B + P	PLCK
9	AK GOA rockfish trawl fishery	K	DEM1, NORK, PEL7, REYE, ROCK, SRKR, THDS
AK BSAI groundfish longline/set line fishery			
10	AK BSAI Greenland turbot longline fishery	T	GTRB
11	AK BSAI Pacific cod longline fishery	C	PCOD
12	AK BSAI Pacific halibut longline fishery	I	HLBT
13	AK BSAI rockfish longline fishery	K	NORK, REYE, ROCK, SRKR
14	AK BSAI sablefish longline fishery	S	SABL
AK GOA groundfish longline/set line fishery			
15	AK GOA Pacific cod longline fishery	C	PCOD
16	AK GOA Pacific halibut longline fishery	I	HLBT
17	AK GOA rockfish longline fishery	K	DEM1, NORK, PEL7, REYE, SRKR
18	AK GOA sablefish longline fishery	S	SABL
19	AK GOA flatfish longline fishery	D + H + W + X + L	ARTH, DFL4, FLO5, SFL1, REXS, FSOL
AK BS and GOA finfish pot fishery			
20	AK BSAI Pacific cod pot fishery	C	PCOD
21	AK BS sablefish pot fishery	S	SABL
22	AK AI sablefish pot fishery	S	SABL
23	A K GOA Pacific cod pot fishery	C	PCOD

Abbreviations:
AK Alaska
BS Bering Sea
BSAI Bering Sea - Aleutian Islands
GOA Gulf of Alaska

Appendix 2. -- Oracle views and tables at AFSC used in bycatch analyses.

Table or view name	Description
NORPAC.AKR_OBS_HAUL_MV[1]	AKR Observer haul data, including observed groundfish weights
NORPAC.AKR_CA_PRIMARY_TXN MV[2]	AKR trip data, including total groundfish weights
OBSINT.DEBRIEFED_MAMMAL	AFSC marine mammal interaction data
NORPAC.AKR_V_VESSEL_MV	Vessel length view

[1] Equivalent to the AKR table AKFISH.V_OBS_HAUL
[2] Equivalent to the AKR table AKFISH.V_GG_TXN_PRIMARY_ALL

Appendix 3. -- Marine mammal interaction codes (Observer Program data)

Code	Description	Bycatch
1	Deterrence used	
2	Entangled in gear (not trailing gear)	
3	Entangled in gear (trailing gear)	
4	***Killed by gear***	✓
5	***Killed by propeller***	✓
6	Previously dead	
7	***Lethal removal (trailing gear)***	✓
8	***Lethal removal (not trailing gear)***	✓
9	Boarded vessel	
10	Feeding on catch (not yet landed)	
12	Other	
13	Unknown	
14	Feeding on discards	

✓= mortality

Appendix 4. -- Gear codes

Observer Program Code	CAS code	Description
1	NPT	Non-pelagic trawl
2	PTR	Pelagic trawl
6	POT	Pot
7	JIG	Jig
8	HAL	Hook and line

Appendix 5. -- Marine mammal species codes, common names and scientific names.

Code	Common name	Scientific name
BA	Minke Whale	*Balaenoptera acutorostrata*
BB	Sei Whale	*Balaenoptera borealis*
BE	Baird's Beaked Whale	*Berardius bairdii*
BG	Black Right Whale	*Balaena glacialis*
BL	Blue Whale	*Balaenoptera musculus*
BM	Bowhead Whale	*Balaena mysticetus*
BP	Fin Whale	*Balaenoptera physalus*
BX	Bryde's Whale	*Balaenoptera edeni*
CU	Northern Fur Seal	*Callorhinus ursinus*
DD	Common Dolphin	*Delphinus delphis*
DL	Beluga	*Delphinapterus leucas*
EB	Bearded seal	*Erignathus barbatus*
EJ	Steller (Northern) Sea Lion	*Eumetopias jubatus*
EL	Sea Otter	*Enhydra lutris*
ER	Gray Whale	*Eschrichtius robustus*
FA	Pygmy Killer Whale	*Feresa attenuata*
GG	Risso's Dolphin	*Grampus griseus*
GM	Shortfin Pilot Whale	*Globicephala macrorhynchus*
LB	Northern Right Whale Dolphin	*Lissodelphis borealis*
LH	Frasier's Dolphin	*Lagenodelphis hosei*
LO	Pacific Whitesided Dolphin	*Lagenorhynchus obliquidens*
MA	Northern Elephant seal	*Mirounga angustirostris*
MM	Narwhal	*Monodon monoceros*
MN	Humpback Whale	*Megaptera novaeangliae*
MS	Bering Sea beaked Whale	*Mesoplodon stejnegeri*
OO	Killer Whale	*Orcinus orca*
OR	Walrus	*Odobenus rosmarus*
PC	False Killer Whale	*Pseudorca crassidens*
PF	Ribbon seal	*Histriophoca fasciata*
PH	Ringed seal	*Phoca hispida*
PL	Spotted Seal (Larga Seal)	*Phoca largha*
PM	Sperm Whale	*Physeter macrocephalus*
PP	Harbor Porpoise	*Phocoena phocoena*
PV	Harbor Seal	*Phoca vitulina*
PX	Dall's Porpoise	*Phocoenoides dalli*
SA	Spotted Dolphin (Cent. Pac.)	*Stenella attenuata*
SB	Rough Toothed Dolphin	*Steno bredanensis*
SC	Striped Dolphin	*Stenella coeruleoalba*
SG	Spotted Dolphin (East. Pac.)	*Stenella attenuata*
SL	Spinner Dolphin	*Stenella longirostris*
TT	Bottlenose Dolphin	*Tursiops truncatus*
UC	Unidentified Cetacean	NA
UD	Unident. Dolphin/Porp.	*Unidentified dolphin/porpoise*
UO	Unident. Otariid	*Unidentified otariid*
UP	Unident. Pinniped	*Unidentified pinniped*
US	Unidentiphied Phocid	*Unidentified phocid*
UW	Unidentified Whale	NA
UX	Unidentified Small Whale	NA
UZ	Unidentified Large Whale	NA
ZC	California Sea Lion	*Zalophus californianus*
ZX	Goosebeak Whale	*Ziphius cavirostris*
ZZ	Unidentified Mammal	NA

Appendix 6. -- Catch Accounting System species group codes and target species codes.

CAS Species Group Codes		Target Species Codes			
Code	**Description**	**Code**	**Description**		
AKPL	Alaska Plaice BSAI Alaska Plaice	**A**	Atka Mackerel	(BSAI	GOA)
AMCK	Atka Mackerel	**B**	Bottom Trawl Pollock	(BSAI	GOA)
ARTH	Arrowtooth Flounder	**C**	Pacific Cod	(BSAI	GOA)
BSKT	GOA Skate Big	**D**	Deep Water Flatfish	(	GOA)
DEM1	GOA Demersal Shelf Rockfish	**E**	Alaska Plaice	(BSAI	)
DFL4	GOA Deep Water Flatfish	**F**	Other Flatfish	(BSAI	)
FLO5	BSAI Other Flatfish; Other Flatfish	**H**	Shallow Water Flatfish	(	GOA)
FSOL	Flathead Sole	**I**	Halibut	(BSAI	GOA)
GTRB	Greenland Turbot	**K**	Rockfish	(BSAI	GOA)
LSKT	GOA Skate Longnose	**L**	Flathead Sole	(BSAI	GOA)
NORK	Northern Rockfish	**P**	Pelagic Pollock	(BSAI	GOA)
OTHR	Other Species	**R**	Rock Sole	(BSAI	)
PCOD	Pacific Cod	**S**	Sablefish	(BSAI	GOA)
PEL7	GOA Pelagic Shelf Rockfish	**T**	Greenland Turbot	(BSAI	)
PLCK	Pollock	**W**	Arrowtooth Flounder	(BSAI	GOA)
POPA	Pacific Ocean Perch	**X**	Rex Sole	(	GOA)
REXS	BOA Rex Sole	**Y**	Yellowfin Sole	(BSAI	)
REYE	GOA, BSAI Rougheye Rockfish	**O**	Other Species		
ROCK	Other Rockfish	**Z**	No Retained Catch		
RSOL	Rock Sole				
SABL	Sablefish				
SFL1	BOA Shallow Water Flatfish				
SQID	BSAI Squid				
SRKR	BSAI GOA Shortraker Rockfish;				
THDS	GOA Thornyhead Rockfish				
USKT	GOA Skate; Other				
YSOL	Yellowfin Sole				

Appendix 7. -- Description of Oracle table: OBSINT.DEBRIEFED_MAMMAL_V

COLUMN_ID	COLUMN_NAME	DATA_TYPE
1	ANIMAL_CONDITION	VARCHAR2(40)
2	ANIMAL_NUMBER	NUMBER
3	COMMON_NAME	VARCHAR2(60)
4	CONDITION_CODE	NUMBER
5	CRUISE	NUMBER(8,0)
6	DETERRENCE_CODE	VARCHAR2(40)
7	DETERRENCE_DEPLOYED	VARCHAR2(100)
8	DETERRENCE_SUCCESS_FLAG	VARCHAR2(1)
9	GEAR_TYPE	NUMBER
10	HAUL_JOIN	NUMBER
11	HAUL_NUMBER	NUMBER
12	HAUL_SEQ	NUMBER
13	INTERACTION_CODE	NUMBER
14	INTERACTION_COMMENTS	VARCHAR2(4000)
15	INTERACTION_DATE	DATE
16	INTERACTION_DESCRIPTION	VARCHAR2(60)
17	LATITUDE_DD	NUMBER
18	LONGITUDE_CONVERTED	NUMBER
19	LONGITUDE_DD	NUMBER
20	MAMMAL_RECORD_ID	NUMBER
21	MAMMAL_SPECIES_CODE	VARCHAR2(2)
22	NMFS_AREA	NUMBER
23	NUMBER_OF_ANIMALS	NUMBER(3,0)
24	OBSERVATION_FLAG	VARCHAR2(1)
25	OFFICIAL_TOTAL_CATCH	NUMBER
26	OFFLOAD_JOIN	NUMBER
27	OFFLOAD_NUMBER	NUMBER
28	OFFLOAD_SEQ	NUMBER
29	PERMIT	VARCHAR2(6)
30	SEX	VARCHAR2(1)
31	SPECIMEN_COMMENTS	VARCHAR2(2000)
32	SPECIMEN_NUMBER	NUMBER
33	SPECIMEN_TYPE	VARCHAR2(100)
34	T_TABLE	VARCHAR2(32)
35	TRIP_JOIN	NUMBER
36	TRIP_NUMBER	NUMBER
37	TRIP_SEQ	NUMBER
38	VALUE	VARCHAR2(40)
39	VESSEL	VARCHAR2(6)
40	YEAR	NUMBER

Appendix 8. -- Description of NORPAC Oracle materialized view: NORPAC.AKR_OBS_HAUL_MV (equivalent to the AKR view AKFISH.V_OBS_HAUL)

COLUMN_ID	COLUMN_NAME	DATA_TYPE
1	CA_REFERENCE_KEY	NUMBER (20,0)
2	CRUISE	NUMBER (8,0)
3	OBS_VESSEL_ID	VARCHAR2 (4 BYTE)
4	HAUL_DATE	DATE
5	HAUL_NUMBER	NUMBER (4,0)
6	HAUL_JOIN	NUMBER (24,0)
7	SAMPLED_FLAG	VARCHAR2 (1 BYTE)
8	EXTRAP_SOURCE_CA_REF_KEY	NUMBER (20,0)
9	AKR_VESSEL_ID	NUMBER (6,0)
10	OBS_PROCESSOR_ID	VARCHAR2 (6 BYTE)
11	CATCHER_BOAT_ADFG	VARCHAR2 (6 BYTE)
12	FISHING_START_DATE	DATE
13	CDQ_GROUP_ID	NUMBER (6,0)
14	OBS_CDQ_CODE	VARCHAR2 (3 BYTE)
15	IFQ_FLAG	VARCHAR2 (1 BYTE)
16	GEAR_ID	NUMBER (6,0)
17	OBS_GEAR_CODE	NUMBER (2,0)
18	AKR_GEAR_CODE	VARCHAR2 (5 BYTE)
19	PERFORMANCE	NUMBER (2,0)
20	OBS_VESSEL_TYPE	NUMBER (2,0)
21	DEPLOYMENT_DATE	DATE
22	DEPLOYMENT_LATITUDE	NUMBER (4,0)
23	DEPLOYMENT_LONGITUDE	NUMBER (5,0)
24	FISHING_DEPTH	NUMBER (4,0)
25	BOTTOM_DEPTH	NUMBER (5,0)
26	RETRIEVAL_DATE	DATE
27	LOCATION	VARCHAR2 (1 BYTE)
28	LATITUDE	NUMBER (5,0)
29	LONGITUDE	NUMBER (5,0)
30	REPORTING_AREA_ID	NUMBER (6,0)
31	REPORTING_AREA_CODE	VARCHAR2 (6 BYTE)
32	FMP_AREA_ID	NUMBER (6,0)
33	GENERIC_AREA	NUMBER (3,0)
34	COBLZ_FLAG	VARCHAR2 (1 BYTE)
35	OFFICIAL_TOTAL_CATCH	NUMBER (6,2)
36	OBSERVER_ESTIMATE	NUMBER (6,2)
37	VESSEL_ESTIMATE	NUMBER (6,2)
38	OBSERVER_ESTIMATE_METHOD	VARCHAR2 (1 BYTE)
39	HAUL_PURPOSE_CODE	VARCHAR2 (3 BYTE)
40	TARGET_FISHERY_CODE	VARCHAR2 (1 BYTE)
41	DENSITY	NUMBER (3,2)
42	SKATES_IN_SET	NUMBER (4,0)
43	HOOKS_PER_SKATE	NUMBER (4,0)
44	TOTAL_HOOKS_POTS	NUMBER (6,0)
45	HAUL_SAMPLED_BY	NUMBER (5,0)
46	RANDOM_SAMPLE_TABLE	VARCHAR2 (1 BYTE)
47	RANDOM_BREAK_TABLE	VARCHAR2 (1 BYTE)
48	MM_PERCENT_MONITORED	NUMBER (3,0)
49	BIRD_DETERRENCE	VARCHAR2 (2 BYTE)
50	BIRD_VERIFICATION	VARCHAR2 (1 BYTE)
51	DELIVERY_NUMBER	NUMBER (4,0)
52	YEAR	NUMBER (4,0)

Appendix 8. -- Cont.

53	LAST_MODIFIED_DATE	DATE
54	DATE_OF_ENTRY	DATE
55	SOURCE_TABLE	VARCHAR2 (8 BYTE)
56	DEPLOYMENT_LATITUDE_DD	NUMBER (10,6)
57	DEPLOYMENT_LONGITUDE_DD	NUMBER (11,6)
58	RETRIEVAL_LATITUDE_DD	NUMBER (10,6)
59	RETRIEVAL_LONGITUDE_DD	NUMBER (11,6)
60	ADFG_STAT_AREA_ID	NUMBER (6,0)
61	ADFG_STAT_AREA_CODE	VARCHAR2 (6 BYTE)
62	CRITICAL_HABITAT_AREA_ID	NUMBER (6,0)
63	CRITICAL_HABITAT_AREA_CODE	VARCHAR2 (6 BYTE)
64	SPECIAL_AREA_ID	NUMBER (6,0)
65	SPECIAL_AREA_CODE	VARCHAR2 (6 BYTE)
66	AFA_COOP	NUMBER (6,0)
67	BSAI_PROC_SECTOR	VARCHAR2 (2 BYTE)
68	GOA_PROC_SECTOR	VARCHAR2 (1 BYTE)
69	AFA_HARVEST_SECTOR	VARCHAR2 (2 BYTE)
70	BSAI_PCOD_VESSEL_SIZE_CAT	VARCHAR2 (1 BYTE)
71	BSAI_POLLOCK_VESSEL_SIZE_CAT	VARCHAR2 (1 BYTE)
72	TARGET_FISHERY_AREA	NUMBER (6,0)
73	TARGET_FISHERY_YEAR	NUMBER
74	PCOD_DIR_FISHING_FLAG	VARCHAR2 (1 BYTE)
75	POLLOCK_DIR_FISHING_FLAG	VARCHAR2 (1 BYTE)
76	TOTAL_GROUNDFISH_WEIGHT	NUMBER (11,2)
77	RETAINED_GROUNDFISH_WEIGHT	NUMBER (11,2)
78	TRIP_TARGET_CODE	VARCHAR2 (1 BYTE)
79	TRIP_TARGET_DATE	DATE
80	PSCNQ_PROCESSING_SECTOR	VARCHAR2 (2 BYTE)
81	SEABIRD_SAMPLE_TYPE	VARCHAR2 (1 BYTE)
82	CATCHER_VESSEL_ID	NUMBER (6,0)
83	CURRENT_STATE_CODE	VARCHAR2 (6 BYTE)
84	PENDING_PROCESS_STATE_CODE	VARCHAR2 (6 BYTE)
85	VERSION_NUMBER	NUMBER (4,0)

Appendix 9. -- Description of NORPAC Oracle materialized view: NORPAC.AKR_CA_PRIMARY_TXN_MV (equivalent to the AKR view AKFISH.V_GG_TXN_PRIMARY_ALL)

COLUMN_ID	COLUMN_NAME	DATA_TYPE
1	PRIMARY_ACCOUNT	NUMBER (9,0)
2	YEAR	NUMBER (4,0)
3	CATCH_REPORT_TYPE_CODE	VARCHAR2 (6 BYTE)
4	HAUL_JOIN	NUMBER
5	REPORT_ID	NUMBER
6	REPORT_DATE	DATE
7	CATCH_ACTIVITY_DATE	DATE
8	TRIP_TARGET_DATE	DATE
9	WEEK_END_DATE	DATE
10	BSAI_PROCESSING_SECTOR	VARCHAR2 (2 BYTE)
11	GOA_PROCESSING_SECTOR	VARCHAR2 (1 BYTE)
12	PSCNQ_PROCESSING_SECTOR	VARCHAR2 (2 BYTE)
13	HARVEST_SECTOR	VARCHAR2 (2 BYTE)
14	PROCESSOR_PERMIT_ID	NUMBER (6,0)
15	VESSEL_ID	NUMBER (6,0)
16	CATCHER_VESSEL_ID	NUMBER (6,0)
17	BSAI_PCOD_VESSEL_SIZE_CAT	VARCHAR2 (1 BYTE)
18	BSAI_POLLOCK_VESSEL_SIZE_CAT	VARCHAR2 (1 BYTE)
19	MANAGEMENT_PROGRAM_ID	NUMBER (6,0)
20	MANAGEMENT_PROGRAM_CODE	VARCHAR2 (5 BYTE)
21	AFA_COOP_ID	NUMBER (6,0)
22	CDQ_GROUP_ID	NUMBER (6,0)
23	AGENCY_GEAR_ID	NUMBER (6,0)
24	AGENCY_GEAR_CODE	VARCHAR2 (5 BYTE)
25	TARGET_FISHERY_AREA	NUMBER (6,0)
26	FMP_AREA_ID	NUMBER
27	FMP_AREA_CODE	VARCHAR2 (6 BYTE)
28	REPORTING_AREA_ID	NUMBER (6,0)
29	REPORTING_AREA_CODE	VARCHAR2 (5 BYTE)
30	SPECIAL_AREA_ID	NUMBER (6,0)
31	SPECIAL_AREA_CODE	VARCHAR2 (5 BYTE)
32	ADFG_STAT_AREA_ID	NUMBER
33	ADFG_STAT_AREA_CODE	VARCHAR2 (6 BYTE)
34	STATE_FEDERAL_WATERS_CODE	VARCHAR2 (1 BYTE)
35	STATE_FISHERY_FLAG	VARCHAR2 (1 BYTE)
36	TRIP_TARGET_CODE	VARCHAR2 (1 BYTE)
37	PCOD_DIRECTED_FISHING_FLAG	VARCHAR2 (1 BYTE)
38	POLLOCK_DIRECTED_FISHING_FLAG	VARCHAR2 (1 BYTE)
39	AGENCY_SPECIES_ID	NUMBER (6,0)
40	AGENCY_SPECIES_CODE	VARCHAR2 (5 BYTE)
41	SPECIES_GROUP_ID	NUMBER (6,0)
42	SPECIES_GROUP_CODE	VARCHAR2 (4 BYTE)
43	WEIGHT_POSTED	NUMBER (11,3)
44	SOURCE_TABLE	CHAR(1 BYTE)
45	POSTED_ON_DATE	DATE
46	CA_REFERENCE_KEY	NUMBER (20,0)
47	CA_SPECIES_REFERENCE_KEY	NUMBER (20,0)
48	PROCESSOR_ID	NUMBER (6,0)

Appendix 10. -- Description of NORPAC Oracle materialized view: NORPAC.AKR_V_VESSEL_MV

COLUMN ID	COLUMN NAME	DATA TYPE
1	ADFG_NUMBER	VARCHAR2(6 BYTE)
2	AFA_ELIGIBLE_FLAG	VARCHAR2(1 BYTE)
3	COAST_GUARD_NUMBER	VARCHAR2(10 BYTE)
4	GROSS_TONNAGE	NUMBER
5	HOMEPORT_CITY_NAME	VARCHAR2(40 BYTE)
6	HOMEPORT_COUNTRY_CODE	VARCHAR2(10 BYTE)
7	HOMEPORT_STATE_CODE	VARCHAR2(5 BYTE)
8	ID	NUMBER(6,0)
9	LENGTH	NUMBER
10	LENGTH_OVERALL	NUMBER
11	NAME	VARCHAR2(60 BYTE)
12	NET_TONNAGE	NUMBER
13	PRIMARY_OWNER_PERSON_ID	NUMBER
14	REGISTERED_LENGTH	NUMBER
15	SHAFT_HORSEPOWER	NUMBER
16	UNDER_SANCTION_FLAG	VARCHAR2(1 BYTE)

Appendix 11. -- Outline of principal R functions used in analyses.

A single R function, BC.fns, is called which in turn calls various other functions to carry out the tasks to estimate bycatch by year, fishery and marine mammal species. The main functions called by BC.fns are given below (various, small utility functions are not included):

BC.fns	Master function
BycatchStats	Obtains variables for bycatch haul joins (Oracle view: NORPAC.AKR_OBS_HAUL_MV)
GetObsHaul	Gets bycatch records from OBSINT.DEBRIEFED_MAMMAL_V table and merges with NORPAC.AKR_OBS_HAUL_MV
GetPrimary	Gets AKR groundfish weight data
AssignFishery	Assigns a fishery number based on target species code, statistical area and gear type
ConvertGearType	Converts gear code to a numeric value
WedByYear	Computes week-ending dates (Saturday) for a given year
WeekEndDate	Computers week-ending date for a given date
GetArea	Gets geographical area (e.g. EGOA, CGOA, WGOA, GOA)
GetStatArea	Gets NMFS statistical area number
GetMmSpp	Gets common names for marine mammal species (from 2-character codes)
FisheryName	Lookup table to convert fishery number to a fishery name
GetVesselLen	Assigns class to vessel according to length
SortDataFrame	Sorts a data frame by column(s)
SAR.table	Creates a table in the form required for SAR report

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