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REGRESSION TREE AND RATIO ESTIMATES OF MARINE MAMMAL, SEA TURTLE, AND SEABIRD BYCATCH IN THE CALIFORNIA DRIFT GILLNET FISHERY: 1990-2015

James V. Carretta[1]
Jeffrey E. Moore[1]
Karin A. Forney[2]

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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James V. Carretta[1]
Jeffrey E. Moore[1]
Karin A. Forney[2]

NOAA National Marine Fisheries Service
Southwest Fisheries Science Center
[1]8901 La Jolla Shores, CA 92037
[2]110 McAllister Way, Santa Cruz
California 95060, USA

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U.S. DEPARTMENT OF COMMERCE
Penny S. Pritzker, Secretary of Commerce

National Oceanic and Atmospheric Administration
Dr. Kathryn D. Sullivan, Administrator

National Marine Fisheries Service
Eileen Sobeck, Assistant Administrator for Fisheries

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Abstract

Marine mammal, sea turtle, and seabird bycatch was estimated for the California swordfish drift gillnet fishery during a 26-year period (1990-2015), using random forest regression trees. Tree estimates were compared with traditional annual ratio estimates generated from the same observer data. Ratio estimates suffer from systematic bias (under- and overestimation of bycatch) when observed bycatch is rare, bycatch rates are inferred only from same-year data, and observer coverage is low. Model-based approaches result in more stable annual bycatch estimates with better precision, because estimates are informed by all available data. Even in years with zero observed bycatch, expected values from regression trees are usually positive (sometimes fractions of animals) and have error estimates (thus acknowledging the possibility that animals may be caught even when none are observed), whereas corresponding ratio estimates would be zero and have no error estimates. Regression tree bycatch models include a suite of oceanographic, location, and gear variables used as predictors to estimate bycatch at the fishing-set level. Variables that significantly influenced bycatch rates were identified with a variable selection approach using the R-package *rfPermute* and validated with a simulated bycatch dataset. Results indicate that *rfPermute* can succeed in identifying significant predictor variables for rare bycatch events, even when these events represent <1% of all data.

Introduction

The California large-mesh drift gillnet fishery for swordfish and thresher shark ('the fishery') began in the 1970s as an experimental fishery targeting pelagic sharks and by the mid-1980s, expanded to 200 vessels and 10,000 annual fishing sets (Hanan et al. 1993, Holts et al. 1998). Fishing effort has steadily declined since then, with current annual levels of about 500 sets (Carretta *et al*. 2014). From 1990-2015, technicians in the NMFS West Coast Regional Office fishery observer program observed 8,711 sets from an estimated 55,023 sets fished, corresponding to 15.8% observer coverage (Carretta and Barlow 2011, NMFS unpublished data). Previous estimates of marine mammal, sea turtle, and seabird bycatch, based on ratio estimates, are published in Julian and Beeson (1998), Carretta *et al*. (2004), and also a series of annual bycatch reports (Carretta and Enriquez 2006, 2007, 2012a, 2012b, Carretta *et al*. 2005, 2014).

Acoustic pingers and net extenders designed to reduce marine mammal bycatch were experimentally introduced into the fishery in 1996 and became mandatory in late 1997 (Federal Register 1997).

Pingers resulted in statistically significant bycatch reductions, driven largely by lower bycatch rates of short-beaked common dolphin (*Delphinus delphis*) (Barlow and Cameron 2003, Carretta and Barlow 2011). Since 2001, a large season/area closure called the Pacific Leatherback Conservation Area (PLCA) has been implemented between 15 August and 15 November in the northern part of the fishing grounds to reduce leatherback sea turtle (*Dermochelys coriacea*) bycatch (Federal Register 2001, Figure 1). The main effects of PLCA have been to limit fishing effort largely to the southeast portion of the California Current ecosystem and reduced observed bycatch rates of leatherback turtles.

Previous bycatch estimates in this fishery were generated with ratio estimators (Julian and Beeson 1998, Carretta *et al.* 2004, Carretta *et al*. 2014). For species with large sample sizes (e.g., short-beaked common dolphin and California sea lion, *Zalophus californianus*), ratio estimates of bycatch are generally unbiased; however, the fishery entangles many species only rarely, including some (e.g., sperm whales, *Physeter macrocephalus* and short-finned pilot whales, *Globicephala macrorhynchus*) that are subject to a mandatory drift gillnet Take Reduction Plan (Federal Register 1997). Amandè *et al.* (2012) and Carretta and Moore (2014) showed via simulations that annual estimates of bycatch derived from ratio estimates for 'rare-event' cases were biased, volatile, and imprecise, particularly when observer coverage was low. Carretta and Moore (2014) also noted that strategies for pooling annual ratio estimates of bycatch in U.S. marine mammal stock assessments (5 years are typically pooled to calculate average annual bycatch) are insufficient to overcome these problems. The problems of rare bycatch events combined with low observer coverage in the drift gillnet fishery were highlighted by Martin *et al.* (2015), who presented a Bayesian model-based alternative to annual ratio estimates that resulted in more stable interannual estimates with better precision for two test case species, humpback whales (*Megaptera novaeangliae*) and leatherback sea turtles. We applied the machine-learning approach of random forest trees (Breiman 2001) to estimate bycatch for all species observed entangled in this fishery, with an emphasis on evaluating the performance of variable selection in rare-event bycatch cases and to compare ratio estimates with tree-based model estimates.

Methods

Bycatch models were constructed using a two-step process, first using random forest *classification trees* for variable selection (see *Variable Selection*). Variables selected for inclusion were then used in a *regression tree* random forest to estimate bycatch in unobserved fishing sets (see *Bycatch Estimation*). Classification and regression trees (Breiman 2001) are partitioning algorithms that recursively split ‘training data’ into subsets according to explanatory variables, so that observations in each successive subset (or ‘daughter nodes’) have reduced variances if variables have predictive value. The training data used to construct each tree represents approximately 2/3 of all observations, due to bootstrap sampling with replacement (Efron and Tibshirani 1997). The remaining ≈1/3 of all observations not included in individual tree construction represent ‘novel data’, which are used as a cross-validation data set to test the performance of tree predictions on these observations. Tree splits are chosen through a bootstrap procedure where random subsets of variables are evaluated for splitting observations at each node and the variable that minimizes the variance in resulting daughter nodes is selected for splitting. Splits proceed until all observations are contained in terminal nodes, although trees can be effectively ‘pruned’ by limiting the number of nodes, resulting in simpler models and reduced processing time. The mean of the observations in each terminal node represents the fitted value (estimate) for each observation in that node. Many bootstrap trees, i.e., a *random forest*, are generated, where each tree is constructed with a different bootstrap set of training data. Novel data (those not used to build trees) are introduced to the forest and resulting predictions are based on which terminal nodes novel data are assigned to. Since each tree provides a unique expected value for each observation, the bootstrap distribution (forest) of expected values provides a measure of prediction uncertainty. The diversity of trees in random forests prevent overfitting of data that can occur with single trees and yield robust generalized predictive models when variables are informative (Breiman 2001). We elaborate the process below as it was applied to the fishery data.

1) Variable selection (classification trees)

All random forest analyses described in this paper were created and implemented in the programming language R, version 2.3.2 (Hornick 2013). The first step in developing bycatch models was variable selection and model validation using classification trees with the R-package *rfPermute* (Archer 2016), an extension of the package *randomForest* (Liaw and Wiener 2002). Our variable selection approach was developed and tested using a simulated rare bycatch dataset, and also applied to the fishery dataset, as described below.

Observed bycatch events in the fishery are generally rare. The most commonly-entangled species (short-beaked common dolphin, *Delphinus delphis*) is entangled in approximately 4% of all observed fishing sets (325 observed entanglements totaling 407 animals in 8,711 observed sets), while rarely-entangled species such as sperm whales are observed in <0.1% of all observed sets (6 sets totaling 10 whales). Given so few entanglement events, determining which (or if) variables have explanatory power is challenging. Faced with high noise-to-signal ratios in bycatch data, the analyst must determine if node-splitting variables used in *randomForest* trees are spurious or reliable predictors of bycatch events. One way to evaluate this issue is through simulation. We randomly generated 30 realizations of a rare-event bycatch dataset that mimicked characteristics of the real bycatch data in the fishery for sperm whales. Each realization contained between 4 and 9 bycatch events, totaling 9 to 11 animals, from approximately

8,500 fishing sets. Simulations were generated by one of the authors using a logistic model that specified an increasing probability of bycatch as a function of the bottom-depth for each set in the fishery (using the true depth values for the real set data). For each realization, a Bernoulli process was used to indicate whether a set actually interacted with a whale group, and a Poisson process was used to determine how many individuals were caught (Poisson mean = 1.3, with values above 3 truncated, so bycatch per set was an integer from 0 to 3). The primary analyst was blind to the simulation parameters and had the task of identifying which variable or variables were important across the 30 realized datasets.

The metric for success in assessing variable importance was the ability of *rfPermute* to correctly identify the unknown variable in most simulated data realizations. For each observation in a realization, bycatch was re-coded as a binary event (i.e., Y for each set that entangled an animal; N for those that did not) (see McCracken 2004), and *classification trees* were constructed by randomly sampling (with replacement) equal numbers of sets with and without bycatch using the *randomForest* function *sampsize* (only available for classification trees). This strategy balances the number of sets with and without bycatch to be evaluated by each tree, which aids potential identification of explanatory variables that would otherwise be lost in the noise of zero-inflation (Xie *et al*. 2009). Variable testing considered 12 variables from the observed fishery sets (Table 1). Variable importance was defined as the total decrease in node impurity (Gini index) from splitting on a given variable, averaged over all random forest trees (Liaw and Werner 2002). In other words, the splitting variable that best discriminates between sets with and without bycatch is the one that yields the greatest increase in node purity (information gain) in daughter nodes. The package *rfPermute* also provides significance levels for variables by permuting the response variable (bycatch) and recalculating the total decrease in node impurity over all trees. This results in a null distribution of information gain for each predictor variable, which is compared to the observed value from non-permuted data to calculate a *p*-value. We applied the package *rfPermute* to the 30 simulated rare event bycatch datasets, using 200 permutation replicates (2x the default) and a default alpha-level = 0.05, with each random forest comprised of 10,000 trees. A large number of forest trees were used because the number of fishing sets used to build each tree was relatively small. For example, if a given data simulation contained 5 positive bycatch events and ~ 8,500 negative bycatch events, each forest tree was built with data from 10 fishing sets (5 positive and 5 negative events). The number of forest trees was also guided by an iterative process that identified a forest size sufficient to asymptotically reduce novel data error rates. Variables that maximized information gain (= greatest reduction in node impurity when used to split data) were assessed for each of 30 bycatch realizations, along with their associated significance levels (see Results).

2) <u>Bycatch Estimation (regression trees)</u>

Significant variables for each species / taxon bycatch model were identified using the same *rfPermute* classification tree procedure described above for simulated data. Variables whose *rfPermute* *p*-value was ≤ 0.05 were included in bycatch models. Following the identification of significant predictor variables, bycatch models were generated with random forest *regression trees*, because the response (bycatch per fishing set) is a rate to be estimated (Watters and Deriso 2000, Walsh and Kleiber 2001, Jiménez *et al*. 2009). In addition to the variables tested from simulated data, we included 4 additional variables as candidates for real bycatch data: sea surface temperature (*sst*), bathymetric slope in degrees (*slope*), days elapsed in the calendar year (*days*), and the distance in km that the gillnet drifted during the fishing set (*drift.km*). The variables *year* and *month* that were used in the data simulation were replaced by the single variable '*days'* to represent a single seasonal variable in the real data set. Small sample sizes for some species necessitated the use of null models for estimating bycatch. For example, only one bycatch event each was observed for killer whales (*Orcinus orca*), striped dolphins (*Stenella coeruleoalba*), and Olive Ridley sea turtles (*Lepidochelys olivacea*), thus regression tree models for these species utilized all available variables. Even if all variables lack predictive value, resulting trees will contain node splits that are essentially random, resulting in a random forest model that will return the mean expected bycatch rate for all fishing sets. We also used this approach for Risso's dolphin (*Grampus griseus)*, where only one significant variable (*lon*) was identified[1] and for bottlenose dolphin (*Tursiops truncatus*), where no variables were identified as significant predictors. Some species of beaked whales had insufficient sample sizes for variable selection, thus a single random forest model for *Kogia*-Ziphiid bycatch was based on pooling of data across all beaked whale species and pygmy sperm whales. The genera *Mesoplodon*, *Ziphius*, *Berardius*, and *Kogia* taxa are similar in their deep-diving habits and apparent sensitivity to anthropogenic sound (Barlow and Gisiner 2006, Cox *et al*. 2006) and observed bycatch of these taxa appear to be similarly influenced by the use of acoustic pingers in this fishery (Carretta *et al*. 2008, Carretta and Barlow 2011). For individual beaked whale species, those variables identified as significant in the pooled *Kogia*-Ziphiid dataset were used when estimating individual species' bycatch. We did not assess variable importance for species with <4 entanglement events, since the simulation analysis did not evaluate variable selection performance for this low of a sample size. For baleen whales with sample sizes too low to assess variable importance (fin whale, *Balaenoptera physalus,* humpback whale, *Megaptera novaeangliae*), or for which only one significant variable was identified[1] (minke whale, *Balaenoptera acutorostrata*), we used a default set of variables (*lat* + *lon* + *days*) in regression tree models, in recognition that most whale species in the California Current exhibit seasonal and spatial movement within the ecosystem (Forney and Barlow 1998). Three pinniped taxa (Steller's sea lion, *Eumatopias jubatus* and unidentified pinnipeds / otariids) also had insufficient sample sizes, and we therefore used null models that included all available variables in regression trees. Variables used in all species models are summarized in Table 3.

Random forest regression trees (n=500) were fully grown for all species models, where the number of tree nodes is generally higher for species with larger sample sizes. Predicted bycatch per set was generated by building random forests with *n*-1 sets (= "leave one out cross-validation"), and the individual forest of 500 trees was used to predict bycatch in each of 8,711 omitted sets. Each tree provides a unique estimate of bycatch for each omitted set, which yields a distribution of 500 summed bycatch predictions for all 8,711 observed sets. As a cross-validation exercise, summed bycatch predictions were compared with the sum of observed bycatch over the same 8,711 sets, to determine the ratio of observed to predicted bycatch. This provided insight into model performance and bias.

[1] Although random forests utilize one variable at each node for splitting data, random forest requires ≥2 variables to select from at each node to be implemented.

For a given species (*s*) in year *y*, the mean annual predicted bycatch per set ($\bar{b}_{s,y}$), was the mean predicted bycatch for all observed sets contained in year *y*, where random forest trees are constructed using all 26 years of data. Mean annual estimates of bycatch from regression trees ($\bar{T}_y$), were calculated as the mean annual predicted bycatch per set ($\bar{b}_{s,y}$), multiplied by the number of unobserved sets (u_y), plus the sum of observed bycatch of species *s* ($o_{s,y}$) in year *y*:

$$(1) \qquad \bar{T}_y = \bar{b}_{s,y} * u_y + \sum o_{s,y}$$

The approach of extrapolating predicted bycatch rates to unobserved fishing effort (u_y) reflects an assumption that observer data are representative of the fishery. Coefficients of variation (CV) of bycatch estimates were calculated as:

$$(2) \quad CV(\bar{T}_y) = \sqrt{var(\bar{b}_{s,y} * u_y)} \,/\, \bar{T}_y$$

where $var(\bar{b}_{s,y} * u_{s,y})$ is the variance of 500 predicted bycatch sums across *unobserved* sets in year *y*. Note that $CV(\bar{T}_y)$ describes parameter uncertainty (i.e., in the expected value for $\bar{T}_y$), not the uncertainty in bycatch for individual sets. For species or groups with sufficient sample sizes, we also estimated 95% confidence limits for estimates of $\bar{T}_y$, using the 2.5th and 97.5th percentiles of bycatch predictions (see Results).

We also estimated mortality and serious injury (MSI) levels for all species, using the fraction of observed entanglements recorded as dead, injured, or 'unknown', to prorate estimates of unobserved bycatch. For example, of the 25 observed leatherback sea turtle entanglements in the fishery, 11 were released alive, 14 were released dead, and one was released in 'unknown' condition. Animals released in unknown condition are conservatively treated as deaths/injuries. In this case, the observed fraction (*f*) of deaths and injuries = 15/25 = 0.60. Total MSI was calculated as the product of unobserved bycatch $(\bar{b}_{s,y} * u_y)$ and *f,* plus observed MSI. Uncertainty in estimates of MSI were included by treating the fraction *f* as a random binomial deviate, where the probability that unobserved bycatch resulted in mortality or injury (p_{mi}) = *rbinom*(n = forest trees, size = observed entanglements, prob=*f*), divided by the number of observed entanglements. Estimates of unobserved bycatch (one for each of 500 forest trees) were multiplied by a randomly drawn (with replacement) value of p_{mi}, yielding a distribution of unobserved MSI estimates of size = 500, to which observed MSI totals were added. Precision of MSI estimates were calculated as CVs using the same method as for total bycatch in Equation 2. For small species such as dolphins, porpoises, and pinnipeds which are rarely released alive because they drown quickly in gillnets, all values of p_{mi} = 1 and MSI estimates are simply equal to $\bar{T}_y$, with the associated CV of $\bar{T}_y$.

Regression tree bycatch estimates were compared to ratio estimates for all years. Ratio estimates were calculated simply as the product of observed bycatch in year *y*, and the inverse of observer coverage for that year. Ratio estimate CVs were calculated via bootstrap, where sets in year *y* were resampled 9,999 times with replacement to generate a distribution of bycatch rates, from which the mean and variance were obtained. In addition to annual estimates, pooled multi-year bycatch regression tree and ratio estimates were generated for three time periods: 1990-2000, 2001-2015 and 2011-2015. The years 1990-2000 represent the pre-closure period of the fishery, when effort was permitted year-round in the PLCA. The years 2001-2015 represent the ‘current state of the fishery’, where most fishing effort occurs off of southern California (Figure 1). Finally, the years 2011-2015 represent the most recent 5-year period for which bycatch estimates are available and reflect the number of years typically used to pool bycatch estimates in NMFS marine mammal stock assessment reports (NOAA 2016). Periods in excess of 5 years have been shown to be superior for pooling estimates when bycatch is based on annual ratio estimates and entanglements are rare (Carretta and Moore 2014), however, regression tree models which incorporate all available data for estimate reduce the need for such pooling.

Results

The application *randomForest* (via *rfPermute*) successfully identified the variable (*depth*) as an important covariate in the simulated rare event bycatch datasets. From a suite of 12 variables, *depth* was identified as the best predictor (largest reduction in tree node impurity) in 19 of 30 data realizations (Table 2) and also had the lowest p-values of all variables (Fig. 2). The variables *lon* and *lat* resulted in the largest reductions in node impurity in 6 other data realizations and were the two variables most-correlated with *depth* (Spearman coefficient = 0.72 and 0.51, respectively). Of the 30 simulated data realizations, 19 contained variables with *p*-values <=0.05, with 14 of these represented by *depth*. Collectively, the three variables *depth*, *lon*, and *lat* had the lowest *p*-values and greatest reductions in node impurities (Table 2). Variables identified as having the highest decrease in node impurities from a given simulated bycatch realization were not always identified as statistically significant ($p<0.05$). Although the simulation exercise conducted here was far from comprehensive, it demonstrated that at least in some circumstances, one or more important drivers of bycatch variation can be identified even when the number of positive events in the dataset is quite small. This aligns with the well-known ability of random forests to provide good generalized predictions using multiple 'weak predictors' (Breiman 2001).

For real bycatch data, variables identified as significant predictors for each species or taxonomic group are summarized in Table 3. The number of variables identified was typically greater for groups containing the largest sample sizes, though there were notable exceptions. The largest number of variables identified (5) as significant predictors of bycatch coincided with the largest sample sizes for the category '*all.delphinoids'* and short-beaked common dolphin (Table 3). No variables were identified as significant predictors of Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) bycatch, despite there being 27 bycatch events available for evaluation. In contrast, multiple variables were identified as significant predictors for 12 other species with fewer bycatch events (Table 3). The lack of significant variables identified as covariates for the Pacific white-sided dolphin bycatch model necessitated using a null model that included all variables in tree construction. A null model would return expected bycatch rates equal to the mean observed bycatch rate if all variables had no predictive value.

Estimates of total bycatch and mortality and serious injuries are presented in Tables 4-40. Bycatch estimates from regression trees were generally more stable across years and had better precision than corresponding ratio estimates. Precision gains from regression trees primarily resulted from the use of all 26 years of observer data in tree construction and estimation of mean bycatch rates based on covariates. This contrasts with previous use of ratio estimates that relied on one year of data for estimating mean bycatch rates. In essence, the information contained in the full dataset provides a better understanding of long-term expected catch rates and covariate effects, which translates into better-informed estimates in individual years.

For many species, a comparison of bycatch estimates using regression trees and ratio methods show that estimates tend to converge as the number of analysis years increases (Tables 4-40). For example, total estimates of beaked whale bycatch for the period 1990-2000 were approximately 224 (CV=0.04) and 220 (CV=0.17) whales, for regression tree and ratio methods respectively (Table 40). The lower CV of the regression tree estimate is, in part, due to using only 2 covariates in tree construction (*n.ping* + *lon*), which effectively limits the number of discrete values possible in terminal nodes in each tree (fewer variables = reduced dimensionality). Intra-annually, beaked whale estimates are highly variable between methods, such as in 1991, when the estimate from regression trees was approximately 32 whales, while the ratio estimate for the same year was zero whales because of an absence of observations that year. Effects and advantages of using regression trees over ratio methods to estimate bycatch is reviewed in the Discussion section for several species / groups.

Some annual regression tree bycatch estimates have rather large CVs, which occurs when the estimated bycatch is close to zero even though the standard error (absolute rather than relative error measure) might be small. This is especially apparent for rarely-entangled species such as striped dolphin and fin whale. In years with fewer observed sets, the precision of regression tree bycatch estimates is generally low, a consequence of fewer observations from which to calculate the predicted mean annual bycatch per set ($\bar{b}_{s,y}$). Regression tree estimate CVs also reflect the diversity of predictions from the random forest, which depends upon the set characteristics of 'novel' data for which predictions are made. In the extreme, if all observed sets in year *y* had identical set characteristics (location, date, depth, etc.), then any random forest would predict the same mean bycatch rate for these sets, resulting in zero variance.

Discussion

Large differences between annual bycatch estimates using regression trees and ratio estimators are usually due to rarely-observed events combined with low observer coverage. For example, in 2010, two sperm whales were observed entangled in one fishing set, from only 59 observed sets that year and a total estimated fishing effort of 492 sets. The bycatch rate of 2 whales in 59 sets, combined with 12% annual observer coverage, yielded a ratio estimate of 16.7 whales (Table 22). In contrast, the regression tree estimate of bycatch for 2010 was 2.0 whales (2 observed + zero estimated in 433 unobserved sets). Given the observed sperm whale bycatch rate in this fishery over 26 years (~ 1 animal for every 1,000 sets), it is highly unlikely that observed + unobserved bycatch in 2010 was ~ 17 whales. It is more likely that there were two entanglements, both of which happened to be observed. Another shortcoming of annual ratio estimates is that when zero bycatch is observed, resulting bycatch estimates are zero (with no variance estimate), even if undetected bycatch occurs. No sperm whale entanglements were observed in 648 sets in the first two years of the observer program (1990-1991, Table 22), when total fishing effort was estimated at over 9,000 sets. Resulting ratio estimates of sperm whale bycatch in 1990-1991 were zero (Julian and Beeson 1998), which seems unrealistic, given the observed long-term bycatch rate of 1 whale in every 1,000 sets (a rate that could not be known after the first two years of the observer program). In contrast, summed 1990-1991 regression tree bycatch estimates are approximately 7 sperm whales, which is more realistic, given the level of fishing effort (Table 22). One result of using regression trees to estimate bycatch is that trees predict some amount of bycatch in most years, even in the absence of observations. This is more in the spirit of a probabilistic estimation approach that moderates inter-annual volatility in bycatch estimates that result from applying ratio estimates to rare bycatch events in the context of low observer coverage.

Bycatch reduction measures introduced into the fishery in 1996 included acoustic pingers, which resulted in significant reductions of short-beaked common dolphin bycatch (Barlow and Cameron 2003, Carretta and Barlow 2011) and the apparent elimination of beaked whale bycatch (Carretta *et al.* 2008). The efficacy of acoustic pingers in reducing bycatch for many cetacean species in this fishery is unknown, because most species lack sufficient observations to reliably test (Carretta and Barlow 2011). Short-beaked common dolphin are the most commonly entangled marine mammal in this fishery (Table 3), but both absolute bycatch and bycatch per fishing set has declined during 1990-2015 (Fig. 3). Bycatch per fishing set declined, even while fishing effort shifted to southern California waters (due to the PLCA closure) where common dolphin densities are highest (Becker *et al*. 2014), and during a period when the abundance of common dolphin increased

(Barlow 2016). This is further evidence that pinger use, and not simply fishing effort reductions, are responsible for the observed decline in common dolphin bycatch rates. Two prior studies of bycatch reduction attributed to pingers in this fishery identified 2 species/groups with more statistically significant bycatch reductions than short-beaked common dolphin: beaked whales and northern elephant seals (Carretta and Barlow 2011). Both of these species/groups include pingers as a significant predictor variable (as identified by *rfPermute*) in the present study.

Prior to the experimental use of pingers in the fishery, the bycatch of all beaked whale species (including *Kogia*) ranged between 20 to 40 animals annually (Table 40). During the pinger experiment of 1996-1997, when 47% of all observed sets utilized pingers (Carretta and Barlow 2011), beaked whale bycatch was estimated at 12 and 7 animals, respectively, despite an absence of observed bycatch in those years. Beginning in 1998, the first full year that pingers were mandatory in the fishery, estimated beaked whale bycatch declined to near zero, which mirrors fishery observations of zero bycatch since 1996 (Table 40, Fig. 3). After 1997, most estimates of beaked whale bycatch are slightly positive, reflecting that the beaked whale random forest model is informed not only by the variable *n.ping*, but also by the variables *depth* and *lon* (Table 3). Carretta *et al*. (2008) reported that acoustic pingers 'eliminated' beaked whale bycatch in this fishery, and that conclusion was based on the very small probability of observing zero bycatch in ~4,300 fishing sets over an 11-year period. Prior to the first experimental use of pingers in the fishery in 1996, there were 33 beaked whale entanglements observed from 3,303 observed sets (roughly one beaked whale per 100 sets) (Table 40). It is unknown if all beaked whale bycatch has been eliminated since pinger use began, because ~80-85%

of all fishing sets are unobserved. However, there has now been zero beaked whale bycatch observed from over 5,300 observed fishing sets over the 20-year period 1996-2015. This observation is not likely due to a geographic shift in fishing effort resulting from implementation of the PLCA in 2001, as Carretta *et al*. (2008) reported that beaked whale bycatch rates were nearly equal inside and outside of the PLCA and that beaked whale bycatch had already dropped to zero in observed 2,670 sets prior to PLCA implementation (but after pingers were introduced). Although there has been an apparent decline in beaked whale abundance in the California Current during our study period (Moore and Barlow 2013), Carretta *et al*. (2008) calculated that the observation of zero beaked whale bycatch was statistically implausible even if beaked whale abundance had declined by 90%. Current evidence still identifies acoustic pingers as the most likely explanation for the reduction in beaked whale bycatch in the fishery.

Observations of short-finned pilot whale bycatch are rare in the fishery (10 events totaling 14 animals). Pilot whales are generally detected in the California Current during warm-water episodes (Barlow 2016) and the identification of the multivariate El Niño index (*mei.index*) as a significant predictor variable supports these observations (Table 3). Short-finned pilot whales were the only cetacean species where *mei.index* was identified as a significant predictor variable (*mei.index* was also a significant predictor of bycatch for the seabird Northern Fulmar, *Fulmarus glacialis*). Observed and predicted annual bycatch rates of short-finned pilot whales appear highly-correlated (Fig. 3), which is due mostly to the strong link between observed pilot whale bycatch and higher annual *mei.index* values. In addition to *mei.index*, the variables *days* and *lon* were identified as significant predictors of pilot whale bycatch, which implies that seasonal and area factors also influence the probability of bycatch within the California Current.

California sea lion bycatch levels declined from 1990-2015, which largely reflects declining fishing effort (Table 26). However, observed and estimated sea lion bycatch per fishing set *increased* during the same period (Fig. 3), due to an increasing sea lion population and implementation of the PLCA, which shifted existing gillnet effort to southern waters where sea lion breeding rookeries are located and sea lion abundance is highest. The California sea lion regression tree bycatch model included the variables *depth* + *lon* + *mesh*, and it was the only model where *mesh* was identified as a significant variable (Table 3). Howorth (1994) and Stewart and Yochem (1987) reported that most California sea lion entanglements in synthetic debris and entangling nets were subadults, while Howorth (1994) suggested that smaller meshes were more likely to result in the entanglement of these age classes. Most sea lions observed entangled in the swordfish drift gillnet fishery are subadults, with the highest bycatch rates linked to the smallest mesh sizes used (< 18 inches).

Martin *et al.* (2015) estimated leatherback sea turtle bycatch in this fishery for the 20-year period 1990-2009, with a total bycatch range of 104–242 leatherbacks (52–153 estimated deaths). Our estimates of total leatherback bycatch for the same 20-year period (~ 175 entanglements, ~ 100 estimated deaths, Table 32) are similar, and both studies estimate 10-25 annual leatherback entanglements in the first 8 years of the observer program. In both studies, estimated leatherback entanglements decline each year, reaching negligible levels after implementation of the PLCA in 2001 (Fig. 1), which Martin *et al.* (2015) reported to have the largest effect on reducing leatherback bycatch levels.

The PLCA area closure in 2001 shifted fishing effort south and east of preferred seasonal leatherback habitat (Eguchi *et al.* 2016), which resulted in significant declines in observed and estimated bycatch per fishing set, with total estimated bycatch declining to less than one turtle annually between 2001 and 2015 (Table 32). Prior to the PLCA (1990-2000), the observed bycatch rate of leatherbacks was 23 turtles from 5,973 fishing sets (0.0038 per set). Following the closure (2001-2015), the observed bycatch rate was 2 turtles from 2,738 fishing sets (0.0007 per set). Individual leatherback entanglements in 2009 and 2012 give the false impression of a high bycatch rate in those years (Fig. 3), but this is an artifact of a small number of sets observed. Our leatherback bycatch model included the significant variables *lat* + *lon* + *depth*, which can be thought of as proxy variables for the PLCA, as the deepest waters in the study area are located north and west of Point Conception. Based on a study of satellite-tagged leatherback turtles in the California Current, Eguchi *et al.* (2016) noted that the seasonal restrictions of the PLCA (15-Aug to 15-Nov) are nearly optimal for reducing leatherback bycatch in this fishery, while still allowing fishing in the area during periods of reduced leatherback presence. It should be noted that observed declines in leatherback entanglements following implementation of the PLCA are also influenced by declines in drift gillnet fishery participation and Pacific leatherback nesting populations (Tapilatu *et al*. 2013).

Although our bycatch dataset contained nearly 9,000 fishing sets spanning 26 years, and might be considered 'data rich' by some standards, bycatch for many species, was represented by fewer than 5 entanglements. For rarely-entangled species, it was necessary to pool data across similar taxa to obtain variables for use in regression trees. The uncertainty in bycatch estimates for rarely entangled species will always be large, but is improved by the use of multi-year data in the modelling process, compared with use of intra-annual data used in many traditional ratio estimation approaches. One consequence of multi-year pooling is that our precision estimates of annual bycatch reflect only the uncertainty from observed mean bycatch rates, and does not reflect variation in true annual bycatch. This problem is lessened as the time period for data-pooling increases, but for annual estimates, our estimates of precision are likely to be too low relative to the intra-annual variability in true bycatch rates.

Variables used in regression tree bycatch models were limited to those identified as statistically-significant ($p<0.05$) by *rfPermute* (Archer 2016). Some 'weak predictors' with explanatory power were certainly excluded from consideration because they did not meet the arbitrary $p<0.05$ *rfPermute* default threshold and thus, some bycatch models may not be optimized. Further variable selection testing using *rfPermute* with higher alpha-levels and cross-validated datasets is recommended to examine if additional variable inclusion improves the performance of bycatch models with respect to bias and precision. Exploration of variable selection strategies using simulated rare-event bycatch data, where multiple variables contribute to the probability of bycatch, would also be a beneficial step in understanding the advantages / disadvantages of expanding variable selection through a relaxation of p-value thresholds using *rfPermute*.

The advantages of model-based bycatch estimation methods that utilize all available data, instead of reliance on intra-annual data are worth noting. The primary advantage is that annual (or multiannual) bycatch estimates will be less volatile, less biased, and more precise, especially where observer data are characterized by rare bycatch and low observer coverage. Reducing the volatility of year-to-year estimates of bycatch for rarely-entangled species is important in the context of protected species management, where decisions involving the regulation of a fishery require accurate and timely assessment of bycatch levels. This is especially so for rare event bycatch, where the absence of bycatch observations may result in the failure to detect a genuine bycatch problem because of low observer coverage. Conversely, the observation of a rare bycatch event in the same low observer coverage situation can result in severely-biased estimates of bycatch that are unrealistically high and contribute to short-term management responses that overestimate the risk to populations. Pooling of data (where appropriate) to improve estimates of mean bycatch rates is the first step towards such bias reduction, but as fishery conditions change over time, it is also necessary to identify and use those fishery variables that may influence changes in bycatch over time. For species where observed bycatch is so rare that no explanatory variables can be identified, use of random forests with a default set of variables (e.g. *lat* + *lon* + *days*) can still provide a ‘null model’ of bycatch that essentially reflects the overall mean bycatch rate, scaled up to total fishing effort. Such null models still represent a large improvement over calculating within-year bycatch rates previously used with ratio estimators in this fishery (Julian and Beeson 1998, Carretta *et al*. 2004).

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developed the method applied to the data without prior knowledge of the variable used to model simulated bycatch.

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Figure 1. Observed fishing sets, 1990-2000 (L), 2001-2015 (R), and Pacific Leatherback Conservation Area (shaded).

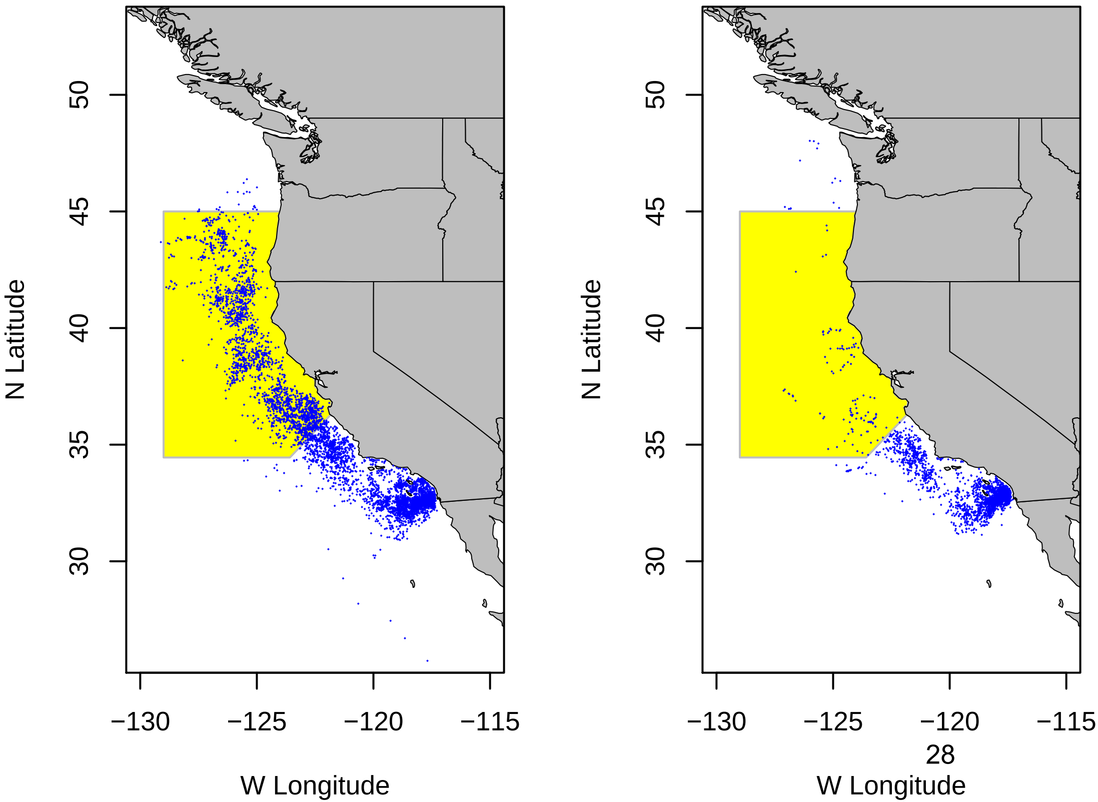


Figure 2. Results of a variable selection test on simulated rare-event bycatch data using rfPermute. The variable 'Depth' was correctly identified as the most significant variable influencing the rate of simulated bycatch.

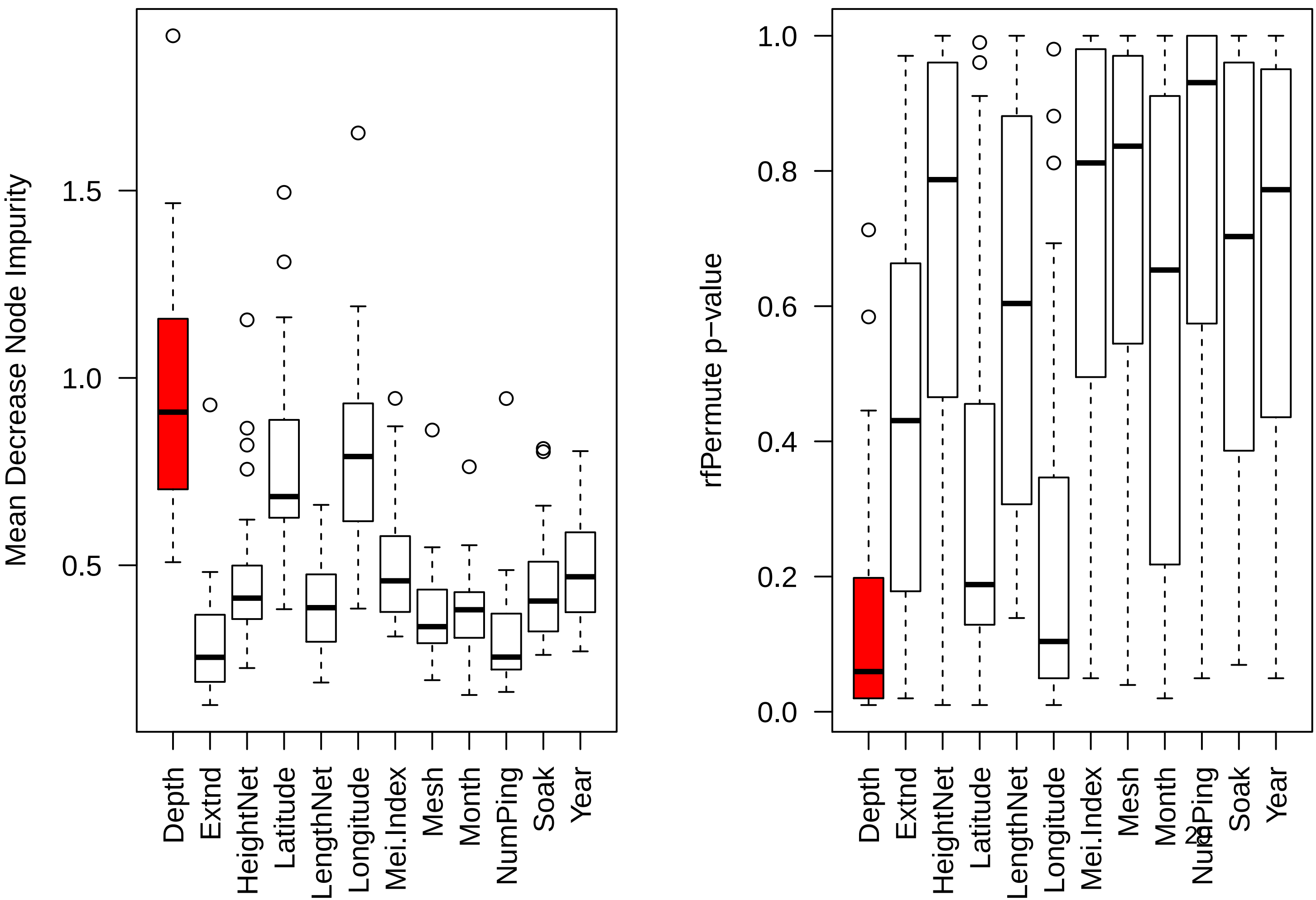
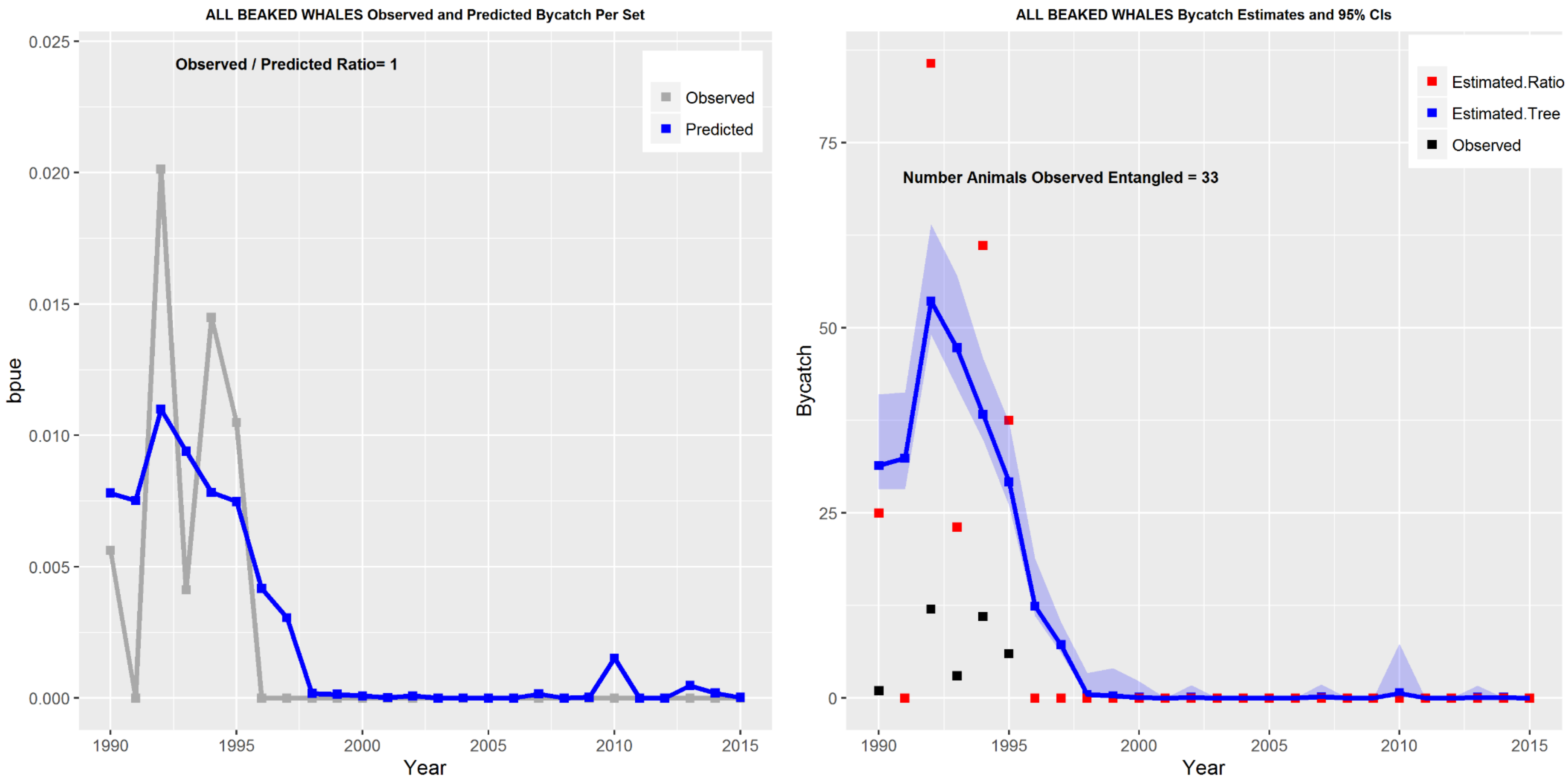


Figure 3. Observed and estimated bycatch for selected species / groups. The left panel shows observed and predicted annual bycatch per fishing set. The right panel shows observed annual bycatch and estimated total bycatch, along with 95% confidence intervals. The ratio of observed to predicted bycatch (for the cross-validated dataset of 8,711 sets) and the number of observed entanglements for each species / group are also shown.



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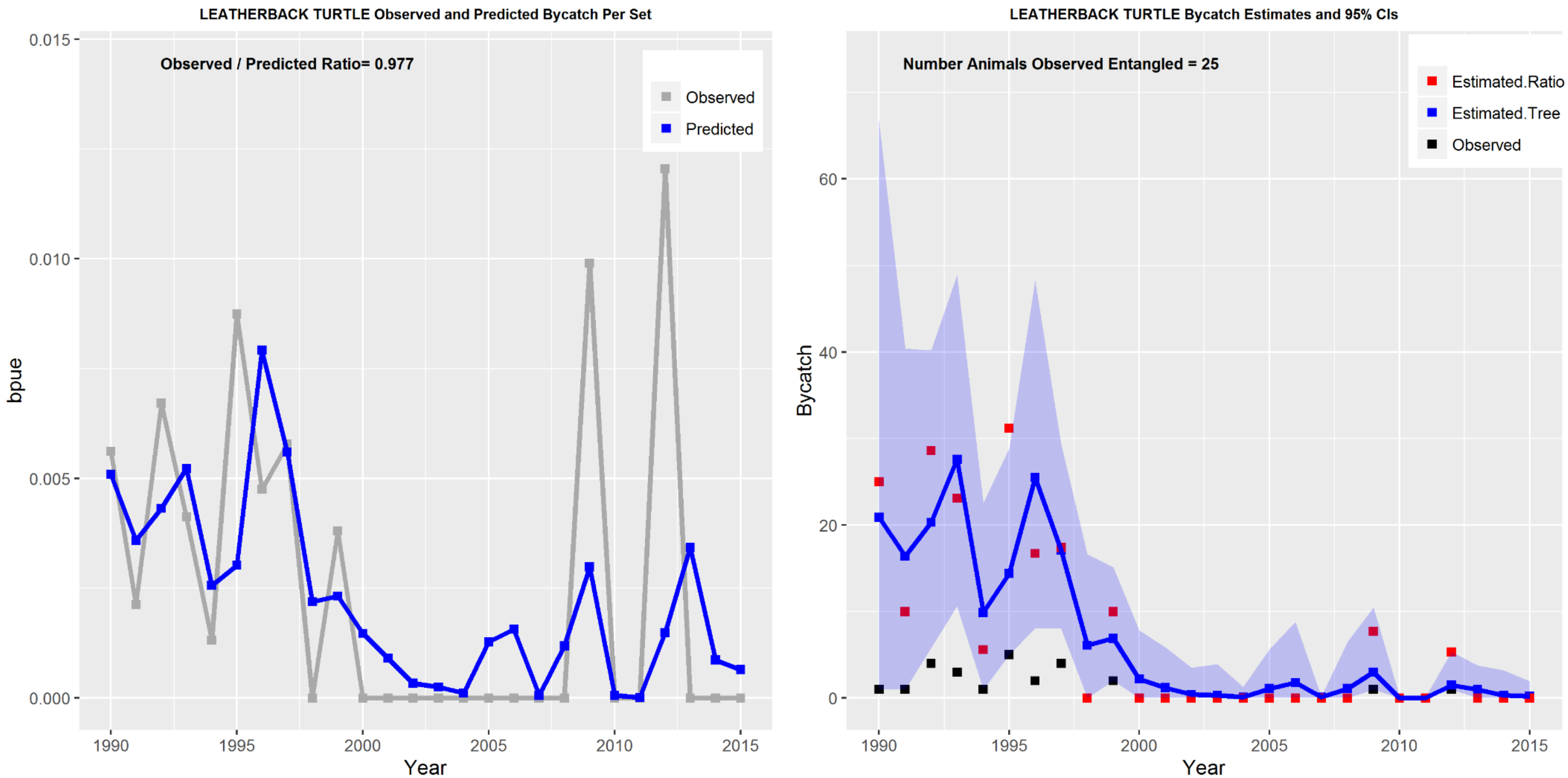

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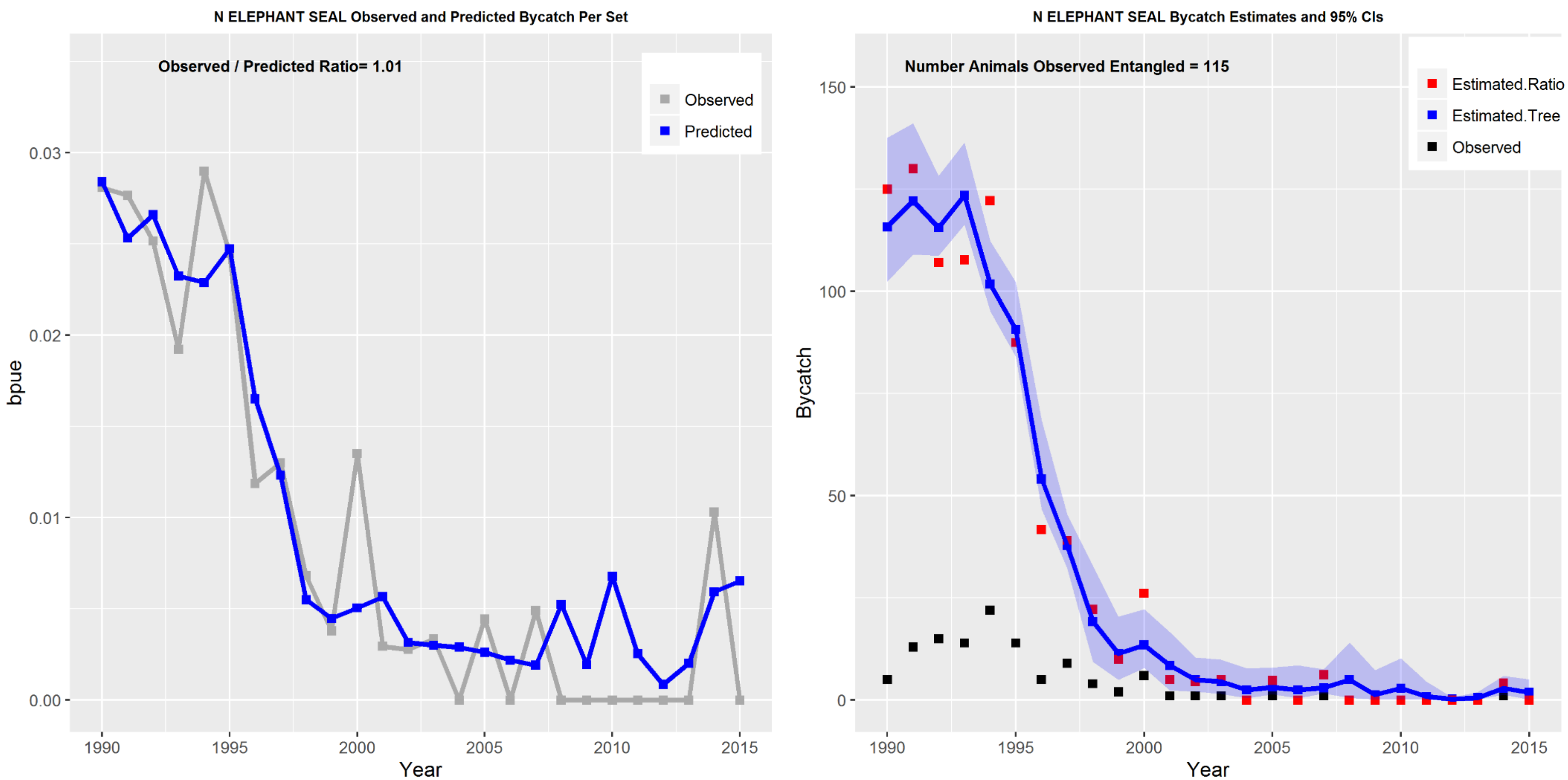

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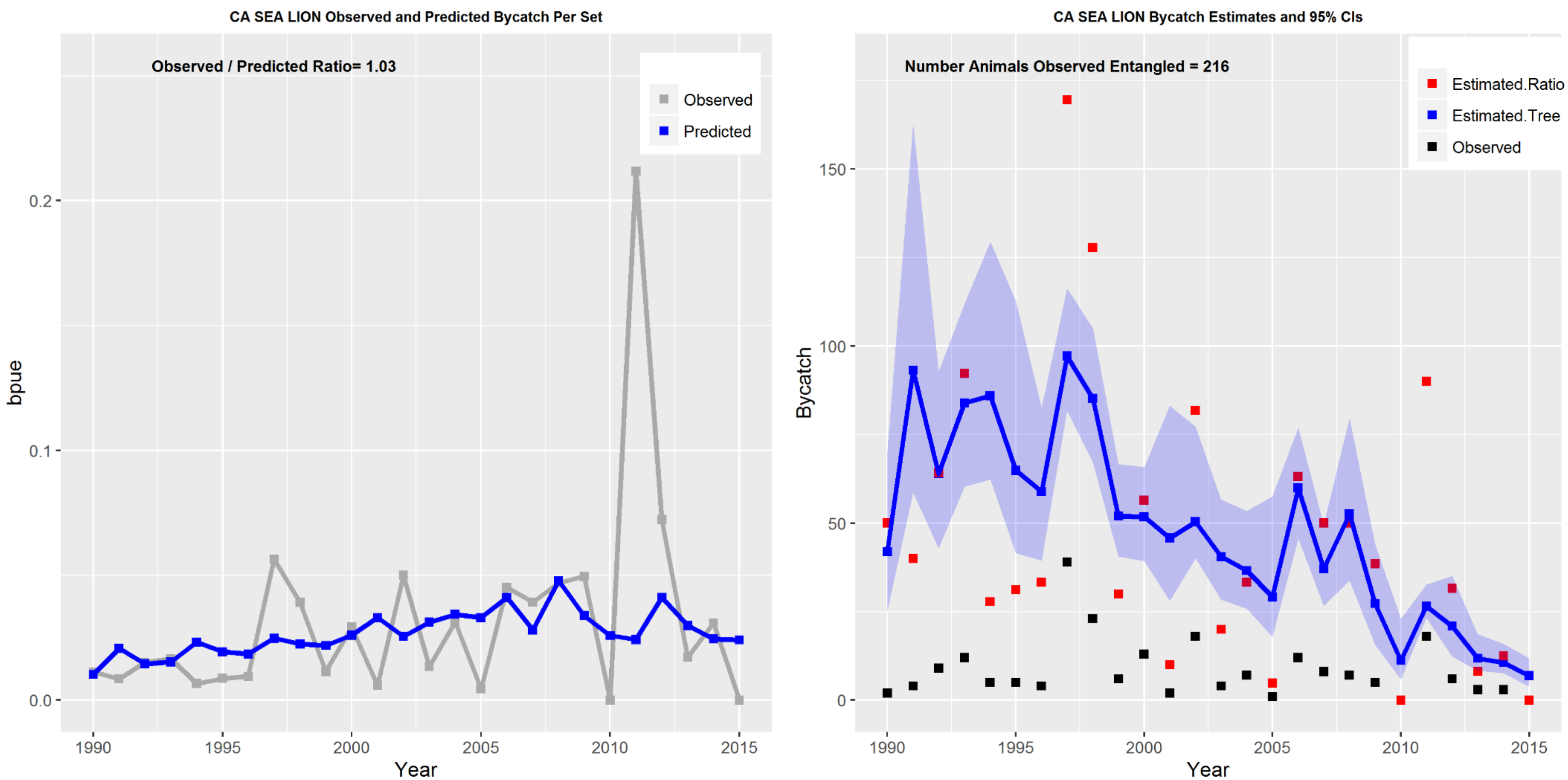

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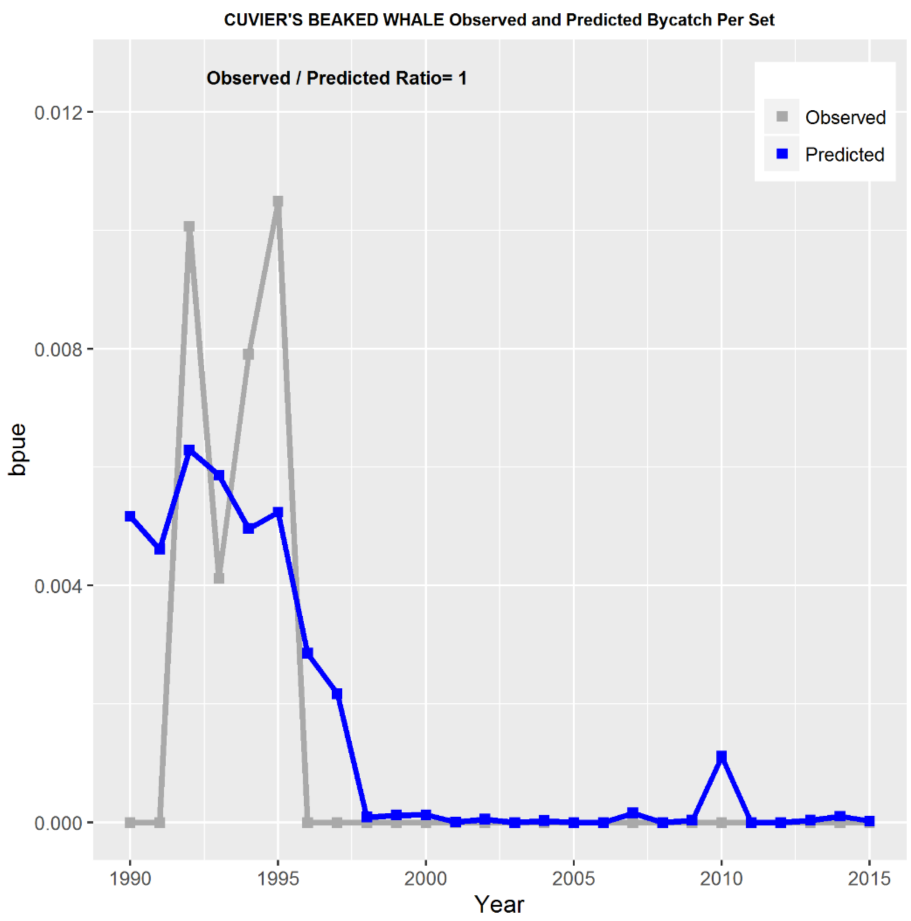

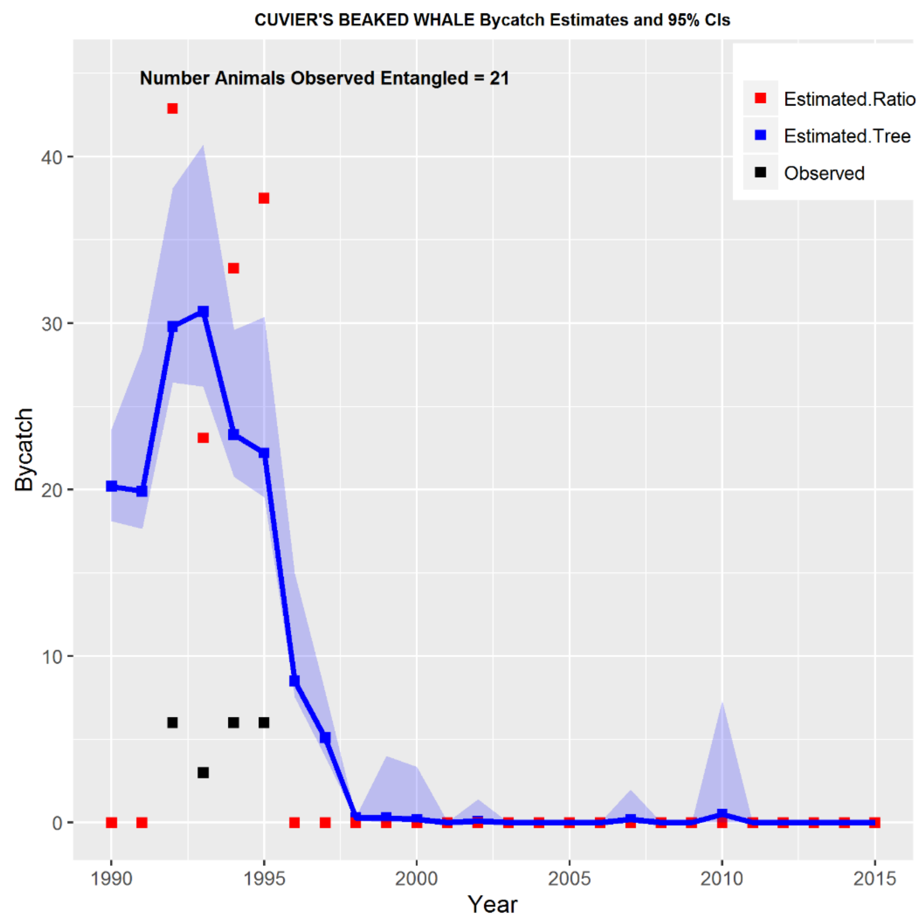

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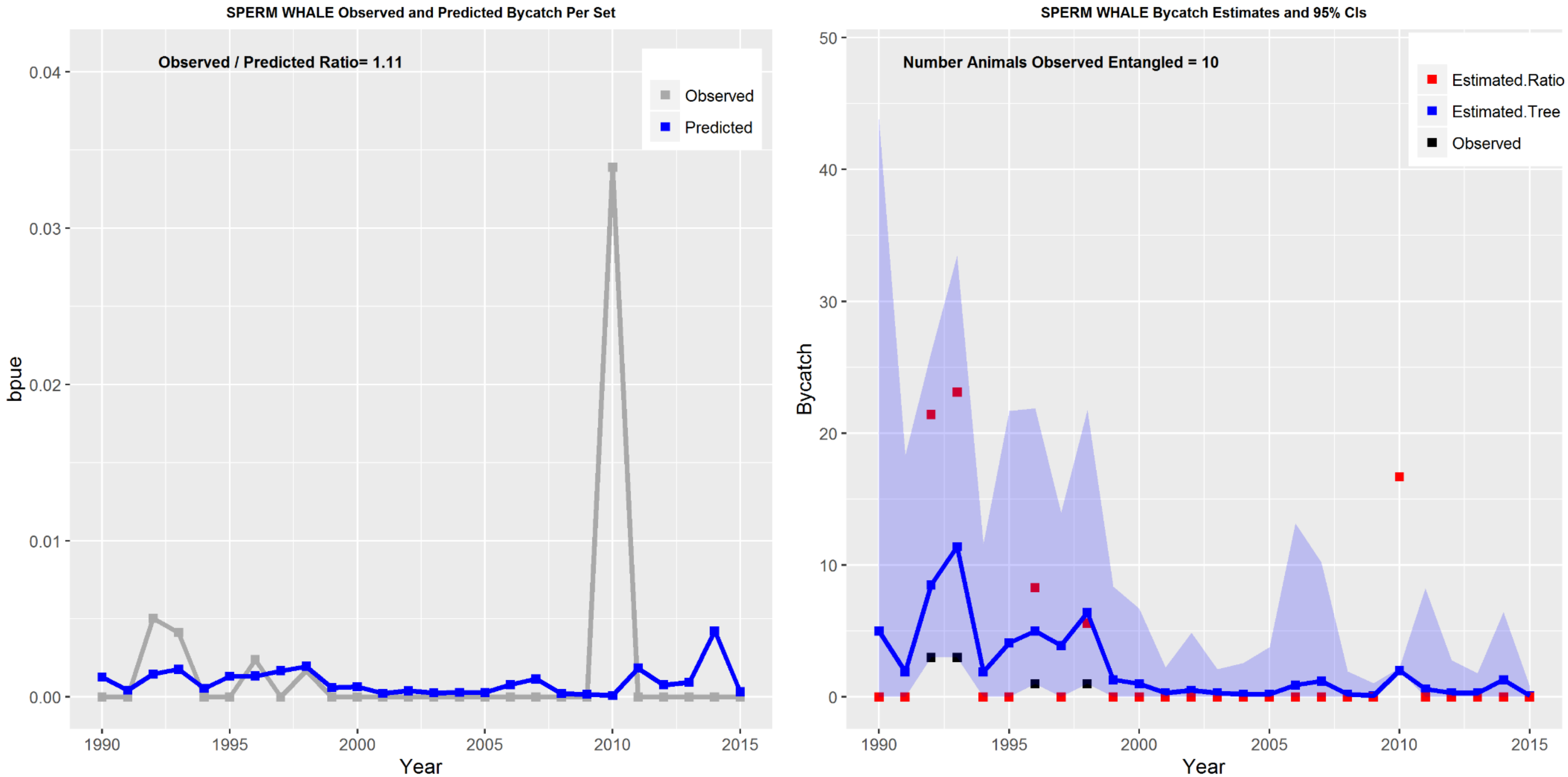

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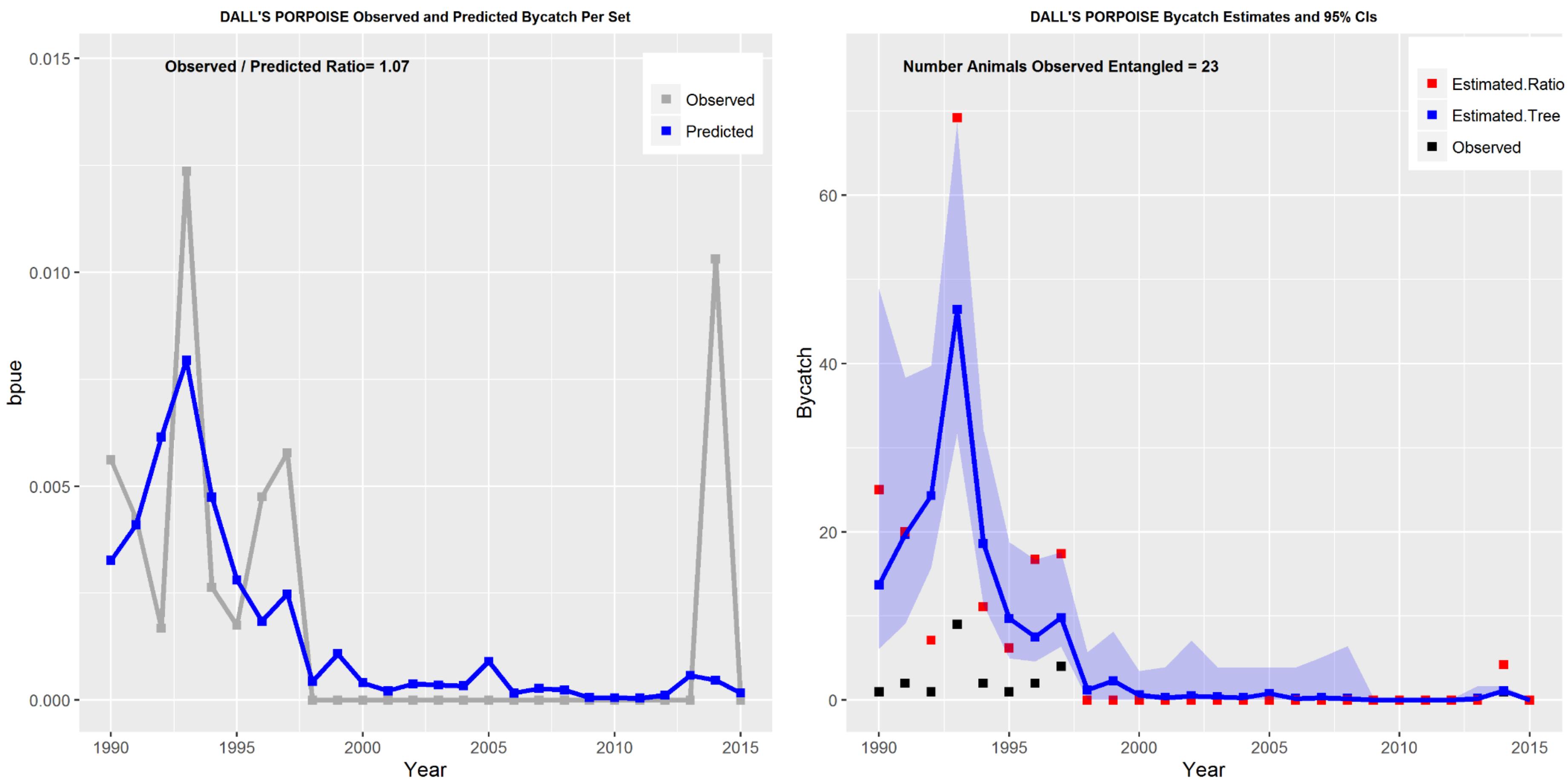

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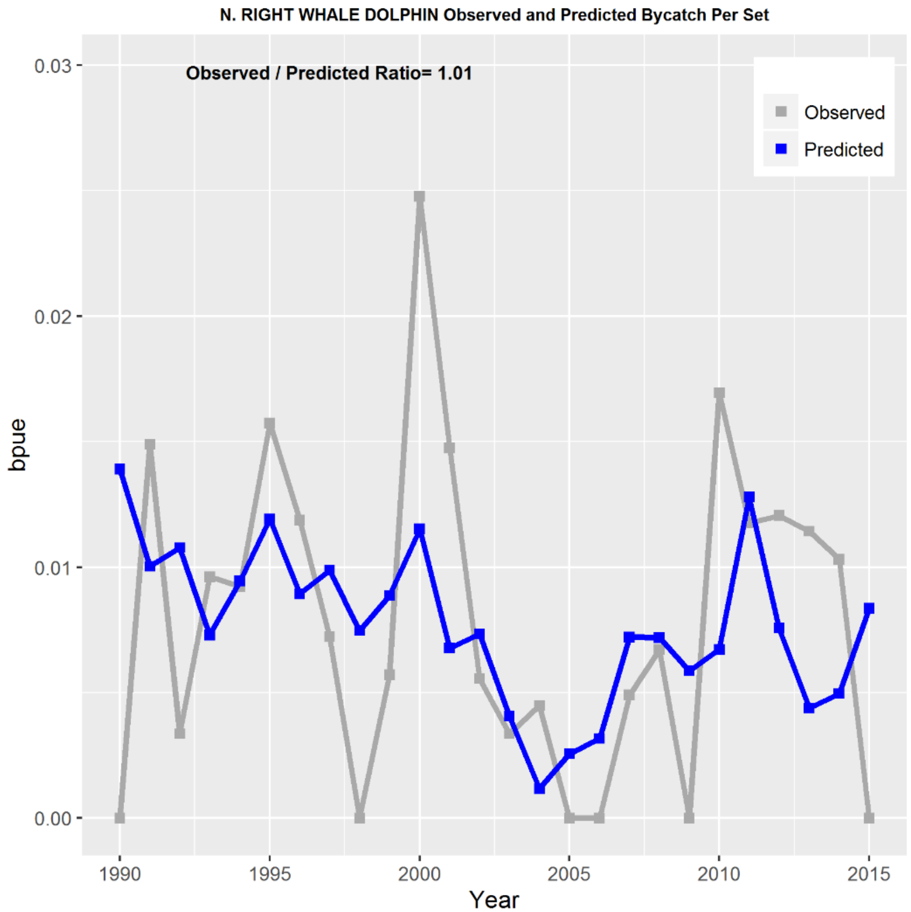

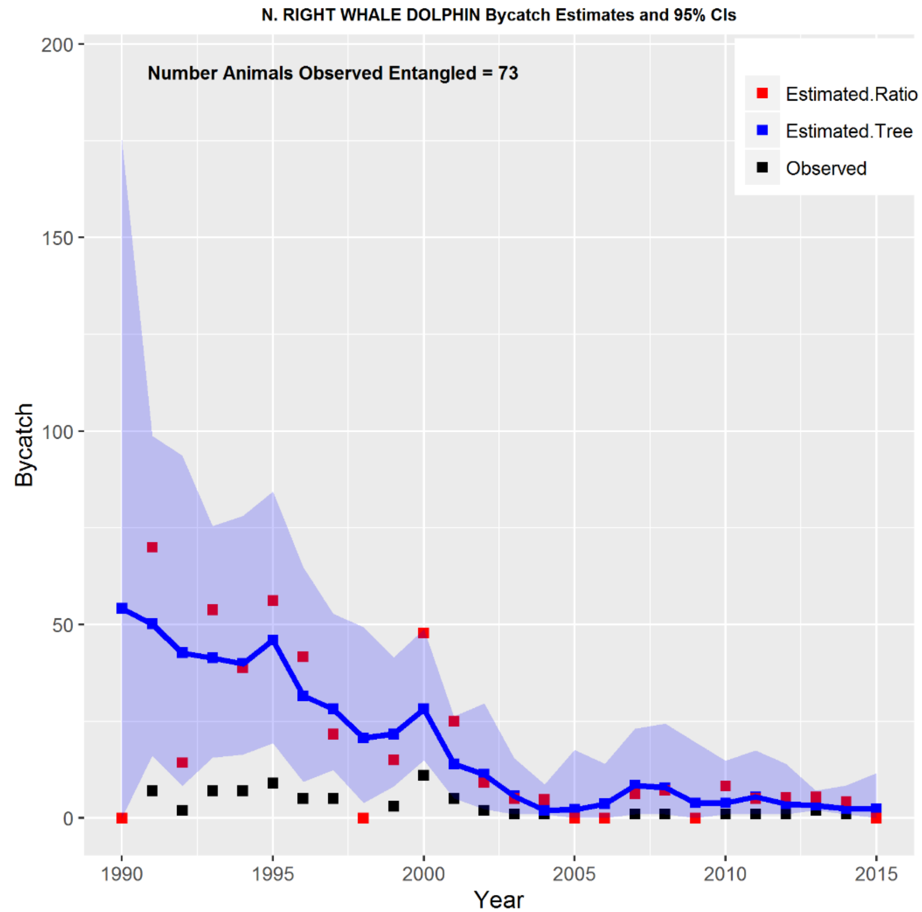

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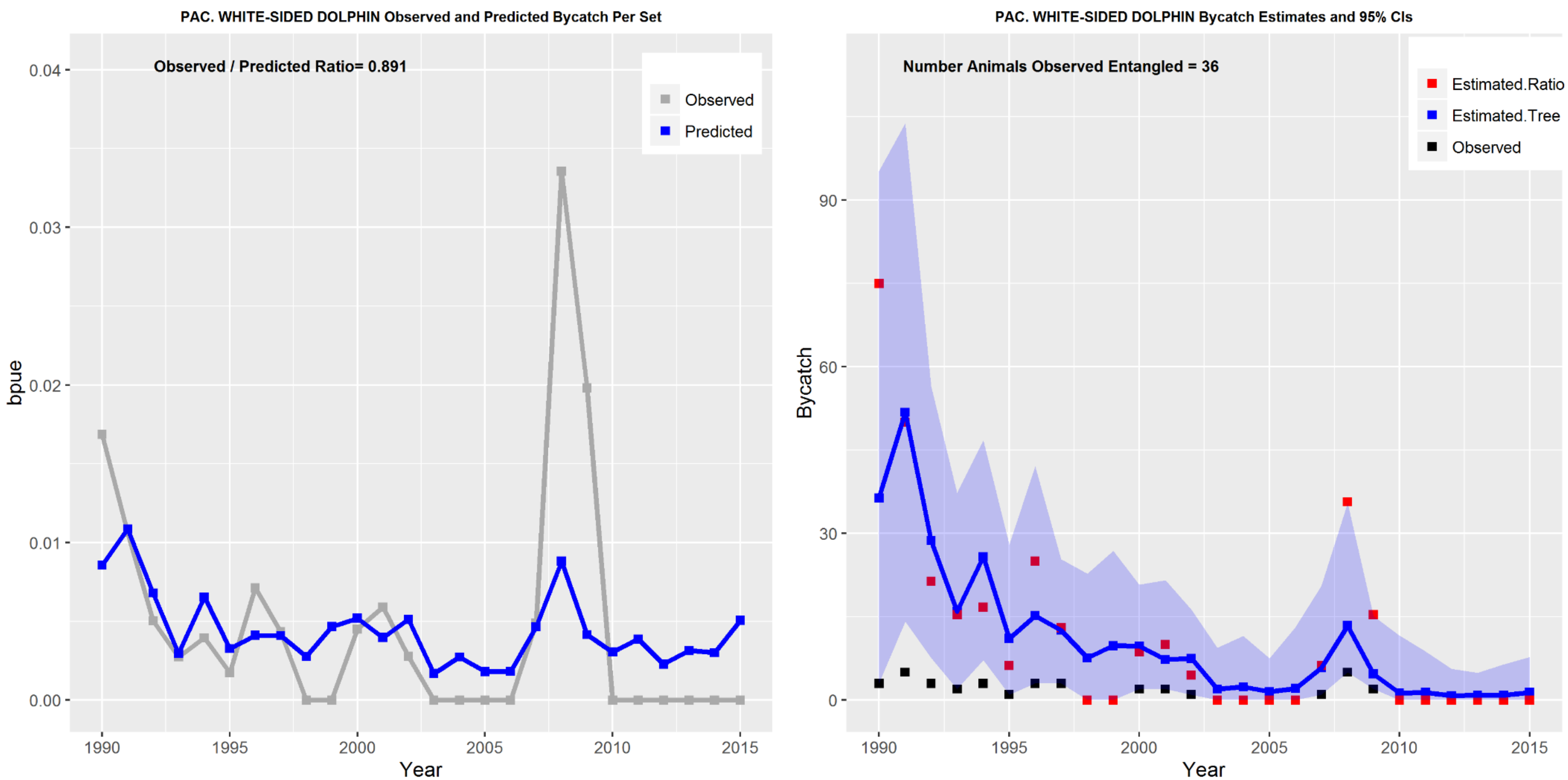

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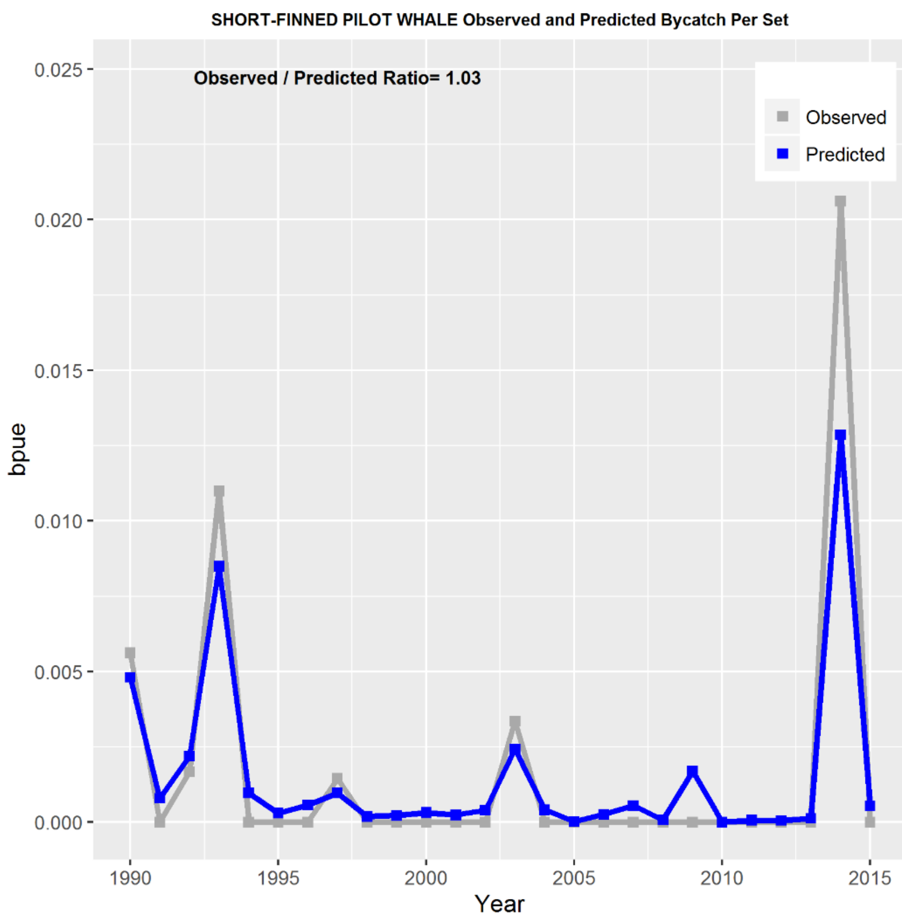

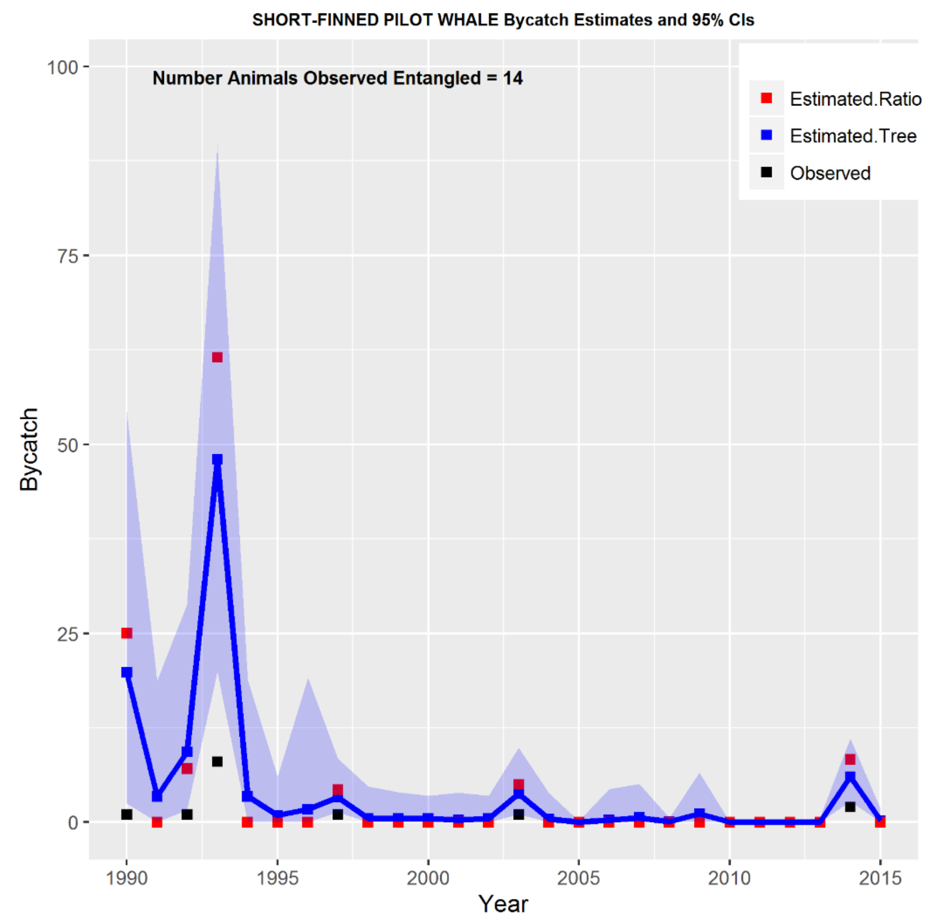

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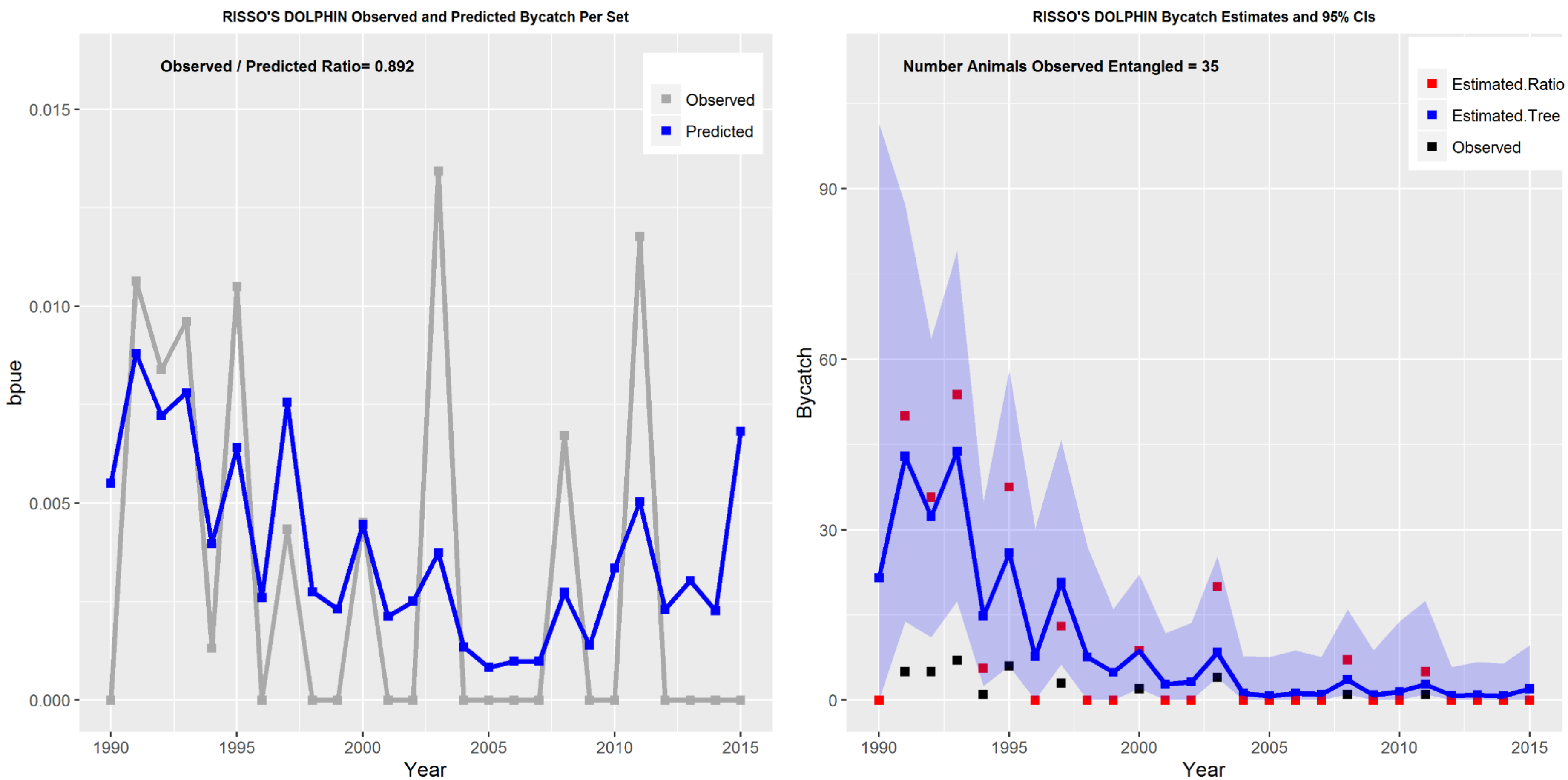

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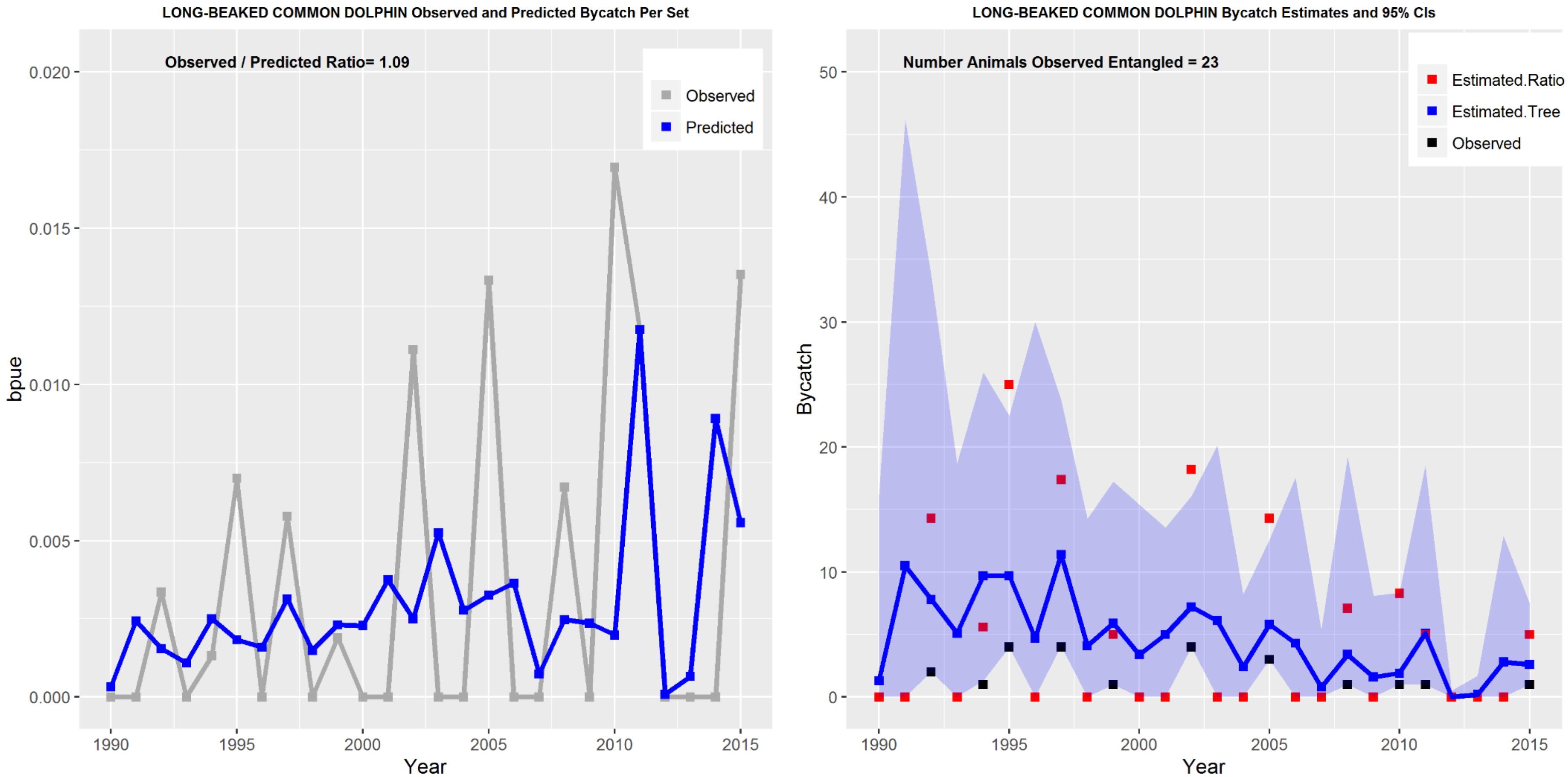

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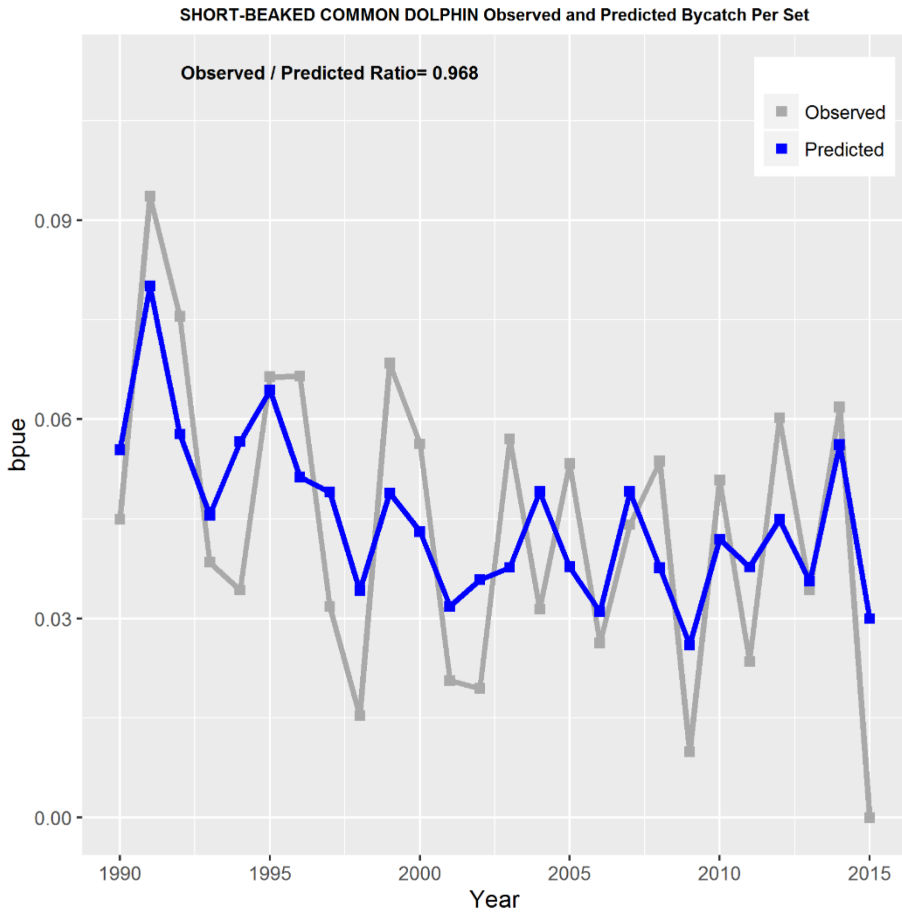

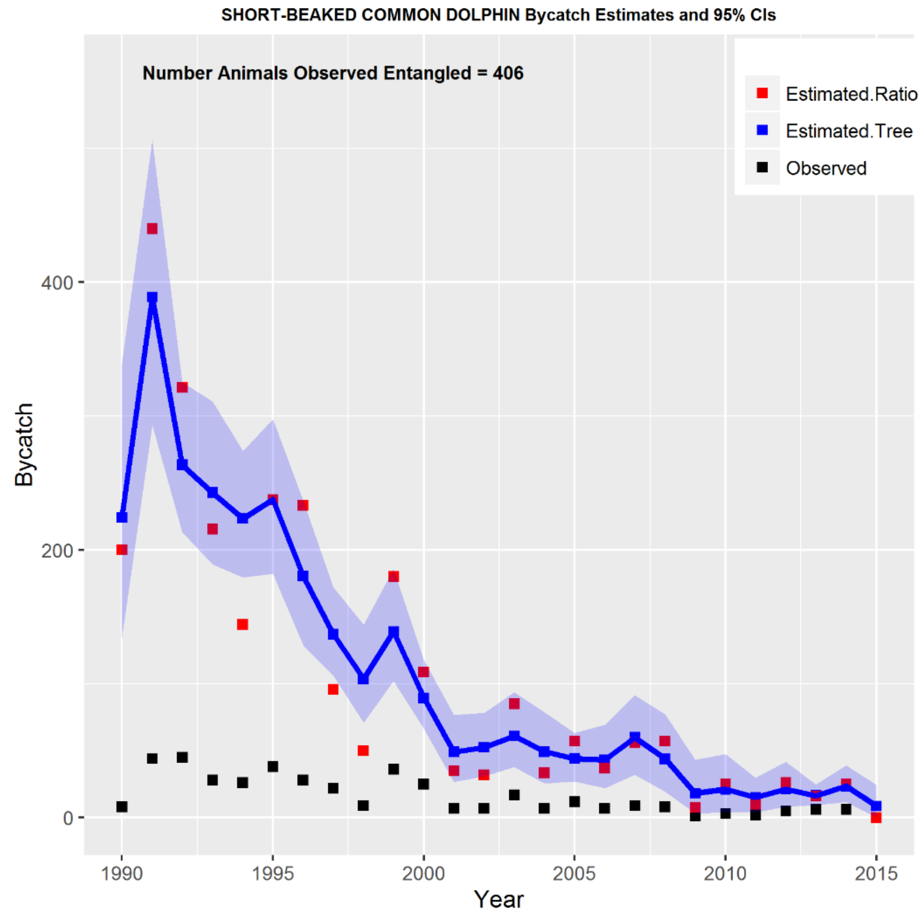

Figure 4. Observed depth (meters) of sets fished annually in the California swordfish and thresher shark drift gillnet fishery, 1990-2015.

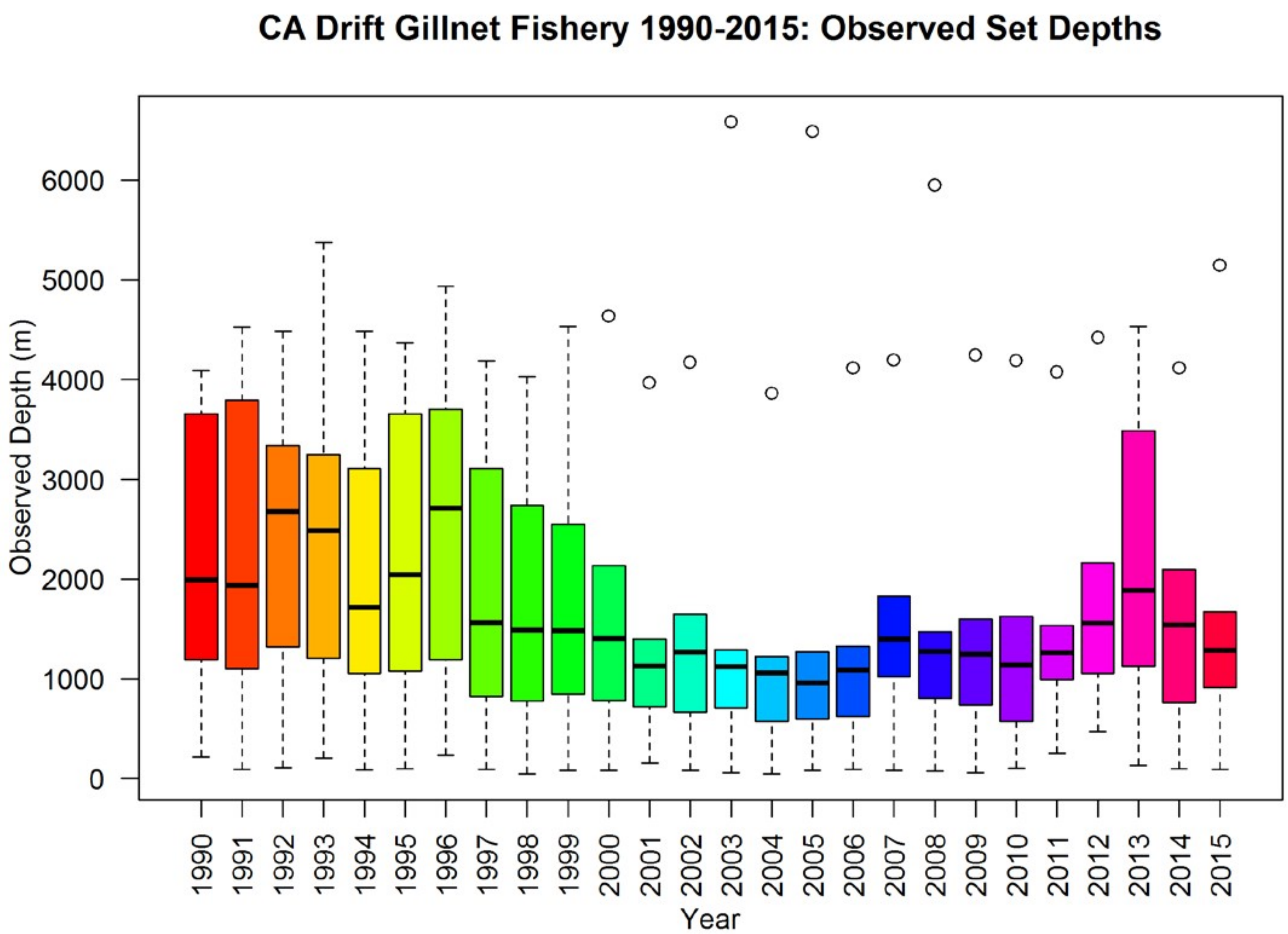

Table 1. Variables tested in random forest models. Variables shown in bold represent variables considered for actual bycatch data. The variables *days*, *drift.km*, and *slope* were not included in the analysis of simulated rare bycatch events.

Variable Name	Variable Description	Range of Values
days	Sequential day of year	1 -365
depth	water depth when net was pulled (meters)	46 - 6584
drift.km	Drift distance between set and retrieval (km)	1 - 300
extnd	top of net depth below surface in (feet)	3 - 99
height.net	Number of meshes from top to bottom of net	14 - 180
lat	Latitude	24.5 - 48
length.net	Length of net (meters)	50 – 2000
lon	Longitude	117 - 129
mei.index	Multivariate El Niño index(annual mean for Aug-Jan)	-1.3 to +2.1
mesh	mesh size in inches	14 - 28
month	Month	1-12
n.ping	Number of acoustic pingers	0 - 49
slope	Bathymetric slope, in degrees	0 - 90
soak	Soak time of net in hours	1 - 62
sst	Sea surface temperature (C)	11.1 – 25.6
year	Year	1990-2015

Table 2. Simulated rare event bycatch realizations used to test variable importance. Variables that resulted in the largest reduction in node impurities based on 10,000 random forest trees are shown for each simulated bycatch realization. The number of 'Bycatch Events' represents simulated fishing sets where bycatch ≥ 1, out of approximately ~8,500 simulated fishing sets.

Simulation	Bycatch Events	Best Predictor	rfPermute Significance p−value
simPM1	5	Depth	0.0099
simPM2	6	Depth	0.0099
simPM3	6	Longitude	0.426
simPM4	9	Longitude	0.0891
simPM5	7	Latitude	0.0099
simPM6	6	Latitude	0.0198
simPM7	6	HeightNet	0.0594
simPM8	7	Depth	0.0297
simPM9	7	Depth	0.0099
simPM10	5	Latitude	0.139
simPM11	7	HeightNet	0.0099
simPM12	6	Depth	0.0099
simPM13	8	Depth	0.0495
simPM14	7	HeightNet	0.0891
simPM15	7	Longitude	0.0693
simPM16	5	Depth	0.0297
simPM17	5	Depth	0.0297
simPM18	7	Depth	0.198
simPM19	6	Depth	0.0099
simPM20	7	Depth	0.0099
simPM21	5	HeightNet	0.0099
simPM22	6	Depth	0.0198
simPM23	6	Depth	0.0099
simPM24	5	Depth	0.129
simPM25	6	Month	0.0198
simPM26	6	Depth	0.0297
simPM27	5	Depth	0.178
simPM28	4	Depth	0.109
simPM29	9	Depth	0.0198
simPM30	4	Depth	0.0693

Table 3. Significant variables identified for regression tree bycatch models via rfPermute for various species / taxa. Species / groups with <4 bycatch events or where <2 significant variables were identified were assigned proxy variables for bycatch modeling (see text).

Species	Entanglement Events	Number Animals	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5
ALL DELPHINOIDS	471	616	sst	lon	n.ping	extnd	days
Delphinus delphis, SHORT−BEAKED COMMON DOLPHIN	324	406	sst	n.ping	lat	lon	days
Zalophus californianus, CALIFORNIA SEA LION	175	216	depth.p	mesh	−	−	−
Mirounga angustirostris, NORTHERN ELEPHANT SEAL	111	115	lon	n.ping	−	−	−
Lissodelphis borealis, NORTHERN RIGHT WHALE DOLPHIN	54	73	lat	lon	sst	−	−
ALL BEAKED WHALES	33	33	lon	n.ping	−	−	−
Grampus griseus, RISSO'S DOLPHIN	27	35	lon	−	−	−	−
Lagenorhynchus obliquidens, PACIFIC WHITE−SIDED DOLPHIN	27	36	−	−	−	−	−
Dermochelys coriacea, LEATHERBACK SEA TURTLE	25	25	lon	lat	depth.p	−	−
Phocoenoides dalli, DALL'S PORPOISE	21	23	lon	lat	n.ping	−	−
Ziphius cavirostris, CUVIER'S BEAKED WHALE	21	21	lon	n.ping	−	−	−
Fulmarus glacialis, NORTHERN FULMAR	20	36	days	mei.index	n.ping	−	−
Delphinus capensis, LONG−BEAKED COMMON DOLPHIN	17	23	lat	depth.p	−	−	−
Caretta caretta, LOGGERHEAD SEA TURTLE	14	16	lon	lat	days	−	−
Globicephala macrorhynchus, SHORT−FINNED PILOT WHALE	10	14	lon	mei.index	days	−	−
Physeter macrocephalus, SPERM WHALE	6	10	lon	depth.p	days	−	−
Mesoplodon hubbsi, HUBB'S BEAKED WHALE	5	5	lat	lon	depth.p	drift.km	−
UNID. BIRD	5	5	slope	−	−	−	−
Balaenoptera acutorostrata, MINKE WHALE	4	4	lat	−	−	−	−
Eschrichtius robustus, GRAY WHALE	4	4	days	−	−	−	−

Table 4. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for MINKE WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0.5 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	2.9	2.9	2.6	0	−	1.4	3.2
1991	470	0.1	0	1.4	1.4	2.2	0	−	0.7	2.4
1992	596	0.14	0	1.5	1.5	1.7	0	−	0.8	1.8
1993	728	0.13	0	2.1	2.1	1.5	0	−	0.9	2
1994	759	0.18	1	2.1	3.1	0.88	5.6	1	2.1	0.79
1995	572	0.16	0	1.5	1.5	1.7	0	−	0.8	1.9
1996	421	0.12	1	2.5	3.5	0.96	8.3	0.99	2.3	0.81
1997	692	0.23	0	0.8	0.8	1.7	0	−	0.4	1.9
1998	587	0.18	0	0.6	0.6	2.4	0	−	0.3	2.6
1999	526	0.2	1	0.6	1.6	0.8	5	1	0.3	2.3
2000	444	0.23	0	0.3	0.3	2.8	0	−	0.2	3.1
2001	339	0.2	0	0.7	0.7	1.7	0	−	0.4	2
2002	360	0.22	0	0.3	0.3	2.7	0	−	0.2	2.8
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0.2	0.2	4.8	0	−	0.1	6.9
2005	225	0.21	0	0.1	0.1	4.9	0	−	0	6.3
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	2.8	2.8	1.2	0	−	1.4	1.4
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0.2	0.2	5.3	0	−	0.1	7.1
2010	59	0.12	0	0.1	0.1	9.2	0	−	0	11
2011	85	0.2	1	0.1	1.1	0.37	5	1	0.1	4.4
2012	83	0.19	0	0.1	0.1	6	0	−	0	8.2
2013	175	0.37	0	0.1	0.1	3.6	0	−	0	4.8
2014	97	0.24	0	0.1	0.1	5.6	0	−	0	5.4
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	3	14.8	17.8	0.44	20	0.58	9.3	0.61
2001−2015	2738	0.19	1	4.4	5.4	0.64	5.3	1	2.2	1
2011−2015	514	0.24	1	0.4	1.4	0.64	4.2	1.01	0.2	2.6

Table 5. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for FIN WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.1	0.1	4.1	0	−	0.1	4.1
1991	470	0.1	0	0.1	0.1	11	0	−	0.1	11
1992	596	0.14	0	0.1	0.1	6.3	0	−	0.1	6.3
1993	728	0.13	0	0.4	0.4	3.2	0	−	0.4	3.2
1994	759	0.18	0	0.7	0.7	2.1	0	−	0.7	2.1
1995	572	0.16	0	0.3	0.3	2.4	0	−	0.3	2.4
1996	421	0.12	0	0	0	−	0	−	0	−
1997	692	0.23	0	0	0	−	0	−	0	−
1998	587	0.18	0	0.1	0.1	4.4	0	−	0.1	4.4
1999	526	0.2	1	0.3	1.3	0.59	5	1	1.3	0.59
2000	444	0.23	0	0.4	0.4	2.3	0	−	0.4	2.3
2001	339	0.2	0	0.3	0.3	2.5	0	−	0.3	2.5
2002	360	0.22	0	0.2	0.2	2.9	0	−	0.2	2.9
2003	298	0.2	0	0.3	0.3	2.9	0	−	0.3	2.9
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0.2	0.2	3.8	0	−	0.2	3.8
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0.3	0.3	3	0	−	0.3	3
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0.1	0.1	2.7	0	−	0.1	2.7
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	1	3.1	4.1	0.76	6.7	1	4.1	0.76
2001−2015	2738	0.19	0	1.7	1.7	1.2	0	−	1.7	1.2
2011−2015	514	0.24	0	0.4	0.4	2	0	−	0.4	2

Table 6. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for GRAY WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0	0	−	0	−	0	−
1991	470	0.1	0	0.7	0.7	2.1	0	−	0.7	2.1
1992	596	0.14	0	0.1	0.1	5.9	0	−	0.1	5.9
1993	728	0.13	0	0.5	0.5	1.9	0	−	0.5	1.9
1994	759	0.18	0	0.6	0.6	2	0	−	0.6	2
1995	572	0.16	0	1.1	1.1	1.6	0	−	1.1	1.6
1996	421	0.12	0	0.7	0.7	2.5	0	−	0.7	2.5
1997	692	0.23	0	1.1	1.1	1.4	0	−	1.1	1.4
1998	587	0.18	1	1.8	2.8	0.78	5.6	1	2.8	0.78
1999	526	0.2	1	0.8	1.8	0.69	5	1	1.8	0.69
2000	444	0.23	0	0.3	0.3	2.3	0	−	0.3	2.3
2001	339	0.2	0	2.1	2.1	1	0	−	2.1	1
2002	360	0.22	0	1	1	1.6	0	−	1	1.6
2003	298	0.2	0	0.7	0.7	1.8	0	−	0.7	1.8
2004	223	0.21	0	1.6	1.6	1.2	0	−	1.6	1.2
2005	225	0.21	1	0.2	1.2	0.46	4.8	1	1.2	0.46
2006	266	0.19	0	0.7	0.7	1.9	0	−	0.7	1.9
2007	204	0.16	0	0.8	0.8	1.9	0	−	0.8	1.9
2008	149	0.14	0	0.2	0.2	3.9	0	−	0.2	3.9
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0.1	0.1	7	0	−	0.1	7
2011	85	0.2	0	0.2	0.2	3.6	0	−	0.2	3.6
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	1	0.5	1.5	0.57	2.7	1	1.5	0.57
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0.5	0.5	2.4	0	−	0.5	2.4
1990−2000	5973	0.15	2	9.1	11.1	0.45	13.3	0.71	11.1	0.45
2001−2015	2738	0.19	2	9.6	11.6	0.43	10.5	0.71	11.6	0.43
2011−2015	514	0.24	1	1.5	2.5	0.74	4.2	0.98	2.5	0.74

Table 7. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for HUMPBACK WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0.25 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.2	0.2	5.6	0	−	0	8.9
1991	470	0.1	0	2.3	2.3	1.6	0	−	0.6	2.3
1992	596	0.14	0	0.1	0.1	3.4	0	−	0	4.4
1993	728	0.13	0	1	1	2	0	−	0.2	2.3
1994	759	0.18	1	1.3	2.3	0.75	5.6	1	0.3	2
1995	572	0.16	0	0.4	0.4	2.5	0	−	0.1	5.9
1996	421	0.12	0	0.1	0.1	4.9	0	−	0	10
1997	692	0.23	0	1	1	1.7	0	−	0.3	2.5
1998	587	0.18	0	1.7	1.7	1.3	0	−	0.4	2.1
1999	526	0.2	1	0.4	1.4	0.66	5	0.99	0.1	4.9
2000	444	0.23	0	0.8	0.8	1.7	0	−	0.2	3.1
2001	339	0.2	0	0.6	0.6	1.9	0	−	0.2	2.7
2002	360	0.22	0	1.2	1.2	1.4	0	−	0.3	2.1
2003	298	0.2	0	0.4	0.4	2.3	0	−	0.1	4
2004	223	0.21	1	0.6	1.6	0.76	4.8	1	0.2	2.4
2005	225	0.21	0	0.2	0.2	3.5	0	−	0.1	3.8
2006	266	0.19	0	0.1	0.1	4.3	0	−	0	5.4
2007	204	0.16	0	0.5	0.5	2.5	0	−	0.1	3.3
2008	149	0.14	0	0.8	0.8	2.2	0	−	0.2	3.5
2009	101	0.13	0	0.1	0.1	3.6	0	−	0	7.8
2010	59	0.12	0	0.1	0.1	9.3	0	−	0	12
2011	85	0.2	0	0.2	0.2	3.8	0	−	0	5.6
2012	83	0.19	0	0.1	0.1	3.9	0	−	0	6.4
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0.2	0.2	4	0	−	0	4.1
1990−2000	5973	0.15	2	10.4	12.4	0.49	13.3	0.71	2.6	1.3
2001−2015	2738	0.19	1	5	6	0.62	5.3	0.99	1.3	1.4
2011−2015	514	0.24	0	0.4	0.4	2	0	−	0.1	3

Table 8. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for SHORT−BEAKED COMMON DOLPHIN. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	8	216.2	224.2	0.24	200	0.47	224.2	0.24
1991	470	0.1	44	345	389	0.13	440	0.2	389	0.13
1992	596	0.14	45	218.6	263.6	0.11	321.4	0.18	263.6	0.11
1993	728	0.13	28	214.8	242.8	0.13	215.4	0.28	242.8	0.13
1994	759	0.18	26	197.6	223.6	0.11	144.4	0.21	223.6	0.11
1995	572	0.16	38	199.7	237.7	0.13	237.5	0.23	237.7	0.13
1996	421	0.12	28	152.4	180.4	0.15	233.3	0.21	180.4	0.15
1997	692	0.23	22	115.1	137.1	0.12	95.7	0.24	137.1	0.12
1998	587	0.18	9	94.6	103.6	0.18	50	0.33	103.6	0.18
1999	526	0.2	36	103.1	139.1	0.16	180	0.24	139.1	0.16
2000	444	0.23	25	64.3	89.3	0.15	108.7	0.24	89.3	0.15
2001	339	0.2	7	42.2	49.2	0.26	35	0.43	49.2	0.26
2002	360	0.22	7	45.5	52.5	0.23	31.8	0.42	52.5	0.23
2003	298	0.2	17	44	61	0.23	85	0.31	61	0.23
2004	223	0.21	7	42.3	49.3	0.27	33.3	0.42	49.3	0.27
2005	225	0.21	12	32.1	44.1	0.21	57.1	0.28	44.1	0.21
2006	266	0.19	7	36.2	43.2	0.29	36.8	0.47	43.2	0.29
2007	204	0.16	9	50.9	59.9	0.26	56.2	0.36	59.9	0.26
2008	149	0.14	8	35.9	43.9	0.33	57.1	0.46	43.9	0.33
2009	101	0.13	1	17.2	18.2	0.56	7.7	1	18.2	0.56
2010	59	0.12	3	18.2	21.2	0.53	25	0.75	21.2	0.53
2011	85	0.2	2	13.2	15.2	0.46	10	0.69	15.2	0.46
2012	83	0.19	5	16.3	21.3	0.41	26.3	0.59	21.3	0.41
2013	175	0.37	6	10.5	16.5	0.25	16.2	0.41	16.5	0.25
2014	97	0.24	6	17.5	23.5	0.31	25	0.47	23.5	0.31
2015	74	0.2	0	8.6	8.6	0.71	0	−	8.6	0.71
1990−2000	5973	0.15	309	1846.9	2155.9	0.04	2060	0.07	2155.9	0.04
2001−2015	2738	0.19	97	431.3	528.3	0.08	510.5	0.12	528.3	0.08
2011−2015	514	0.24	19	65.1	84.1	0.17	79.2	0.26	84.1	0.17

Table 9. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for LONG−BEAKED COMMON DOLPHIN. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	1.3	1.3	4.5	0	−	1.3	4.5
1991	470	0.1	0	10.5	10.5	1.2	0	−	10.5	1.2
1992	596	0.14	2	5.8	7.8	1.1	14.3	0.7	7.8	1.1
1993	728	0.13	0	5.1	5.1	1.1	0	−	5.1	1.1
1994	759	0.18	1	8.7	9.7	0.68	5.6	1	9.7	0.68
1995	572	0.16	4	5.7	9.7	0.55	25	1	9.7	0.55
1996	421	0.12	0	4.7	4.7	1.9	0	−	4.7	1.9
1997	692	0.23	4	7.4	11.4	0.48	17.4	0.61	11.4	0.48
1998	587	0.18	0	4.1	4.1	0.99	0	−	4.1	0.99
1999	526	0.2	1	4.9	5.9	0.82	5	1	5.9	0.82
2000	444	0.23	0	3.4	3.4	1.2	0	−	3.4	1.2
2001	339	0.2	0	5	5	0.75	0	−	5	0.75
2002	360	0.22	4	3.2	7.2	0.46	18.2	0.8	7.2	0.46
2003	298	0.2	0	6.1	6.1	1	0	−	6.1	1
2004	223	0.21	0	2.4	2.4	1	0	−	2.4	1
2005	225	0.21	3	2.8	5.8	0.52	14.3	0.57	5.8	0.52
2006	266	0.19	0	4.3	4.3	1	0	−	4.3	1
2007	204	0.16	0	0.8	0.8	2.1	0	−	0.8	2.1
2008	149	0.14	1	2.4	3.4	1.3	7.1	0.99	3.4	1.3
2009	101	0.13	0	1.6	1.6	1.5	0	−	1.6	1.5
2010	59	0.12	1	0.9	1.9	1.1	8.3	0.99	1.9	1.1
2011	85	0.2	1	4.1	5.1	1.3	5	0.99	5.1	1.3
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0.2	0.2	2.2	0	−	0.2	2.2
2014	97	0.24	0	2.8	2.8	1.4	0	−	2.8	1.4
2015	74	0.2	1	1.6	2.6	0.78	5	0.99	2.6	0.78
1990−2000	5973	0.15	12	69.1	81.1	0.29	80	0.43	81.1	0.29
2001−2015	2738	0.19	11	38.6	49.6	0.3	57.9	0.37	49.6	0.3
2011−2015	514	0.24	2	7.5	9.5	0.7	8.3	0.71	9.5	0.7

Table 10. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for RISSO'S DOLPHIN. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	21.5	21.5	1.3	0	−	21.5	1.3
1991	470	0.1	5	37.9	42.9	0.42	50	0.44	42.9	0.42
1992	596	0.14	5	27.3	32.3	0.41	35.7	0.45	32.3	0.41
1993	728	0.13	7	36.8	43.8	0.36	53.8	0.42	43.8	0.36
1994	759	0.18	1	13.8	14.8	0.57	5.6	1	14.8	0.57
1995	572	0.16	6	19.9	25.9	0.53	37.5	0.62	25.9	0.53
1996	421	0.12	0	7.7	7.7	1.1	0	−	7.7	1.1
1997	692	0.23	3	17.7	20.7	0.48	13	0.74	20.7	0.48
1998	587	0.18	0	7.6	7.6	0.97	0	−	7.6	0.97
1999	526	0.2	0	4.9	4.9	0.93	0	−	4.9	0.93
2000	444	0.23	2	6.7	8.7	0.63	8.7	0.71	8.7	0.63
2001	339	0.2	0	2.8	2.8	1.3	0	−	2.8	1.3
2002	360	0.22	0	3.2	3.2	1.2	0	−	3.2	1.2
2003	298	0.2	4	4.4	8.4	0.78	20	1	8.4	0.78
2004	223	0.21	0	1.2	1.2	2.2	0	−	1.2	2.2
2005	225	0.21	0	0.7	0.7	2.7	0	−	0.7	2.7
2006	266	0.19	0	1.2	1.2	2.3	0	−	1.2	2.3
2007	204	0.16	0	1	1	2.4	0	−	1	2.4
2008	149	0.14	1	2.6	3.6	1.3	7.1	1	3.6	1.3
2009	101	0.13	0	0.9	0.9	3.6	0	−	0.9	3.6
2010	59	0.12	0	1.5	1.5	2.5	0	−	1.5	2.5
2011	85	0.2	1	1.8	2.8	1.3	5	0.99	2.8	1.3
2012	83	0.19	0	0.8	0.8	2.8	0	−	0.8	2.8
2013	175	0.37	0	0.9	0.9	1.9	0	−	0.9	1.9
2014	97	0.24	0	0.7	0.7	2.8	0	−	0.7	2.8
2015	74	0.2	0	2	2	1.5	0	−	2	1.5
1990−2000	5973	0.15	29	192.8	221.8	0.16	193.3	0.22	221.8	0.16
2001−2015	2738	0.19	6	26.1	32.1	0.42	31.6	0.72	32.1	0.42
2011−2015	514	0.24	1	5.9	6.9	0.81	4.2	1	6.9	0.81

Table 11. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for SHORT−FINNED PILOT WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	1	18.8	19.8	0.74	25	0.97	19.8	0.74
1991	470	0.1	0	3.4	3.4	1.5	0	−	3.4	1.5
1992	596	0.14	1	8.3	9.3	0.83	7.1	1	9.3	0.83
1993	728	0.13	8	40	48	0.39	61.5	0.58	48	0.39
1994	759	0.18	0	3.4	3.4	1.3	0	−	3.4	1.3
1995	572	0.16	0	0.9	0.9	2.2	0	−	0.9	2.2
1996	421	0.12	0	1.7	1.7	3.1	0	−	1.7	3.1
1997	692	0.23	1	2.3	3.3	0.62	4.3	1	3.3	0.62
1998	587	0.18	0	0.5	0.5	2.3	0	−	0.5	2.3
1999	526	0.2	0	0.5	0.5	2.2	0	−	0.5	2.2
2000	444	0.23	0	0.5	0.5	3.1	0	−	0.5	3.1
2001	339	0.2	0	0.3	0.3	3.3	0	−	0.3	3.3
2002	360	0.22	0	0.5	0.5	2.3	0	−	0.5	2.3
2003	298	0.2	1	2.8	3.8	0.67	5	0.99	3.8	0.67
2004	223	0.21	0	0.4	0.4	2.6	0	−	0.4	2.6
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0.3	0.3	3.3	0	−	0.3	3.3
2007	204	0.16	0	0.6	0.6	2.9	0	−	0.6	2.9
2008	149	0.14	0	0.1	0.1	7	0	−	0.1	7
2009	101	0.13	0	1.1	1.1	2.2	0	−	1.1	2.2
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	2	4	6	0.39	8.3	0.7	6	0.39
2015	74	0.2	0	0.2	0.2	3.9	0	−	0.2	3.9
1990−2000	5973	0.15	11	63.9	74.9	0.28	73.3	0.45	74.9	0.28
2001−2015	2738	0.19	3	11.3	14.3	0.35	15.8	0.58	14.3	0.35
2011−2015	514	0.24	2	4.1	6.1	0.39	8.3	0.71	6.1	0.39

Table 12. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for PAC. WHITE−SIDED DOLPHIN. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	3	33.4	36.4	0.74	75	0.57	36.4	0.74
1991	470	0.1	5	46.8	51.8	0.43	50	0.66	51.8	0.43
1992	596	0.14	3	25.7	28.7	0.43	21.4	0.74	28.7	0.43
1993	728	0.13	2	14	16	0.58	15.4	0.71	16	0.58
1994	759	0.18	3	22.8	25.8	0.43	16.7	0.75	25.8	0.43
1995	572	0.16	1	10.1	11.1	0.66	6.2	1	11.1	0.66
1996	421	0.12	3	12.2	15.2	0.7	25	0.73	15.2	0.7
1997	692	0.23	3	9.6	12.6	0.45	13	0.58	12.6	0.45
1998	587	0.18	0	7.6	7.6	0.82	0	−	7.6	0.82
1999	526	0.2	0	9.8	9.8	0.7	0	−	9.8	0.7
2000	444	0.23	2	7.7	9.7	0.51	8.7	0.7	9.7	0.51
2001	339	0.2	2	5.3	7.3	0.73	10	0.72	7.3	0.73
2002	360	0.22	1	6.5	7.5	0.53	4.5	1	7.5	0.53
2003	298	0.2	0	2	2	1.5	0	−	2	1.5
2004	223	0.21	0	2.4	2.4	1.5	0	−	2.4	1.5
2005	225	0.21	0	1.5	1.5	1.6	0	−	1.5	1.6
2006	266	0.19	0	2.1	2.1	1.6	0	−	2.1	1.6
2007	204	0.16	1	4.8	5.8	1	6.2	1	5.8	1
2008	149	0.14	5	8.4	13.4	0.66	35.7	0.73	13.4	0.66
2009	101	0.13	2	2.7	4.7	0.97	15.4	1	4.7	0.97
2010	59	0.12	0	1.3	1.3	2.5	0	−	1.3	2.5
2011	85	0.2	0	1.4	1.4	2	0	−	1.4	2
2012	83	0.19	0	0.8	0.8	2.2	0	−	0.8	2.2
2013	175	0.37	0	0.9	0.9	1.5	0	−	0.9	1.5
2014	97	0.24	0	0.9	0.9	2	0	−	0.9	2
2015	74	0.2	0	1.4	1.4	1.5	0	−	1.4	1.5
1990−2000	5973	0.15	25	179.3	204.3	0.17	166.7	0.24	204.3	0.17
2001−2015	2738	0.19	11	40.5	51.5	0.27	57.9	0.42	51.5	0.27
2011−2015	514	0.24	0	5.4	5.4	0.79	0	−	5.4	0.79

Table 13. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for N. RIGHT WHALE DOLPHIN. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	54.2	54.2	0.9	0	−	54.2	0.9
1991	470	0.1	7	43.2	50.2	0.43	70	0.43	50.2	0.43
1992	596	0.14	2	40.7	42.7	0.56	14.3	0.71	42.7	0.56
1993	728	0.13	7	34.4	41.4	0.38	53.8	0.42	41.4	0.38
1994	759	0.18	7	32.9	39.9	0.4	38.9	0.43	39.9	0.4
1995	572	0.16	9	37	46	0.36	56.2	0.66	46	0.36
1996	421	0.12	5	26.6	31.6	0.47	41.7	0.66	31.6	0.47
1997	692	0.23	5	23.2	28.2	0.37	21.7	0.44	28.2	0.37
1998	587	0.18	0	20.7	20.7	0.56	0	−	20.7	0.56
1999	526	0.2	3	18.7	21.7	0.38	15	0.57	21.7	0.38
2000	444	0.23	11	17.2	28.2	0.32	47.8	0.5	28.2	0.32
2001	339	0.2	5	9	14	0.4	25	0.53	14	0.4
2002	360	0.22	2	9.3	11.3	0.63	9.1	0.71	11.3	0.63
2003	298	0.2	1	4.7	5.7	0.69	5	1	5.7	0.69
2004	223	0.21	1	1	2	1.2	4.8	1	2	1.2
2005	225	0.21	0	2.2	2.2	2	0	−	2.2	2
2006	266	0.19	0	3.7	3.7	1	0	−	3.7	1
2007	204	0.16	1	7.5	8.5	0.72	6.2	0.99	8.5	0.72
2008	149	0.14	1	6.9	7.9	0.85	7.1	0.98	7.9	0.85
2009	101	0.13	0	3.9	3.9	1.4	0	−	3.9	1.4
2010	59	0.12	1	2.9	3.9	1	8.3	0.99	3.9	1
2011	85	0.2	1	4.5	5.5	0.85	5	1	5.5	0.85
2012	83	0.19	1	2.7	3.7	0.95	5.3	0.99	3.7	0.95
2013	175	0.37	2	1.3	3.3	0.45	5.4	0.99	3.3	0.45
2014	97	0.24	1	1.5	2.5	0.83	4.2	1	2.5	0.83
2015	74	0.2	0	2.4	2.4	1.4	0	−	2.4	1.4
1990−2000	5973	0.15	56	337.6	393.6	0.14	373.3	0.19	393.6	0.14
2001−2015	2738	0.19	17	61.9	78.9	0.23	89.5	0.27	78.9	0.23
2011−2015	514	0.24	5	11.2	16.2	0.4	20.8	0.52	16.2	0.4

Table 14. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for KILLER WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	1.1	1.1	3.7	0	−	1.1	3.7
1991	470	0.1	0	0.5	0.5	3.8	0	−	0.5	3.8
1992	596	0.14	0	0.3	0.3	3.9	0	−	0.3	3.9
1993	728	0.13	0	0.5	0.5	3	0	−	0.5	3
1994	759	0.18	0	0.7	0.7	2.3	0	−	0.7	2.3
1995	572	0.16	1	0.5	1.5	0.99	6.2	0.99	1.5	0.99
1996	421	0.12	0	0.7	0.7	2.9	0	−	0.7	2.9
1997	692	0.23	0	0.2	0.2	3.6	0	−	0.2	3.6
1998	587	0.18	0	1.3	1.3	1.7	0	−	1.3	1.7
1999	526	0.2	0	0.1	0.1	7.1	0	−	0.1	7.1
2000	444	0.23	0	0.4	0.4	2.6	0	−	0.4	2.6
2001	339	0.2	0	0.1	0.1	6.4	0	−	0.1	6.4
2002	360	0.22	0	0.1	0.1	7.1	0	−	0.1	7.1
2003	298	0.2	0	0.1	0.1	7.7	0	−	0.1	7.7
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0.2	0.2	4.3	0	−	0.2	4.3
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0.1	0.1	11	0	−	0.1	11
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0.1	0.1	5.5	0	−	0.1	5.5
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	1	6	7	0.73	6.7	1	7	0.73
2001−2015	2738	0.19	0	0.7	0.7	2.1	0	−	0.7	2.1
2011−2015	514	0.24	0	0.2	0.2	3.4	0	−	0.2	3.4

Table 15. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for DALL'S PORPOISE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	1	12.7	13.7	0.78	25	1	13.7	0.78
1991	470	0.1	2	17.7	19.7	0.42	20	0.71	19.7	0.42
1992	596	0.14	1	23.3	24.3	0.28	7.1	1	24.3	0.28
1993	728	0.13	9	37.4	46.4	0.21	69.2	0.37	46.4	0.21
1994	759	0.18	2	16.6	18.6	0.31	11.1	0.71	18.6	0.31
1995	572	0.16	1	8.7	9.7	0.42	6.2	0.99	9.7	0.42
1996	421	0.12	2	5.5	7.5	0.44	16.7	0.71	7.5	0.44
1997	692	0.23	4	5.8	9.8	0.33	17.4	0.62	9.8	0.33
1998	587	0.18	0	1.2	1.2	1.5	0	−	1.2	1.5
1999	526	0.2	0	2.3	2.3	1	0	−	2.3	1
2000	444	0.23	0	0.6	0.6	2.1	0	−	0.6	2.1
2001	339	0.2	0	0.3	0.3	2.8	0	−	0.3	2.8
2002	360	0.22	0	0.5	0.5	3.2	0	−	0.5	3.2
2003	298	0.2	0	0.4	0.4	2.7	0	−	0.4	2.7
2004	223	0.21	0	0.3	0.3	3.1	0	−	0.3	3.1
2005	225	0.21	0	0.8	0.8	2	0	−	0.8	2
2006	266	0.19	0	0.2	0.2	4	0	−	0.2	4
2007	204	0.16	0	0.3	0.3	3.9	0	−	0.3	3.9
2008	149	0.14	0	0.2	0.2	5.1	0	−	0.2	5.1
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0.2	0.2	2.3	0	−	0.2	2.3
2014	97	0.24	1	0.1	1.1	0.29	4.2	1	1.1	0.29
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	22	121	143	0.11	146.7	0.23	143	0.11
2001−2015	2738	0.19	1	3.8	4.8	0.77	5.3	1.01	4.8	0.77
2011−2015	514	0.24	1	0.5	1.5	0.56	4.2	1.01	1.5	0.56

Table 16. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for STRIPED DOLPHIN. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.1	0.1	12	0	−	0.1	12
1991	470	0.1	0	0.1	0.1	7.1	0	−	0.1	7.1
1992	596	0.14	0	1	1	2.3	0	−	1	2.3
1993	728	0.13	0	0.5	0.5	3.4	0	−	0.5	3.4
1994	759	0.18	1	3	4	0.87	5.6	1	4	0.87
1995	572	0.16	0	0	0	−	0	−	0	−
1996	421	0.12	0	0.3	0.3	4.7	0	−	0.3	4.7
1997	692	0.23	0	0.1	0.1	5.2	0	−	0.1	5.2
1998	587	0.18	0	0.2	0.2	5.1	0	−	0.2	5.1
1999	526	0.2	0	0	0	−	0	−	0	−
2000	444	0.23	0	0	0	−	0	−	0	−
2001	339	0.2	0	0	0	−	0	−	0	−
2002	360	0.22	0	0	0	−	0	−	0	−
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	1	6.1	7.1	0.81	6.7	1	7.1	0.81
2001−2015	2738	0.19	0	0.1	0.1	6	0	−	0.1	6
2011−2015	514	0.24	0	0.1	0.1	6.2	0	−	0.1	6.2

Table 17. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for BOTTLENOSE DOLPHIN. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.1	0.1	22	0	−	0.1	22
1991	470	0.1	0	0.3	0.3	7.7	0	−	0.3	7.7
1992	596	0.14	3	8	11	1	21.4	1	11	1
1993	728	0.13	0	3.8	3.8	2	0	−	3.8	2
1994	759	0.18	0	1	1	3.3	0	−	1	3.3
1995	572	0.16	0	0.5	0.5	4.8	0	−	0.5	4.8
1996	421	0.12	0	0.3	0.3	8	0	−	0.3	8
1997	692	0.23	0	0.6	0.6	3.3	0	−	0.6	3.3
1998	587	0.18	0	0.9	0.9	3.7	0	−	0.9	3.7
1999	526	0.2	0	0.8	0.8	3.1	0	−	0.8	3.1
2000	444	0.23	0	0.9	0.9	3.1	0	−	0.9	3.1
2001	339	0.2	0	0.2	0.2	4.1	0	−	0.2	4.1
2002	360	0.22	0	0.1	0.1	8	0	−	0.1	8
2003	298	0.2	0	0.1	0.1	11	0	−	0.1	11
2004	223	0.21	0	0.1	0.1	6.6	0	−	0.1	6.6
2005	225	0.21	0	0.2	0.2	5.2	0	−	0.2	5.2
2006	266	0.19	0	0.1	0.1	6.4	0	−	0.1	6.4
2007	204	0.16	0	0.2	0.2	8.6	0	−	0.2	8.6
2008	149	0.14	0	0.1	0.1	7.7	0	−	0.1	7.7
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	1	5.8	6.8	0.75	8.3	0.99	6.8	0.75
2011	85	0.2	0	0.1	0.1	7.6	0	−	0.1	7.6
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0.9	0.9	3.5	0	−	0.9	3.5
1990−2000	5973	0.15	3	18	21	0.76	20	0.98	21	0.76
2001−2015	2738	0.19	1	5.6	6.6	0.82	5.3	1	6.6	0.82
2011−2015	514	0.24	0	0.9	0.9	3	0	−	0.9	3

Table 18. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for PYGMY SPERM WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	8.6	8.6	1.2	0	−	8.6	1.2
1991	470	0.1	0	1.2	1.2	0.095	0	−	1.2	0.095
1992	596	0.14	1	1.3	2.3	0.059	7.1	1	2.3	0.059
1993	728	0.13	1	1.9	2.9	0.42	7.7	1	2.9	0.42
1994	759	0.18	0	1.9	1.9	0.97	0	−	1.9	0.97
1995	572	0.16	0	1.5	1.5	0.99	0	−	1.5	0.99
1996	421	0.12	0	0.6	0.6	0.2	0	−	0.6	0.2
1997	692	0.23	0	0.3	0.3	0.57	0	−	0.3	0.57
1998	587	0.18	0	0.4	0.4	3	0	−	0.4	3
1999	526	0.2	0	0	0	−	0	−	0	−
2000	444	0.23	0	0	0	−	0	−	0	−
2001	339	0.2	0	0	0	−	0	−	0	−
2002	360	0.22	0	0	0	−	0	−	0	−
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	2	11.6	13.6	0.33	13.3	0.7	13.6	0.33
2001−2015	2738	0.19	0	0	0	−	0	−	0	−
2011−2015	514	0.24	0	0	0	−	0	−	0	−

Table 19. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for BAIRD'S BEAKED WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.3	0.3	0.25	0	−	0.3	0.25
1991	470	0.1	0	0.4	0.4	0.16	0	−	0.4	0.16
1992	596	0.14	0	1.7	1.7	0.94	0	−	1.7	0.94
1993	728	0.13	0	2	2	0.98	0	−	2	0.98
1994	759	0.18	1	0.5	1.5	0.16	5.6	0.99	1.5	0.16
1995	572	0.16	0	1.3	1.3	1.3	0	−	1.3	1.3
1996	421	0.12	0	0.1	0.1	0.18	0	−	0.1	0.18
1997	692	0.23	0	0.1	0.1	0.19	0	−	0.1	0.19
1998	587	0.18	0	0	0	−	0	−	0	−
1999	526	0.2	0	0	0	−	0	−	0	−
2000	444	0.23	0	0.3	0.3	2.6	0	−	0.3	2.6
2001	339	0.2	0	0	0	−	0	−	0	−
2002	360	0.22	0	0	0	−	0	−	0	−
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	1	6.5	7.5	0.44	6.7	1	7.5	0.44
2001−2015	2738	0.19	0	0	0	−	0	−	0	−
2011−2015	514	0.24	0	0	0	−	0	−	0	−

Table 20. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for HUBB'S BEAKED WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	3.4	3.4	1.3	0	−	3.4	1.3
1991	470	0.1	0	4.4	4.4	0.72	0	−	4.4	0.72
1992	596	0.14	3	6	9	0.18	21.4	0.58	9	0.18
1993	728	0.13	0	6.4	6.4	0.39	0	−	6.4	0.39
1994	759	0.18	2	5.1	7.1	0.37	11.1	0.71	7.1	0.37
1995	572	0.16	0	1.8	1.8	0.25	0	−	1.8	0.25
1996	421	0.12	0	0.9	0.9	0.091	0	−	0.9	0.091
1997	692	0.23	0	0.7	0.7	0.35	0	−	0.7	0.35
1998	587	0.18	0	0.2	0.2	3.7	0	−	0.2	3.7
1999	526	0.2	0	0.2	0.2	3.8	0	−	0.2	3.8
2000	444	0.23	0	0.3	0.3	3.2	0	−	0.3	3.2
2001	339	0.2	0	0	0	−	0	−	0	−
2002	360	0.22	0	0.2	0.2	4	0	−	0.2	4
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0.3	0.3	2.3	0	−	0.3	2.3
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	5	26.5	31.5	0.17	33.3	0.44	31.5	0.17
2001−2015	2738	0.19	0	0.8	0.8	1.9	0	−	0.8	1.9
2011−2015	514	0.24	0	0.5	0.5	2.3	0	−	0.5	2.3

Table 21. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for STEJNEGER'S BEAKED WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.3	0.3	0.3	0	−	0.3	0.3
1991	470	0.1	0	3.8	3.8	1.2	0	−	3.8	1.2
1992	596	0.14	0	1.3	1.3	1	0	−	1.3	1
1993	728	0.13	0	1.2	1.2	1	0	−	1.2	1
1994	759	0.18	1	0.3	1.3	0.032	5.6	0.99	1.3	0.032
1995	572	0.16	0	0.2	0.2	0.15	0	−	0.2	0.15
1996	421	0.12	0	0.1	0.1	0.17	0	−	0.1	0.17
1997	692	0.23	0	0.1	0.1	0.21	0	−	0.1	0.21
1998	587	0.18	0	0	0	−	0	−	0	−
1999	526	0.2	0	0	0	−	0	−	0	−
2000	444	0.23	0	0	0	−	0	−	0	−
2001	339	0.2	0	0	0	−	0	−	0	−
2002	360	0.22	0	0	0	−	0	−	0	−
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	1	5.7	6.7	0.5	6.7	1	6.7	0.5
2001−2015	2738	0.19	0	0	0	−	0	−	0	−
2011−2015	514	0.24	0	0	0	−	0	−	0	−

Table 22. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for SPERM WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0.7 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	5	5	2.5	0	−	3.4	2.6
1991	470	0.1	0	1.9	1.9	2.4	0	−	1.3	2.4
1992	596	0.14	3	5.5	8.5	0.78	21.4	1	4.8	0.97
1993	728	0.13	3	8.4	11.4	0.77	23.1	0.74	7.7	0.83
1994	759	0.18	0	1.9	1.9	1.7	0	−	1.3	1.8
1995	572	0.16	0	4.1	4.1	1.5	0	−	2.9	1.6
1996	421	0.12	1	4	5	1.1	8.3	1	3.8	1.1
1997	692	0.23	0	3.9	3.9	0.99	0	−	2.8	1
1998	587	0.18	1	5.4	6.4	0.93	5.6	1	4.8	0.93
1999	526	0.2	0	1.3	1.3	1.8	0	−	0.9	1.9
2000	444	0.23	0	1	1	1.7	0	−	0.7	1.8
2001	339	0.2	0	0.3	0.3	3.3	0	−	0.2	3.3
2002	360	0.22	0	0.5	0.5	2.5	0	−	0.4	2.7
2003	298	0.2	0	0.3	0.3	4	0	−	0.2	4.6
2004	223	0.21	0	0.2	0.2	3	0	−	0.2	3.2
2005	225	0.21	0	0.2	0.2	3.4	0	−	0.2	3.2
2006	266	0.19	0	0.9	0.9	3.2	0	−	0.6	3.4
2007	204	0.16	0	1.2	1.2	2.3	0	−	0.9	2.4
2008	149	0.14	0	0.2	0.2	4	0	−	0.1	4.2
2009	101	0.13	0	0.1	0.1	3.4	0	−	0.1	3.6
2010	59	0.12	2	0	2	0	16.7	0.98	2	0
2011	85	0.2	0	0.6	0.6	3.3	0	−	0.4	3.7
2012	83	0.19	0	0.3	0.3	2.9	0	−	0.2	2.8
2013	175	0.37	0	0.3	0.3	2.4	0	−	0.2	2.3
2014	97	0.24	0	1.3	1.3	1.8	0	−	0.9	1.9
2015	74	0.2	0	0.1	0.1	6.3	0	−	0.1	6.8
1990−2000	5973	0.15	8	42.4	50.4	0.36	53.3	0.51	35	0.42
2001−2015	2738	0.19	2	7.2	9.2	0.66	10.5	1	7.1	0.64
2011−2015	514	0.24	0	2.6	2.6	1.2	0	−	1.8	1.3

Table 23. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for CUVIER'S BEAKED WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0.95 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	20.2	20.2	0.13	0	−	19.2	0.13
1991	470	0.1	0	19.9	19.9	0.14	0	−	18.9	0.15
1992	596	0.14	6	23.8	29.8	0.11	42.9	0.4	28.6	0.12
1993	728	0.13	3	27.7	30.7	0.14	23.1	0.58	29.3	0.15
1994	759	0.18	6	17.3	23.3	0.11	33.3	0.41	22.5	0.11
1995	572	0.16	6	16.2	22.2	0.13	37.5	0.4	20.5	0.15
1996	421	0.12	0	8.5	8.5	0.19	0	−	8.1	0.18
1997	692	0.23	0	5.1	5.1	0.27	0	−	4.9	0.27
1998	587	0.18	0	0.3	0.3	1.1	0	−	0.2	1.1
1999	526	0.2	0	0.3	0.3	3.6	0	−	0.3	3.6
2000	444	0.23	0	0.2	0.2	3.5	0	−	0.2	3.5
2001	339	0.2	0	0	0	−	0	−	0	−
2002	360	0.22	0	0.1	0.1	5.4	0	−	0.1	5.5
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0.2	0.2	3.3	0	−	0.2	3.3
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0.5	0.5	3.8	0	−	0.5	3.7
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	21	121.6	142.6	0.05	140	0.22	135.7	0.07
2001−2015	2738	0.19	0	0.6	0.6	2	0	−	0.6	2
2011−2015	514	0.24	0	0.1	0.1	2.8	0	−	0.1	2.8

Table 24. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for UNID. ZIPHIID. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	1.5	1.5	0.13	0	−	1.5	0.13
1991	470	0.1	0	4.3	4.3	0.98	0	−	4.3	0.98
1992	596	0.14	2	4.6	6.6	0.46	14.3	0.71	6.6	0.46
1993	728	0.13	0	3.7	3.7	0.45	0	−	3.7	0.45
1994	759	0.18	1	1.2	2.2	0.098	5.6	1	2.2	0.098
1995	572	0.16	0	1	1	0.064	0	−	1	0.064
1996	421	0.12	0	0.6	0.6	0.08	0	−	0.6	0.08
1997	692	0.23	0	0.3	0.3	0.09	0	−	0.3	0.09
1998	587	0.18	0	0	0	−	0	−	0	−
1999	526	0.2	0	0	0	−	0	−	0	−
2000	444	0.23	0	0	0	−	0	−	0	−
2001	339	0.2	0	0	0	−	0	−	0	−
2002	360	0.22	0	0	0	−	0	−	0	−
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	1.1	1.1	2.4	0	−	1.1	2.4
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	3	14.6	17.6	0.24	20	0.58	17.6	0.24
2001−2015	2738	0.19	0	0.7	0.7	2.3	0	−	0.7	2.3
2011−2015	514	0.24	0	0	0	−	0	−	0	−

Table 25. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for UNID. MESOPLODON. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	1	1.4	2.4	1.3	25	1	2.4	1.3
1991	470	0.1	0	0.9	0.9	0.077	0	−	0.9	0.077
1992	596	0.14	1	3.6	4.6	0.76	7.1	0.99	4.6	0.76
1993	728	0.13	0	3.4	3.4	0.73	0	−	3.4	0.73
1994	759	0.18	0	1.2	1.2	0.95	0	−	1.2	0.95
1995	572	0.16	0	0.7	0.7	0.07	0	−	0.7	0.07
1996	421	0.12	0	0.5	0.5	0.095	0	−	0.5	0.095
1997	692	0.23	0	0.3	0.3	0.95	0	−	0.3	0.95
1998	587	0.18	0	0.5	0.5	2.2	0	−	0.5	2.2
1999	526	0.2	0	0	0	−	0	−	0	−
2000	444	0.23	0	0.5	0.5	2.3	0	−	0.5	2.3
2001	339	0.2	0	0	0	−	0	−	0	−
2002	360	0.22	0	0	0	−	0	−	0	−
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	2	11.9	13.9	0.34	13.3	0.71	13.9	0.34
2001−2015	2738	0.19	0	0	0	−	0	−	0	−
2011−2015	514	0.24	0	0	0	−	0	−	0	−

Table 26. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for CA SEA LION. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0.98 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	2	39.9	41.9	0.29	50	0.99	41.2	0.29
1991	470	0.1	4	89.2	93.2	0.29	40	0.5	91.5	0.29
1992	596	0.14	9	55	64	0.21	64.3	0.33	63	0.21
1993	728	0.13	12	71.9	83.9	0.16	92.3	0.33	82.6	0.16
1994	759	0.18	5	81	86	0.19	27.8	0.44	83.5	0.2
1995	572	0.16	5	59.9	64.9	0.28	31.2	0.44	62.8	0.29
1996	421	0.12	4	54.9	58.9	0.19	33.3	0.49	57.8	0.19
1997	692	0.23	39	58.2	97.2	0.091	169.6	0.3	95.1	0.091
1998	587	0.18	23	62.2	85.2	0.11	127.8	0.24	84.1	0.11
1999	526	0.2	6	46	52	0.14	30	0.41	52.2	0.13
2000	444	0.23	13	38.8	51.8	0.13	56.5	0.33	50.1	0.13
2001	339	0.2	2	43.8	45.8	0.31	10	0.71	45	0.31
2002	360	0.22	18	32.4	50.4	0.2	81.8	0.24	49.9	0.19
2003	298	0.2	4	36.5	40.5	0.17	20	0.49	39.8	0.17
2004	223	0.21	7	29.6	36.6	0.2	33.3	0.37	35	0.21
2005	225	0.21	1	28.1	29.1	0.32	4.8	0.99	28.5	0.32
2006	266	0.19	12	47.9	59.9	0.13	63.2	0.37	59.1	0.13
2007	204	0.16	8	29.1	37.1	0.18	50	0.39	36.6	0.18
2008	149	0.14	7	45.6	52.6	0.24	50	0.42	51.7	0.24
2009	101	0.13	5	22.3	27.3	0.27	38.5	0.44	26.9	0.27
2010	59	0.12	0	11.2	11.2	0.38	0	−	11	0.38
2011	85	0.2	18	8.5	26.5	0.097	90	0.52	26.3	0.095
2012	83	0.19	6	14.9	20.9	0.3	31.6	0.39	20.6	0.3
2013	175	0.37	3	8.8	11.8	0.23	8.1	0.58	11.6	0.23
2014	97	0.24	3	7.6	10.6	0.19	12.5	1	10.5	0.19
2015	74	0.2	0	6.9	6.9	0.31	0	−	6.8	0.31
1990−2000	5973	0.15	122	709.5	831.5	0.05	813.3	0.12	815.9	0.06
2001−2015	2738	0.19	94	365.7	459.7	0.07	494.7	0.14	451.7	0.07
2011−2015	514	0.24	30	46.4	76.4	0.1	125	0.35	75.6	0.1

Table 27. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for STELLER'S SEA LION. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.9	0.9	4.6	0	−	0.9	4.6
1991	470	0.1	0	1.9	1.9	2	0	−	1.9	2
1992	596	0.14	1	3.2	4.2	0.95	7.1	0.98	4.2	0.95
1993	728	0.13	0	0.4	0.4	3.3	0	−	0.4	3.3
1994	759	0.18	1	1.5	2.5	1	5.6	0.99	2.5	1
1995	572	0.16	0	0.7	0.7	2.6	0	−	0.7	2.6
1996	421	0.12	0	0.6	0.6	3.2	0	−	0.6	3.2
1997	692	0.23	0	0.5	0.5	2.6	0	−	0.5	2.6
1998	587	0.18	0	0.1	0.1	5.7	0	−	0.1	5.7
1999	526	0.2	0	0.2	0.2	3.9	0	−	0.2	3.9
2000	444	0.23	0	0	0	−	0	−	0	−
2001	339	0.2	0	0.3	0.3	3.2	0	−	0.3	3.2
2002	360	0.22	0	1	1	1.7	0	−	1	1.7
2003	298	0.2	0	0.2	0.2	3.4	0	−	0.2	3.4
2004	223	0.21	0	0.1	0.1	6.4	0	−	0.1	6.4
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0.1	0.1	5.3	0	−	0.1	5.3
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	2	9.2	11.2	0.64	13.3	0.71	11.2	0.64
2001−2015	2738	0.19	0	2.1	2.1	1.3	0	−	2.1	1.3
2011−2015	514	0.24	0	0.1	0.1	4.5	0	−	0.1	4.5

Table 28. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for UNID. PINNIPED. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.1	0.1	0.65	0	−	0.1	0.65
1991	470	0.1	0	0.3	0.3	1.1	0	−	0.3	1.1
1992	596	0.14	0	0.2	0.2	3.5	0	−	0.2	3.5
1993	728	0.13	0	0.2	0.2	2.7	0	−	0.2	2.7
1994	759	0.18	0	0.6	0.6	1.8	0	−	0.6	1.8
1995	572	0.16	0	0.6	0.6	2	0	−	0.6	2
1996	421	0.12	0	0.9	0.9	2.3	0	−	0.9	2.3
1997	692	0.23	0	0.5	0.5	1.6	0	−	0.5	1.6
1998	587	0.18	2	3.2	5.2	0.53	11.1	0.7	5.2	0.53
1999	526	0.2	0	0.6	0.6	1.4	0	−	0.6	1.4
2000	444	0.23	0	1.2	1.2	1.3	0	−	1.2	1.3
2001	339	0.2	0	0.1	0.1	2.1	0	−	0.1	2.1
2002	360	0.22	0	0.4	0.4	2.2	0	−	0.4	2.2
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0.1	0.1	1.4	0	−	0.1	1.4
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0.5	0.5	2.1	0	−	0.5	2.1
2007	204	0.16	0	0.1	0.1	2.5	0	−	0.1	2.5
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	2	10.4	12.4	0.45	13.3	0.71	12.4	0.45
2001−2015	2738	0.19	0	1.3	1.3	1.2	0	−	1.3	1.2
2011−2015	514	0.24	0	0	0	−	0	−	0	−

Table 29. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for N ELEPHANT SEAL. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	5	110.8	115.8	0.082	125	0.44	115.8	0.082
1991	470	0.1	13	109.1	122.1	0.07	130	0.28	122.1	0.07
1992	596	0.14	15	100.6	115.6	0.043	107.1	0.26	115.6	0.043
1993	728	0.13	14	109.5	123.5	0.043	107.7	0.28	123.5	0.043
1994	759	0.18	22	79.8	101.8	0.045	122.2	0.24	101.8	0.045
1995	572	0.16	14	76.7	90.7	0.054	87.5	0.29	90.7	0.054
1996	421	0.12	5	49.1	54.1	0.1	41.7	0.45	54.1	0.1
1997	692	0.23	9	28.9	37.9	0.09	39.1	0.33	37.9	0.09
1998	587	0.18	4	15.2	19.2	0.32	22.2	0.49	19.2	0.32
1999	526	0.2	2	9.4	11.4	0.35	10	0.7	11.4	0.35
2000	444	0.23	6	7.5	13.5	0.27	26.1	0.4	13.5	0.27
2001	339	0.2	1	7.5	8.5	0.47	5	1	8.5	0.47
2002	360	0.22	1	4	5	0.48	4.5	1	5	0.48
2003	298	0.2	1	3.5	4.5	0.53	5	1	4.5	0.53
2004	223	0.21	0	2.5	2.5	0.82	0	−	2.5	0.82
2005	225	0.21	1	2.2	3.2	0.57	4.8	1	3.2	0.57
2006	266	0.19	0	2.5	2.5	0.87	0	−	2.5	0.87
2007	204	0.16	1	2	3	0.51	6.2	0.98	3	0.51
2008	149	0.14	0	5	5	0.76	0	−	5	0.76
2009	101	0.13	0	1.3	1.3	1.3	0	−	1.3	1.3
2010	59	0.12	0	2.9	2.9	0.98	0	−	2.9	0.98
2011	85	0.2	0	0.9	0.9	1.2	0	−	0.9	1.2
2012	83	0.19	0	0.3	0.3	0.82	0	−	0.3	0.82
2013	175	0.37	0	0.6	0.6	0.91	0	−	0.6	0.91
2014	97	0.24	1	1.9	2.9	0.47	4.2	1	2.9	0.47
2015	74	0.2	0	1.9	1.9	1.1	0	−	1.9	1.1
1990−2000	5973	0.15	109	612.3	721.3	0.03	726.7	0.1	721.3	0.03
2001−2015	2738	0.19	6	38.2	44.2	0.18	31.6	0.41	44.2	0.18
2011−2015	514	0.24	1	5.3	6.3	0.38	4.2	1	6.3	0.38

Table 30. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for LOGGERHEAD TURTLE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0.25 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	16.1	16.1	1.1	0	−	4	1.2
1991	470	0.1	0	10.8	10.8	0.79	0	−	2.7	0.98
1992	596	0.14	2	5.1	7.1	0.71	14.3	0.71	2.3	0.64
1993	728	0.13	5	13	18	0.4	38.5	0.45	3.2	0.69
1994	759	0.18	0	4.7	4.7	0.88	0	−	1.1	1.1
1995	572	0.16	0	2.7	2.7	1.2	0	−	0.7	1.4
1996	421	0.12	0	3.2	3.2	1.2	0	−	0.8	1.4
1997	692	0.23	3	5.4	8.4	0.62	13	0.58	2.2	0.65
1998	587	0.18	4	2.3	6.3	0.46	22.2	0.78	2.6	0.32
1999	526	0.2	0	3.8	3.8	1	0	−	0.9	1.2
2000	444	0.23	0	4	4	0.98	0	−	1	1.1
2001	339	0.2	1	2.6	3.6	0.89	5	1	0.7	1.5
2002	360	0.22	0	2.2	2.2	0.99	0	−	0.6	1.2
2003	298	0.2	0	2.2	2.2	1.4	0	−	0.6	1.6
2004	223	0.21	0	1.3	1.3	1.4	0	−	0.3	1.7
2005	225	0.21	0	0.6	0.6	2.3	0	−	0.1	2.2
2006	266	0.19	1	2.5	3.5	0.85	5.3	1	0.6	1.2
2007	204	0.16	0	3.9	3.9	1.4	0	−	1	1.5
2008	149	0.14	0	0.3	0.3	3.5	0	−	0.1	4.6
2009	101	0.13	0	0.8	0.8	2.9	0	−	0.2	3.1
2010	59	0.12	0	0.5	0.5	3.2	0	−	0.1	3.4
2011	85	0.2	0	0.1	0.1	5.4	0	−	0	5.6
2012	83	0.19	0	0.1	0.1	5.1	0	−	0	5.3
2013	175	0.37	0	0.2	0.2	2.9	0	−	0	2.8
2014	97	0.24	0	0.5	0.5	2.6	0	−	0.1	3
2015	74	0.2	0	0.6	0.6	3.5	0	−	0.2	3.5
1990−2000	5973	0.15	14	64	78	0.24	93.3	0.32	19.2	0.43
2001−2015	2738	0.19	2	18.3	20.3	0.42	10.5	0.71	4.4	0.65
2011−2015	514	0.24	0	1.5	1.5	1.7	0	−	0.3	1.9

Table 31. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for GREEN TURTLE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.2	0.2	10	0	−	0.2	10
1991	470	0.1	0	0	0	−	0	−	0	−
1992	596	0.14	0	0	0	−	0	−	0	−
1993	728	0.13	0	0.1	0.1	10	0	−	0.1	10
1994	759	0.18	0	0	0	−	0	−	0	−
1995	572	0.16	0	0.1	0.1	7.5	0	−	0.1	7.5
1996	421	0.12	0	0.2	0.2	5.5	0	−	0.2	5.5
1997	692	0.23	0	0.1	0.1	5.3	0	−	0.1	5.3
1998	587	0.18	0	0	0	−	0	−	0	−
1999	526	0.2	1	2.6	3.6	0.77	5	1	3.6	0.77
2000	444	0.23	0	0.1	0.1	4.5	0	−	0.1	4.5
2001	339	0.2	0	0.1	0.1	6.8	0	−	0.1	6.8
2002	360	0.22	0	0	0	−	0	−	0	−
2003	298	0.2	0	0.1	0.1	5.7	0	−	0.1	5.7
2004	223	0.21	0	0.1	0.1	8	0	−	0.1	8
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0.1	0.1	7.2	0	−	0.1	7.2
2007	204	0.16	0	0.1	0.1	7.8	0	−	0.1	7.8
2008	149	0.14	0	0.1	0.1	8.3	0	−	0.1	8.3
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0.3	0.3	4.2	0	−	0.3	4.2
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	1	4.6	5.6	0.81	6.7	1.01	5.6	0.81
2001−2015	2738	0.19	0	0.7	0.7	2.2	0	−	0.7	2.2
2011−2015	514	0.24	0	0	0	−	0	−	0	−

Table 32. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for LEATHERBACK TURTLE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0.56 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	1	19.9	20.9	0.9	25	1	12.2	0.87
1991	470	0.1	1	15.4	16.4	0.62	10	1	8.7	0.71
1992	596	0.14	4	16.3	20.3	0.43	28.6	0.5	11.2	0.45
1993	728	0.13	3	24.6	27.6	0.38	23.1	0.57	16.7	0.39
1994	759	0.18	1	8.9	9.9	0.55	5.6	1	5.1	0.64
1995	572	0.16	5	9.4	14.4	0.44	31.2	0.45	9.2	0.41
1996	421	0.12	2	23.5	25.5	0.41	16.7	0.71	15.1	0.44
1997	692	0.23	4	13.1	17.1	0.32	17.4	0.49	9.5	0.37
1998	587	0.18	0	6.1	6.1	0.77	0	−	3.4	0.8
1999	526	0.2	2	4.9	6.9	0.55	10	0.71	2.8	0.81
2000	444	0.23	0	2.2	2.2	1.1	0	−	1.2	1.1
2001	339	0.2	0	1.2	1.2	1.6	0	−	0.7	1.6
2002	360	0.22	0	0.4	0.4	2.2	0	−	0.2	2.2
2003	298	0.2	0	0.3	0.3	3.4	0	−	0.2	3.6
2004	223	0.21	0	0.1	0.1	4.3	0	−	0.1	4.3
2005	225	0.21	0	1.1	1.1	1.6	0	−	0.6	1.7
2006	266	0.19	0	1.8	1.8	1.4	0	−	1	1.5
2007	204	0.16	0	0.1	0.1	8.3	0	−	0	8.4
2008	149	0.14	0	1.1	1.1	2	0	−	0.6	2.1
2009	101	0.13	1	2	3	0.98	7.7	1	1.1	1.5
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	1	0.5	1.5	0.78	5.3	0.99	0.3	2.4
2013	175	0.37	0	1	1	1.1	0	−	0.6	1.2
2014	97	0.24	0	0.3	0.3	3.2	0	−	0.1	3.3
2015	74	0.2	0	0.2	0.2	3.5	0	−	0.1	3.3
1990−2000	5973	0.15	23	134.8	157.8	0.14	153.3	0.21	90.2	0.21
2001−2015	2738	0.19	2	10.7	12.7	0.45	10.5	0.71	6	0.58
2011−2015	514	0.24	1	2.7	3.7	0.67	4.2	1	1.5	0.94

Table 33. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for OLIVE RIDLEY TURTLE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.5	0.5	6.2	0	−	0	0
1991	470	0.1	0	0.1	0.1	7.2	0	−	0	0
1992	596	0.14	0	0	0	−	0	−	0	−
1993	728	0.13	0	0	0	−	0	−	0	−
1994	759	0.18	0	0.2	0.2	4.8	0	−	0	0
1995	572	0.16	0	0	0	−	0	−	0	−
1996	421	0.12	0	0.2	0.2	6.1	0	−	0	0
1997	692	0.23	0	0.2	0.2	3.8	0	−	0	0
1998	587	0.18	0	0.1	0.1	5.8	0	−	0	0
1999	526	0.2	1	3.1	4.1	0.76	5	0.99	0	0
2000	444	0.23	0	0.3	0.3	3.2	0	−	0	0
2001	339	0.2	0	0	0	−	0	−	0	−
2002	360	0.22	0	0.1	0.1	5.7	0	−	0	0
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0.1	0.1	10	0	−	0	0
2009	101	0.13	0	0.1	0.1	6.5	0	−	0	0
2010	59	0.12	0	0.2	0.2	4.8	0	−	0	0
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	1	6.1	7.1	0.74	6.7	1	0	−
2001−2015	2738	0.19	0	0.5	0.5	2.4	0	−	0	−
2011−2015	514	0.24	0	0	0	−	0	−	0	−

Table 34. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for UNID. TURTLE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0.33 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	1.1	1.1	4.1	0	−	0.4	4.3
1991	470	0.1	0	7.1	7.1	0.98	0	−	2.5	1.3
1992	596	0.14	0	1.7	1.7	1.8	0	−	0.6	2.1
1993	728	0.13	3	9.2	12.2	0.49	23.1	0.58	3.9	0.84
1994	759	0.18	0	1.1	1.1	1.8	0	−	0.3	2.9
1995	572	0.16	0	0.9	0.9	2.3	0	−	0.2	3.6
1996	421	0.12	0	0.3	0.3	4.1	0	−	0.1	5.2
1997	692	0.23	0	0.4	0.4	2.6	0	−	0.1	3.5
1998	587	0.18	0	0.8	0.8	2.3	0	−	0.3	2.9
1999	526	0.2	0	0.1	0.1	4.6	0	−	0	7.8
2000	444	0.23	0	0.2	0.2	3.8	0	−	0.1	6
2001	339	0.2	0	0.1	0.1	7.2	0	−	0	10
2002	360	0.22	0	0.1	0.1	6.4	0	−	0	6.8
2003	298	0.2	0	0.1	0.1	6.2	0	−	0	12
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0.1	0.1	9.7	0	−	0	8.7
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	3	19.5	22.5	0.41	20	0.57	7.2	0.91
2001−2015	2738	0.19	0	0.5	0.5	2.8	0	−	0.1	3.8
2011−2015	514	0.24	0	0.1	0.1	5.3	0	−	0	7

Table 35. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for UNID. BIRD. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	1	8.1	9.1	1.3	25	1	9.1	1.3
1991	470	0.1	0	3.2	3.2	1.5	0	−	3.2	1.5
1992	596	0.14	1	4.7	5.7	0.86	7.1	1	5.7	0.86
1993	728	0.13	0	2.5	2.5	1.4	0	−	2.5	1.4
1994	759	0.18	1	2.7	3.7	0.87	5.6	0.99	3.7	0.87
1995	572	0.16	0	1.1	1.1	1.9	0	−	1.1	1.9
1996	421	0.12	0	1.7	1.7	1.8	0	−	1.7	1.8
1997	692	0.23	1	3.5	4.5	0.62	4.3	0.99	4.5	0.62
1998	587	0.18	0	0.5	0.5	2.9	0	−	0.5	2.9
1999	526	0.2	0	1.1	1.1	1.7	0	−	1.1	1.7
2000	444	0.23	0	0.3	0.3	3.1	0	−	0.3	3.1
2001	339	0.2	0	0.2	0.2	4.3	0	−	0.2	4.3
2002	360	0.22	1	1.7	2.7	0.69	4.5	1	2.7	0.69
2003	298	0.2	0	0.4	0.4	2.9	0	−	0.4	2.9
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0.1	0.1	6.3	0	−	0.1	6.3
2006	266	0.19	0	0.1	0.1	5.5	0	−	0.1	5.5
2007	204	0.16	0	0.1	0.1	6.3	0	−	0.1	6.3
2008	149	0.14	0	0.1	0.1	6.2	0	−	0.1	6.2
2009	101	0.13	0	0.1	0.1	6.7	0	−	0.1	6.7
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0.2	0.2	3.7	0	−	0.2	3.7
1990−2000	5973	0.15	4	25.7	29.7	0.37	26.7	0.49	29.7	0.37
2001−2015	2738	0.19	1	3.3	4.3	0.69	5.3	0.98	4.3	0.69
2011−2015	514	0.24	0	0.3	0.3	2.8	0	−	0.3	2.8

Table 36. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for UNID. CORMORANT. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.1	0.1	12	0	–	0.1	12
1991	470	0.1	0	0.1	0.1	9.5	0	–	0.1	9.5
1992	596	0.14	0	0	0	–	0	–	0	–
1993	728	0.13	0	0	0	–	0	–	0	–
1994	759	0.18	0	0.1	0.1	6.2	0	–	0.1	6.2
1995	572	0.16	0	0.1	0.1	5.9	0	–	0.1	5.9
1996	421	0.12	0	0.8	0.8	2.7	0	–	0.8	2.7
1997	692	0.23	0	0.1	0.1	6.8	0	–	0.1	6.8
1998	587	0.18	0	0.3	0.3	3.3	0	–	0.3	3.3
1999	526	0.2	0	0.1	0.1	4.9	0	–	0.1	4.9
2000	444	0.23	0	0.4	0.4	2.4	0	–	0.4	2.4
2001	339	0.2	0	0	0	–	0	–	0	–
2002	360	0.22	0	0.6	0.6	2	0	–	0.6	2
2003	298	0.2	1	0.4	1.4	0.8	5	1	1.4	0.8
2004	223	0.21	0	0.4	0.4	2.9	0	–	0.4	2.9
2005	225	0.21	0	0.2	0.2	3.8	0	–	0.2	3.8
2006	266	0.19	0	0	0	–	0	–	0	–
2007	204	0.16	0	0.1	0.1	6.2	0	–	0.1	6.2
2008	149	0.14	0	0	0	–	0	–	0	–
2009	101	0.13	0	0	0	–	0	–	0	–
2010	59	0.12	0	0	0	–	0	–	0	–
2011	85	0.2	0	0.1	0.1	5.8	0	–	0.1	5.8
2012	83	0.19	0	0	0	–	0	–	0	–
2013	175	0.37	0	0	0	–	0	–	0	–
2014	97	0.24	0	0	0	–	0	–	0	–
2015	74	0.2	0	0	0	–	0	–	0	–
1990–2000	5973	0.15	0	2.4	2.4	1.4	0	–	2.4	1.4
2001–2015	2738	0.19	1	2.2	3.2	0.81	5.3	1	3.2	0.81
2011–2015	514	0.24	0	0.1	0.1	4.5	0	–	0.1	4.5

Table 37. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for NORTHERN FULMAR. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0.14 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	1.3	1.3	4.1	0	−	0.2	4.4
1991	470	0.1	0	0.3	0.3	1.9	0	−	0	2.3
1992	596	0.14	0	0.2	0.2	1.7	0	−	0	1.7
1993	728	0.13	0	0.2	0.2	1.8	0	−	0	1.9
1994	759	0.18	0	0.1	0.1	1.7	0	−	0	1.9
1995	572	0.16	0	0.3	0.3	2.3	0	−	0	3.1
1996	421	0.12	0	2.8	2.8	0.87	0	−	0.4	0.97
1997	692	0.23	0	2.2	2.2	0.8	0	−	0.3	0.96
1998	587	0.18	0	4.7	4.7	0.7	0	−	0.7	0.91
1999	526	0.2	0	8.3	8.3	0.55	0	−	1.1	0.73
2000	444	0.23	16	38.3	54.3	0.17	69.6	0.36	8.3	0.31
2001	339	0.2	0	3.1	3.1	0.75	0	−	0.4	0.89
2002	360	0.22	1	3.9	4.9	0.54	4.5	0.99	0.6	0.83
2003	298	0.2	14	41.3	55.3	0.2	70	0.41	7.7	0.37
2004	223	0.21	0	2	2	1.4	0	−	0.3	1.5
2005	225	0.21	5	13	18	0.39	23.8	0.82	1.7	0.73
2006	266	0.19	0	1.7	1.7	1.2	0	−	0.2	1.5
2007	204	0.16	0	3.2	3.2	1.2	0	−	0.5	1.3
2008	149	0.14	0	2.5	2.5	1	0	−	0.3	1.2
2009	101	0.13	0	1.4	1.4	1.8	0	−	0.2	1.8
2010	59	0.12	0	0.9	0.9	1.8	0	−	0.1	2
2011	85	0.2	0	0.7	0.7	2.2	0	−	0.1	2.3
2012	83	0.19	0	3.7	3.7	1.4	0	−	0.5	1.4
2013	175	0.37	0	0.8	0.8	0.99	0	−	0.1	1.1
2014	97	0.24	0	1.7	1.7	1.4	0	−	0.2	1.8
2015	74	0.2	0	0.6	0.6	2.3	0	−	0.1	3
1990−2000	5973	0.15	16	92.4	108.4	0.17	106.7	0.36	16.1	0.4
2001−2015	2738	0.19	20	84.2	104.2	0.16	105.3	0.36	13.4	0.42
2011−2015	514	0.24	0	6.9	6.9	0.69	0	−	1	0.9

Table 38. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for UNID. WHALE. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0.5 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.1	0.1	3.6	0	−	0	4.4
1991	470	0.1	0	0.1	0.1	8	0	−	0.1	6.7
1992	596	0.14	0	0.6	0.6	3.1	0	−	0.3	4.2
1993	728	0.13	1	3.6	4.6	0.85	7.7	0.98	2.8	0.96
1994	759	0.18	0	0.1	0.1	4.4	0	−	0.1	3.4
1995	572	0.16	0	0.4	0.4	3.4	0	−	0.2	2.8
1996	421	0.12	0	0.3	0.3	2.4	0	−	0.1	2.6
1997	692	0.23	0	0.7	0.7	1.9	0	−	0.4	1.9
1998	587	0.18	0	1.2	1.2	1.7	0	−	0.7	2
1999	526	0.2	0	0.9	0.9	1.6	0	−	0.5	2
2000	444	0.23	0	0.2	0.2	3.3	0	−	0.1	3.3
2001	339	0.2	0	0.1	0.1	6.1	0	−	0	8.5
2002	360	0.22	0	0	0	−	0	−	0	−
2003	298	0.2	1	0	1	0	5	1	0	0
2004	223	0.21	0	0.2	0.2	3	0	−	0.1	3.3
2005	225	0.21	0	0.4	0.4	2.5	0	−	0.2	3.3
2006	266	0.19	0	0.5	0.5	2.4	0	−	0.3	2.5
2007	204	0.16	0	0.1	0.1	4.5	0	−	0	4.6
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0	0	−	0	−	0	−
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	1	9	10	0.58	6.7	1.02	5.4	0.85
2001−2015	2738	0.19	1	1.4	2.4	0.75	5.3	1.01	0.7	1.6
2011−2015	514	0.24	0	0	0	−	0	−	0	−

Table 39. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for UNID. CETACEAN. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 1 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	0	0.1	0.1	8.7	0	−	0.1	8.7
1991	470	0.1	1	4	5	1	10	0.99	5	1
1992	596	0.14	1	1.7	2.7	1	7.1	1	2.7	1
1993	728	0.13	0	0.9	0.9	2.4	0	−	0.9	2.4
1994	759	0.18	0	2.3	2.3	1.1	0	−	2.3	1.1
1995	572	0.16	0	0.7	0.7	2.6	0	−	0.7	2.6
1996	421	0.12	0	1.4	1.4	1.8	0	−	1.4	1.8
1997	692	0.23	0	0.2	0.2	3.5	0	−	0.2	3.5
1998	587	0.18	0	0.1	0.1	7	0	−	0.1	7
1999	526	0.2	0	0	0	−	0	−	0	−
2000	444	0.23	0	0.1	0.1	4.3	0	−	0.1	4.3
2001	339	0.2	0	0	0	−	0	−	0	−
2002	360	0.22	0	0	0	−	0	−	0	−
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0	0	−	0	−	0	−
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0	0	−	0	−	0	−
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0.1	0.1	4.7	0	−	0.1	4.7
2014	97	0.24	0	0	0	−	0	−	0	−
2015	74	0.2	0	0.5	0.5	2.2	0	−	0.5	2.2
1990−2000	5973	0.15	2	10.6	12.6	0.51	13.3	0.71	12.6	0.51
2001−2015	2738	0.19	0	0.9	0.9	1.8	0	−	0.9	1.8
2011−2015	514	0.24	0	0.6	0.6	2	0	−	0.6	2

Table 40. Observed sets (Obs.Sets), observer coverage (Obs.Cov), and observed bycatch (Obs.Bycatch) for ALL BEAKED WHALES. Unobserved bycatch estimated from regression trees (Tree.Est) and total bycatch (Bycatch.Tot) are shown with corresponding ratio estimates (Ratio.Est). Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations resulting in death or serious injury. The probability that a bycatch event resulted in mortality or serious injury was 0.97 for this species. Precision for all estimates are given as CVs.

Year	Obs.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	0.04	1	30.4	31.4	0.12	25	1	30.5	0.13
1991	470	0.1	0	32.4	32.4	0.14	0	−	31.5	0.14
1992	596	0.14	12	41.6	53.6	0.071	85.7	0.28	52.4	0.074
1993	728	0.13	3	44.3	47.3	0.094	23.1	0.58	46	0.098
1994	759	0.18	11	27.3	38.3	0.082	61.1	0.3	37.5	0.084
1995	572	0.16	6	23.2	29.2	0.11	37.5	0.41	27.5	0.11
1996	421	0.12	0	12.4	12.4	0.13	0	−	12	0.13
1997	692	0.23	0	7.2	7.2	0.17	0	−	7	0.18
1998	587	0.18	0	0.5	0.5	1.5	0	−	0.5	1.5
1999	526	0.2	0	0.3	0.3	3.2	0	−	0.3	3.2
2000	444	0.23	0	0.1	0.1	4.2	0	−	0.1	4.2
2001	339	0.2	0	0	0	−	0	−	0	−
2002	360	0.22	0	0.1	0.1	5	0	−	0.1	4.9
2003	298	0.2	0	0	0	−	0	−	0	−
2004	223	0.21	0	0	0	−	0	−	0	−
2005	225	0.21	0	0	0	−	0	−	0	−
2006	266	0.19	0	0	0	−	0	−	0	−
2007	204	0.16	0	0.2	0.2	3.2	0	−	0.2	3.2
2008	149	0.14	0	0	0	−	0	−	0	−
2009	101	0.13	0	0	0	−	0	−	0	−
2010	59	0.12	0	0.7	0.7	3.2	0	−	0.6	3.2
2011	85	0.2	0	0	0	−	0	−	0	−
2012	83	0.19	0	0	0	−	0	−	0	−
2013	175	0.37	0	0.1	0.1	3.1	0	−	0.1	3.1
2014	97	0.24	0	0.1	0.1	2.6	0	−	0.1	2.6
2015	74	0.2	0	0	0	−	0	−	0	−
1990−2000	5973	0.15	33	191.1	224.1	0.04	220	0.17	217.3	0.05
2001−2015	2738	0.19	0	1.1	1.1	1.6	0	−	1.1	1.6
2011−2015	514	0.24	0	0.3	0.3	2.5	0	−	0.3	2.5