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ESTIMATES OF MARINE MAMMAL, SEA TURTLE, AND SEABIRD BYCATCH IN THE CALIFORNIA LARGE-MESH DRIFT GILLNET FISHERY: 1990-2019

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Abstract

Bycatch of marine mammals, sea turtles, and seabirds in the California thresher shark / swordfish drift gillnet fishery from 1990 to 2019 is estimated using random forest classification and regression trees. Estimates from trees are compared with annual ratio estimates generated from the same observer data. Biases associated with ratio estimators (systematic under- and overestimation of bycatch) are notable when observed bycatch is rare, bycatch rates are inferred from within-year data, and observer coverage is low. Estimates from regression trees result in more stable annual bycatch estimates with better precision, because estimates are informed by all available data. Even in years without observed bycatch, expected values from regression trees may be positive and include estimates of error, whereas corresponding ratio estimates are zero and lack error estimates. Regression tree bycatch models include oceanographic, location, and gear variables used as predictors to estimate bycatch at the fishing-set level. Model variables were identified using 'balanced random forest' classification trees that deliberately oversample sets with observed bycatch to overcome zero-inflated data signal-to-noise challenges. This method was previously validated with a simulated rare bycatch dataset where significant predictor variables were correctly identified in most cases, even when simulated bycatch events represented <1% of all data (Carretta et al. 2017).

Introduction

The California thresher shark and swordfish drift gillnet fishery ('the fishery') began in the 1970s as an experimental fishery targeting pelagic sharks. By the mid-1980s, the fishery included 200 vessels and annual effort was ~10,000 fishing sets (Hanan et al. 1993, Holts et al. 1998). Fishing effort has declined since, with recent annual effort of ~350-600 sets (Carretta 2020). From 1990-2019, trained fishery observers aboard vessels observed 9,158 sets from an estimated 57,194 sets fished, or 16% observer coverage (Figures 1-2). Prior 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 in a comparison of ratio and regression tree estimates from 1990-2018 (Carretta 2020). Here, we present updated estimates of bycatch using both methods, using one additional year of observer data from 2019. For commonly-entangled species with large sample sizes (e.g., short-beaked common dolphin, *Delphinus delphis* and California sea lion, *Zalophus californianus*), ratio estimates of bycatch are generally unbiased. However, there are many species that are rarely-entangled, including sperm whales (*Physeter microcephalus)* and short-finned pilot whales (*Globicephala macrorhynchus*) that are subject to a mandatory drift gillnet Take Reduction Plan (Federal Register 1997) and for which ratio estimates are subject to low-observer coverage biases (Carretta and Moore 2014).

Amandè et al. (2012) and Carretta and Moore (2014) showed via simulations that annual bycatch estimates derived from ratio estimates are biased, volatile, and imprecise, when events are rare and observer coverage is low. Strategies to provide mean annual estimates of bycatch in U.S. marine mammal stock assessments by pooling 5 years of estimates is insufficient to overcome such biases when estimates are based on annual data (Carretta and Moore 2014). McCracken (2004) noted challenges in identifying predictor variables in the context of rare event bycatch, while Curtis and Carretta (2020) developed a tool for use in assessing observer coverage levels necessary to detect rare events and estimate bycatch with varying precision goals. Estimation problems associated with low observer coverage and rare events in the drift gillnet fishery were highlighted by Martin *et al*. (2015), who presented a Bayesian model-based alternative to annual ratio estimates, resulting in more stable interannual estimates with better precision for two test cases; humpback whales (*Megaptera novaeangliae*) and leatherback sea turtles.

We applied the machine-learning approach of random forest trees (Breiman *et al*. 1984, 2001a, 2001b) to estimate bycatch for all species observed entangled in this fishery, with a secondary emphasis on comparing annual ratio estimates and random forest tree-based estimates.

Methods

Modeling approach

Bycatch models were constructed using a two-step process, first, using random forest *classification trees* for variable selection (see *Variable Selection*). Second, variables selected for inclusion were used in a *regression tree* random forest to estimate bycatch in unobserved fishing sets (see *Bycatch Estimation*).

1) <u>Variable selection (classification trees)</u>

The first step in developing bycatch models was variable selection with random forest classification trees in the R-package *randomForest* (Breiman *et al*. 1984, Breiman 2001a, 2001b, Liaw and Wiener 2002). Classification trees are recursive partitioning algorithms. Subsets of variables (default = $\sqrt{n}$ where n equals the number of variables) are randomly-selected at each tree node and the variable which results in the greatest variance reduction of the response variable is used to split the data into successive daughter nodes. Variable splits continue until all observations in terminal nodes contain the same response variable or the terminal nodes contain a single observation. Each classification tree is constructed from a bootstrap sample of data. Those data omitted from tree construction are referred to as 'out-of-bag' (OOB) data. The OOB data are introduced to constructed RF trees and classifications are made for all OOB data, based on variable characteristics of the OOB data, which determine the terminal node that the OOB data are assigned to. In addition, each tree provides a unique expected value of the response variable in the OOB data, providing a direct measure of model uncertainty. The diversity of tree structures in random forests prevents overfitting of data that can occur with single trees and yields robust generalized predictive models where variables are informative (Breiman 2001a, 2001b).

The random forest (RF) variable selection model consists of classification trees, where the response to be classified is bycatch presence or absence for an observed fishing set. Evaluation of the RF model is based on cross-validated classification accuracy: how often are OOB data correctly classified over all RF trees? The number of RF trees (n = 5000 in this study) is based on the approximate number of RF trees required to return an asymptotic OOB error rate. Cross-validated bycatch presence - absence classifications for OOB data are summarized as a confusion matrix that includes the number of correctly and incorrectly classified bycatch presence - absence cases. All RF analyses in this analysis were created and implemented in the programming language R, version 4.1 (R Core Team 2021).

Observed bycatch in the fishery is considered a rare event. The most commonly-entangled species (short-beaked common dolphin, *Delphinus delphis*) is observed in approximately 4% of all observed fishing sets, while rarely-entangled species such as sperm whales are observed in <0.1% of all observed sets. 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 RF trees are reliable predictors of bycatch.

Our variable selection strategy for zero-inflated data was to boost the signal-to-noise ratio by oversampling fishing sets with bycatch. This is analogous to approaches that purposefully alter data class distributions to maximize the predictive accuracy of the minority data class of interest (Xie *et al*. 2009, Lin and Chen 2013). In our case, the minority class are fishing sets with observed bycatch. Random forest models included 5000 individual classification trees that were each constructed from equal numbers of cases (n=1/2 of smaller class size) of sets with and without bycatch. Fishing sets used in construction of each classification tree were sampled without replacement. Each variable selection RF included randomly selected variables for tree construction, ranging from a minimum of three and potentially including all 12 variables in Table 1. A total of 5000 RFs (of 5000 trees each) were generated, each with a unique variable set. The individual RF that minimized the OOB error rate for bycatch presence was used to identify which variables would be used to estimate total bycatch (see 'Regression Trees'). In the case of ties in classification rate errors between different RF models, the model that included the fewest variables was selected. Other approaches for variable selection include identifying 'significant' predictors, an approach used in prior bycatch reports (Carretta et al. 2017). This variable selection approach was updated to reflect minimization of out-of-bag error rates, because variable significance is assessed at the level of individual variables, which ignores interactions with other variables. In complex systems where a suite of 'weak predictors' (non-significant in the traditional alpha-level < 0.05 sense) may yield superior predictive accuracy, reliance on 'variable significance' may limit model accuracy and identification of important predictors.

A confusion matrix of correct and incorrect classification rates is generated for each RF and suite of variables. Confusion matrices represent the prediction accuracy of 5000 RF trees on cross-validated data omitted during tree construction, or OOB data (Breiman 2001). In a bycatch presence / absence context, a RF model's ability to correctly predict presence is known as 'sensitivity' and the ability to correctly predict absence is ‘specificity’ (Allouche *et al*. 2006). The overall accuracy of a RF model can be expressed as a metric called the ‘true skill statistic’ (TSS, Allouche *et al*. 2006). The TSS is calculated as follows, given the following confusion matrix:

	Cross-Validated OOB Data	
RF Model	Presence	Absence
Presence	*a*	*b*
Absence	*c*	*d*

where

(1) Overall Accuracy = $\frac{a+d}{a+b+c+d}$;

(2) Sensitivity = $\frac{a}{a+c}$;

(3) Specificity = $\frac{d}{b+d}$;

and

(4) TSS = Sensitivity + Specificity – 1

The TSS ranges from +1 (perfect prediction) to -1 (always inaccurate), with scores less than zero indicating prediction accuracy no better than random chance (Allouche *et al.* 2006). We focus on 'sensitivity' as the variable selection metric, because we are interested in correctly predicting bycatch occurrence. For all species, the expected value for sensitivity if all variables lack predictive power = 0.50 because classification trees are built using equal numbers of sets with and without bycatch events. Use of the TSS metric is consistent with quantitative approaches used to estimate the strength of presence / absence models (Allouche et al. 2006). Variables evaluated for bycatch models included a suite of fishing gear, oceanographic, and location variables described in Table 1.

2) Bycatch Estimation (regression trees)

Variables for each species / taxon bycatch model were identified using the balanced random forest classification tree procedure described above and 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). For regression trees, sample splits occur along lines of 'least variance', where the variable that minimizes the sample variance in daughter nodes of the tree is chosen for a given split. Splits continue until the sample variance is minimized or all observations have the same value. The mean of the observations in each terminal node of a regression tree represents the fitted value (estimate) for each observation in that node. Variables used for splitting data in species regression tree models were obtained using the balanced classification tree approach described in the previous section. For all species where the number of observed bycatch events <=5, we used a default set of variables (*lat* + *lon* + *days*) in regression tree models, in recognition that most species in the California Current show seasonal / spatial movements within the region (Forney and Barlow 1998, Becker *et al*. 2014). An exception was made for beaked whales (*Berardius, Mesoplodon, Ziphius*) and other deep-divers (*Kogia*), where variables were selected based on a pooled multispecies category called '*all beaked whales*', since these species are known to be sensitive to anthropogenic sounds and whose bycatch has apparently been eliminated in this fishery due to the use of acoustic pingers (Carretta et al. 2008, Carretta and Barlow 2011). Variables used in regression tree models for species with observed sample sizes ≥6 are shown in Table 2.

Random forest regression trees (n=1000) were fully-grown for all species models, where the number of tree nodes is generally greater for species with larger sample sizes. Predicted bycatch per set is obtained by building random forests with all data, except one fishing trip is omitted for cross-validation. Individual vessel trips averaged 5.8 sets fished (range = 1 – 19). The resulting random forest of 1000 trees was used to predict bycatch for each fishing set in the omitted fishing trip. Each tree provides a unique estimate of bycatch for omitted fishing sets, which yields a distribution of 1000 summed bycatch predictions for all 9,158 observed sets.

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 in year *y*, where random forest trees are constructed using all 30 years of data. Mean annual estimates of bycatch from regression trees ($\bar{T}_{s,y}$), 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*:

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

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:

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

where $var\left(\bar{b}_{s,y} * u_{s,y} * d\right)$ is the variance of 1000 predicted bycatch sums across observed sets in year *y* and (*d*) is the dispersion index of observed bycatch per fishing trip, calculated as the variance to mean ratio of the number of observed bycatch events. The dispersion index is required to reflect uncertainty in the bycatch process (Curtis and Carretta 2020), because $var\ \left(\bar{b}_{s,y}\right)$ on its own reflects only uncertainty in estimating mean bycatch rates. The variance also includes a finite population correction (*fpc*) (Snedecor and Cochran 1967) to account for incomplete observer coverage, where

$$(3) \quad fpc = \sqrt{\frac{total\ effort - observed\ effort}{total\ effort - 1}}$$

and

$$(4) \quad \sqrt{var(\bar{b}_{s,y} * u_{s,y} * d)} = sd(\bar{b}_{s,y} * u_{s,y} * d) * fpc.$$

For all bycatch estimates, our value for *fpc* = 0.91 (*total effort* = 57,194 sets, *observed effort* = 9,158 sets).

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, 13 were released dead, and one was released in ‘unknown’ condition. Turtles released in unknown condition were conservatively treated as deaths. Of the 11 turtles released alive, 3 were injured to the point where survival was unlikely (NMFS 2013). In this case, the observed fraction (*f*) of deaths and injuries = 13 known deaths + 4 probable deaths = 17/25 = 0.68 (NMFS 2013). Total MSI was calculated as the product of unobserved bycatch $(\bar{b}_{s,y} * u_y)$ and *f,* plus observed MSI. Uncertainty in MSI estimates was estimated by treating *f* as a random binomial deviate, based on observed entanglement and injury/death sample sizes for each species. Estimates of unobserved bycatch (one for each of 1000 forest trees) were multiplied by a randomly drawn (with replacement) value of *f*, yielding a distribution of unobserved MSI estimates of size = 1000, to which observed MSI totals were added. Precision of MSI estimates were calculated as CVs as in Equation 2. Small species such as dolphins, porpoises, and pinnipeds are rarely released alive because they drown quickly in gillnets, thus, they have *f* values equal to 1, and therefore MSI estimates are simply equal to $\bar{T}_y$, with the associated CV of $\bar{T}_y$.

Regression tree bycatch estimates were compared to annual ratio estimates for all years. Ratio estimates were calculated 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 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 and the most recent 5 years of data, or 2015-2019. The years 2015-2019 represent the most recent 5-year period for which bycatch estimates are available and reflect the number of years used to pool bycatch estimates in NMFS marine mammal stock assessment reports (NOAA 2016). Periods > 5 years are known to be superior for pooling estimates when bycatch is based on annual ratio estimates and entanglements are rare, assuming that fishing methods and conditions have remained relatively static (Carretta and Moore 2014). However, bycatch models such as regression trees which incorporate all available data for estimation and rely upon covariates other than fishing effort reduces the need for such pooling.

Results

Variables identified as important predictors for each species / taxonomic group are summarized in Table 2. For most species, minimum OOB error rates for bycatch presence were achieved with random forest models that included only 3 of 12 variables tested, but up to 7 variables (California sea lion) were included in some models (Table 2). Model performance measures (variables selected, sensitivity, selectivity, TSS metrics) for selected species are given in Table 2.

Estimates of total bycatch and mortality and serious injury levels are shown in Tables 3-34. Bycatch estimates from regression trees were more stable across years and had better precision (lower CVs) than corresponding ratio estimates. Precision gains from regression trees primarily resulted from the use of all 30 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 sum, the information contained in the full dataset provides a better estimate of long-term expected bycatch rates and covariate effects, which translates into better annual and multi-year estimates.

Some annual regression tree bycatch estimates have large CVs (>1), which occurs when estimated bycatch is near zero even though the standard error (absolute rather than relative error measure) might be small. This is apparent for rarely-entangled species such as striped dolphin and fin whale. In years with few observed sets, the precision of regression tree bycatch estimates can be poor, 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 variability in fishing set characteristics in year *y* used to extrapolate bycatch to unobserved fishing. In the extreme, if all observed sets in year *y* had identical set characteristics (location, date, depth, etc.), then a random forest would predict the same mean bycatch rate for these sets, resulting in zero variance.

Discussion

Some large differences between annual bycatch estimates using regression trees and ratio estimators are due to the combination of rarely-observed events and low observer coverage. For example, in 2010, two sperm whales were observed entangled in one fishing set, out of only 59 observed sets that year and total estimated fishing effort of 492 sets. The observed bycatch rate of 2 whales in 59 sets, combined with 12% annual observer coverage, yielded a ratio estimate of 16.7 whales (Table 21). In contrast, the regression tree estimate of bycatch for 2010 is approximately 2.3 whales (2 observed + 0.3 whales estimated in 433 unobserved sets). Given the observed sperm whale bycatch rate in this fishery over 30 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 only two entanglements, both of which happened to be observed. Another problem with annual ratio estimates is when observed bycatch is zero, the resulting bycatch estimate is zero (with no variance estimate), even if undetected bycatch occurs. No sperm whale entanglements were observed in 648 sets in the first two years (1990-1991) of the observer program (Table 21), and resulting ratio estimates of bycatch were zero when total fishing effort exceeded 9,000 sets (Julian and Beeson 1998). The zero estimate is unrealistic, given observed long-term bycatch rates of 1 sperm 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 10 sperm whales, which is more realistic, given the level of fishing effort (Table 21). One feature of using regression trees for bycatch estimation 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 that moderates inter-annual volatility in estimates resulting from applying ratio estimates to rare bycatch events with low observer coverage.

Bycatch reduction measures adopted by 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 other cetacean species in this fishery is unknown, because most species lack enough observations for reliable statistical inference (Carretta and Barlow 2011). However, Carretta and Barlow (2011) identified beaked whales and northern elephant seals as having more statistically significant bycatch reductions attributed to pingers than short-beaked common dolphin. In the present study, all three species bycatch presence / absence models include pingers as an explanatory covariate (Table 2). Current evidence still identifies pingers as the most likely factor in reducing beaked whale bycatch in the fishery, which makes sense, given their sensitivity to anthropogenic sound (Cox *et al.* 2006). Although no beaked whale bycatch has been observed in the fishery since 1995 (Carretta *et al.* 2008), bycatch estimates are slightly positive in subsequent years, which reflects that in addition to pingers, the variables *lat* and *sst* also influence current estimates (Figure 3-5 and Table 2).

California sea lion bycatch levels declined from 1990-2019, which largely reflects declining fishing effort (Table 24). However, observed and estimated sea lion bycatch per fishing set *increased* during the same period (Fig. 3-2), due to a long-term increase of the sea lion population (Laake *et al*. 2018) and implementation of the Pacific Leatherback Closure Area (PLCA) (Figure 1), which shifted gillnet effort to shallower southern waters closer to sea lion breeding rookeries where abundance is highest.

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 (~160 entanglements, ~106 estimated deaths, Table 29) are similar. In both studies, estimated leatherback entanglements decline each year, reaching low levels after PLCA implementation in 2001 (Fig. 1), which Martin *et al.* (2015) reported as the driving factor in reducing leatherback bycatch. The PLCA closure shifted fishing effort south of preferred summer / autumn leatherback habitat, resulting in declines in observed bycatch (Eguchi *et al.* 2016). After 2001, estimated leatherback bycatch is between 0 and 3.8 turtles annually, which reflects both PLCA effectiveness, and declining fishing effort (Table 31). Prior to the PLCA (1990-2000), the observed leatherback bycatch rate was 23 turtles in 5,973 fishing sets (0.0038 per set). After the closure (2001-2019), the observed bycatch rate was 2 turtles in 2,983 fishing sets (0.0007 per set). Individual leatherback entanglements in 2009 and 2012 give a false impression of a high bycatch rate in those years, because they are artifacts of the small number of sets observed (Fig. 3-8). Our leatherback bycatch model included the variables *lat + sst + mesh.* Latitude is a proxy variable for the PLCA (Fig. 1), where fishing effort is now rare since the closure began. Based on 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. Observed reductions in leatherback entanglements following PLCA implementation are also driven by declines in fishing effort and Pacific leatherback nesting and foraging populations (Tapilatu *et al*. 2013, Benson *et al.* 2020).

Our bycatch dataset includes >9,000 fishing sets spanning 30 years, and while it might be considered 'data rich' by some standards, bycatch for many species is represented by <=5 entanglements. For rarely-entangled species, it was necessary to assign a set of default variables (*days* + *lat* + *lon*) for use in regression trees. The uncertainty in bycatch estimates for rarely-entangled species will always be large, but compared with intra-annual ratio estimates, the precision of model-based estimates is greatly improved. The estimation variance associated with variability in true annual bycatch rates is unknown due to incomplete observer coverage, but is partially addressed here by including a variance term reflecting the observed fishing trip variance (dispersion indices). However, calculated CVs reported for bycatch estimates may still be underestimated relative to intra-annual variability in true bycatch rates. Management advantages of model-based bycatch estimation methods that utilize all available data are that annual bycatch estimates are less volatile, less biased, and more precise, especially where observer data are characterized by rare bycatch and low observer coverage. Reducing the annual estimation volatility is important in protected species management, where decisions involving fishery regulation require accurate and timely assessment of bycatch. This is especially true for rare event bycatch, where an absence of bycatch observations may result in the failure to detect a genuine bycatch problem due to low observer coverage. Conversely, the observation of a rare bycatch event in a low observer coverage situation can result in unrealistically high estimates 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 fishery and environmental variables that may influence bycatch rates over time. For species where observed bycatch is so rare that explanatory variables cannot be reliably identified, use of random forests with a default set of variables (e.g. *lat* + *lon* + *days*) can provide a 'null model' of bycatch that mirrors the overall mean bycatch rate, which can then be 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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Figure 1. Observed fishing sets, 1990-2000 (L), 2001-2019 (R), and Pacific Leatherback Conservation Area (shaded).

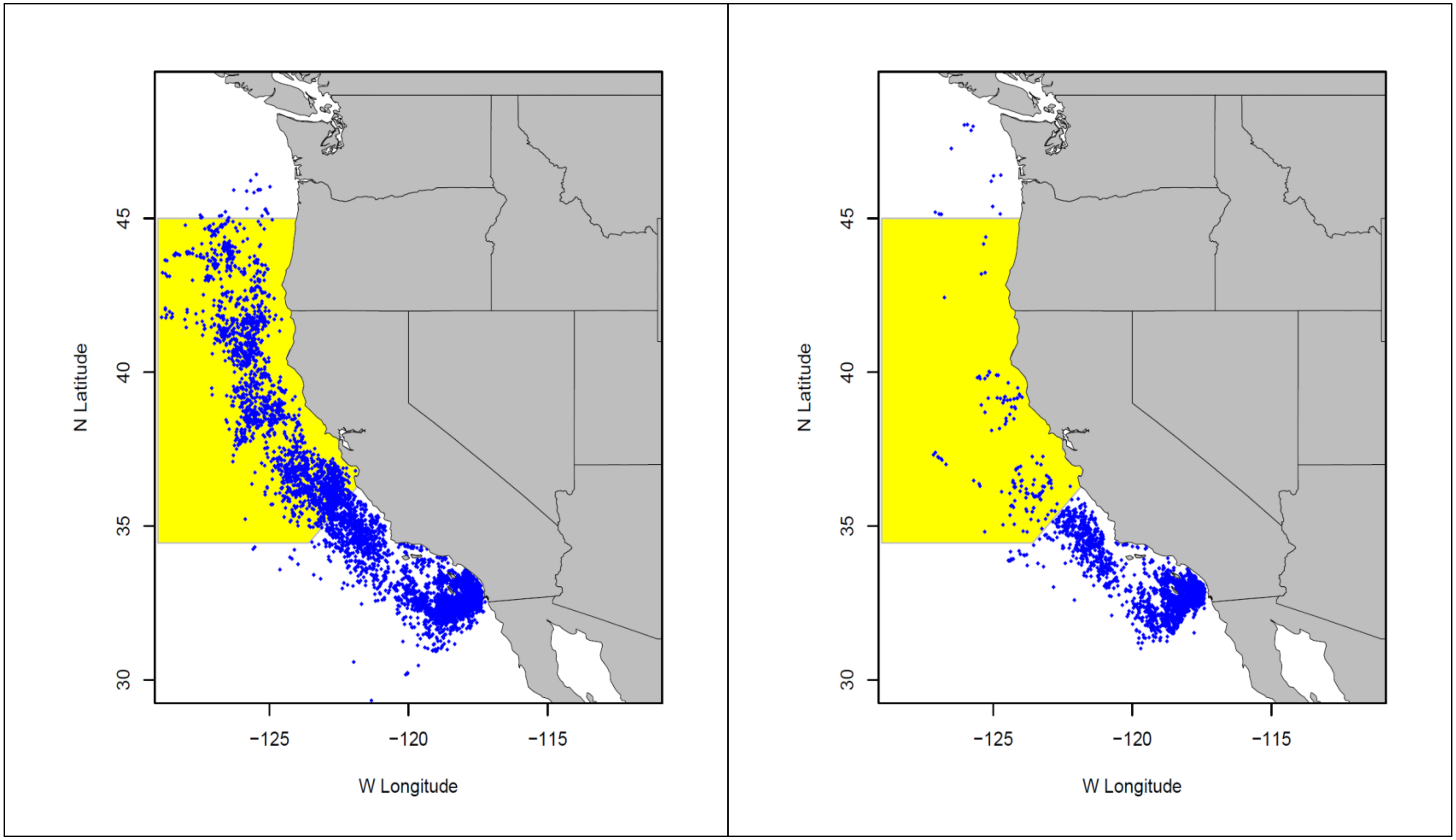

Figure 2. Observed and estimated number of fishing sets in the California large-mesh drift gillnet fishery, 1990-2019. Values in bars represent approximate fraction of annual observer coverage.

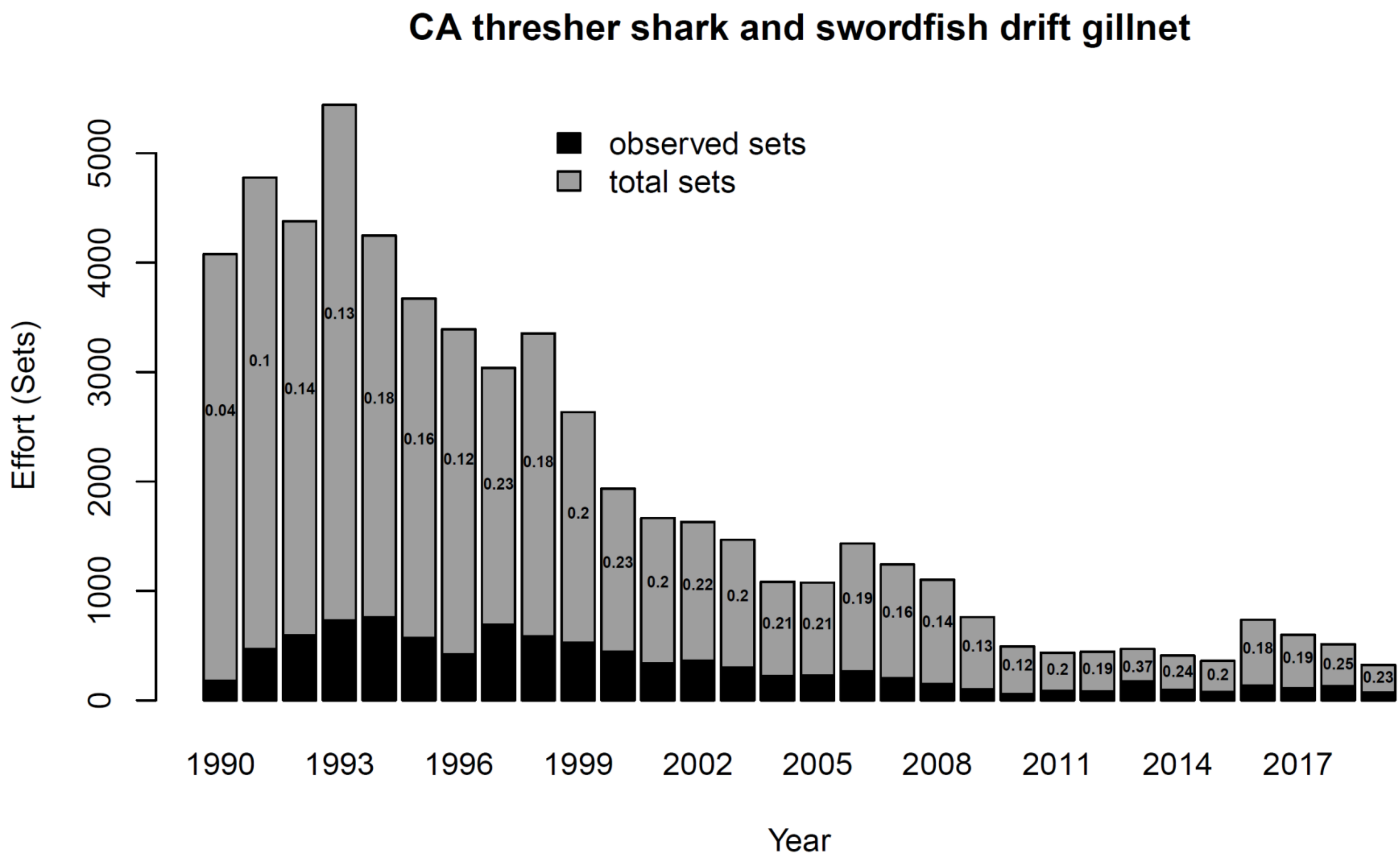

Figure 3-1. Observed and estimated bycatch of short-beaked common dolphin. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

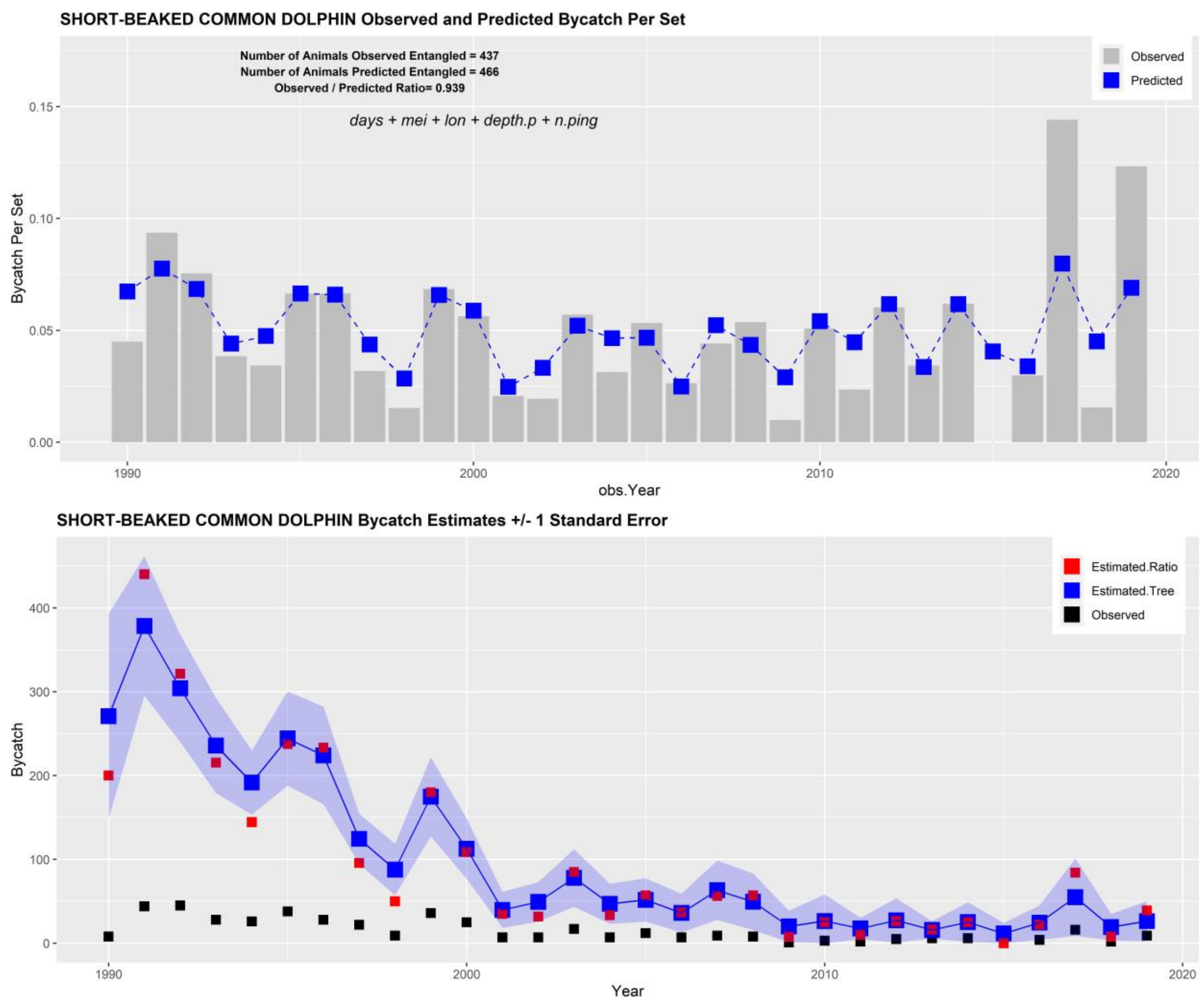

Figure 3-2. Observed and estimated bycatch of California sea lion. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

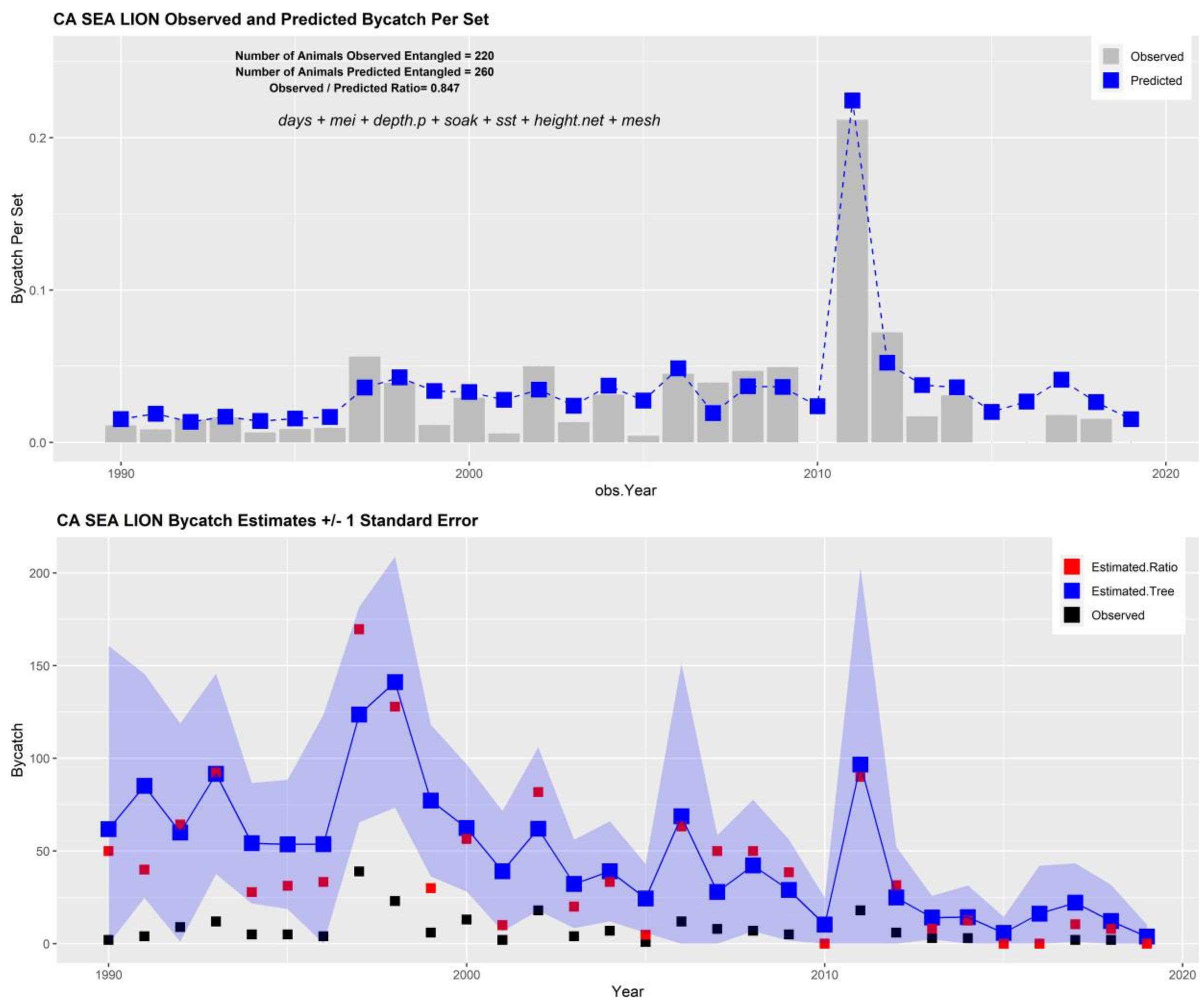

Figure 3-3. Observed and estimated bycatch of northern elephant seal. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

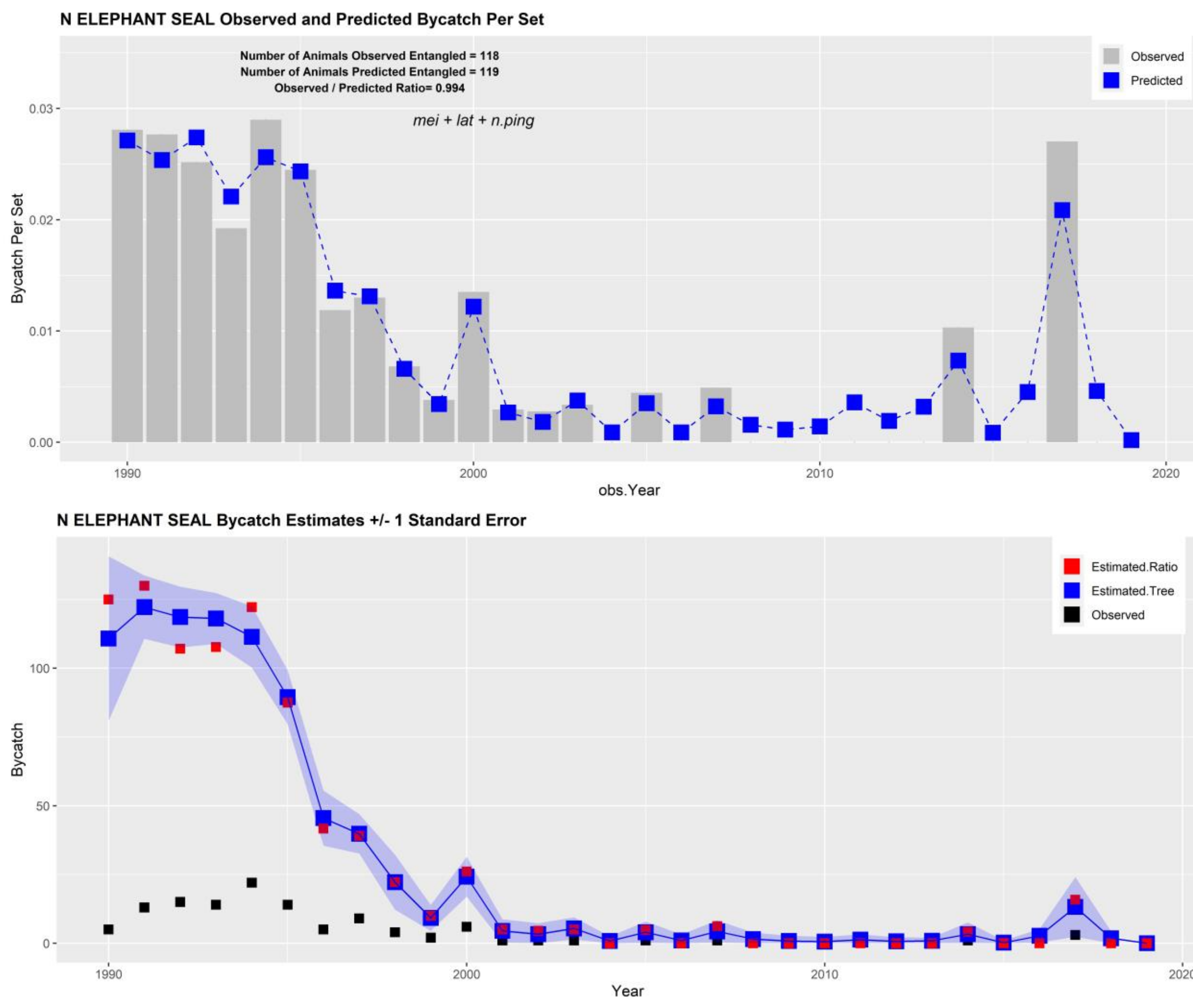

Figure 3-4. Observed and estimated bycatch of northern right whale dolphin. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

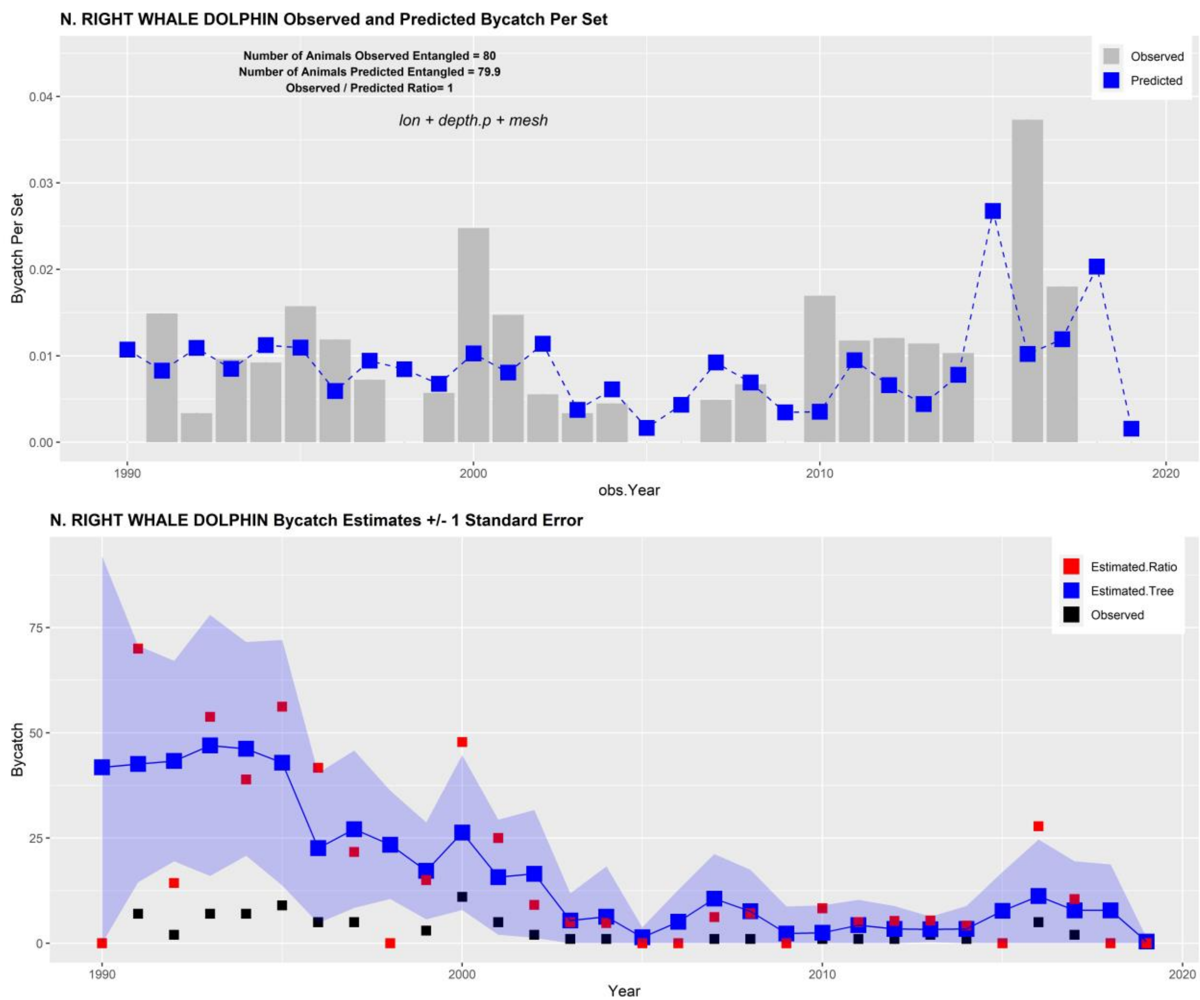

Figure 3-5. Observed and estimated bycatch of all beaked whales. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

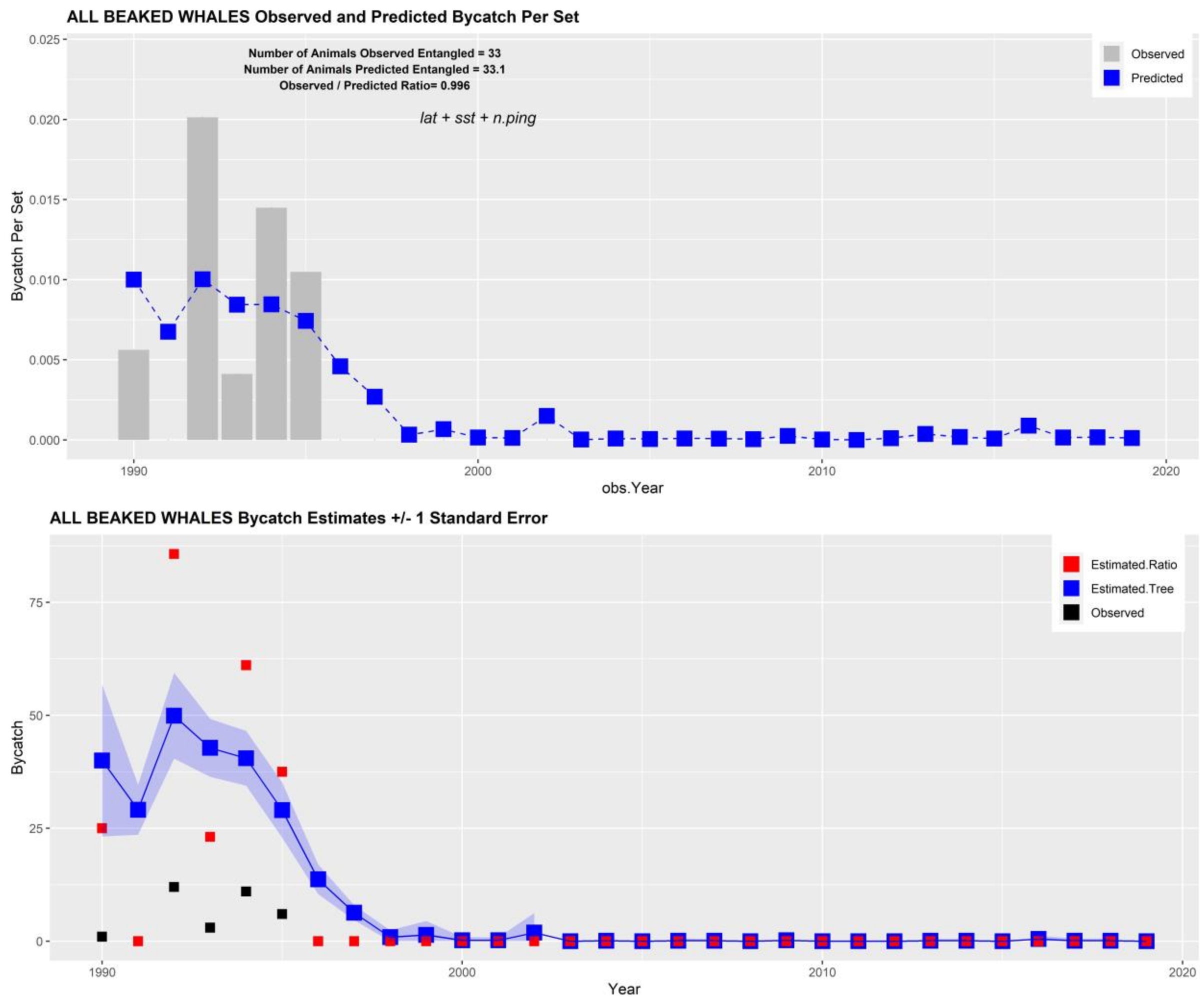

Figure 3-6. Observed and estimated bycatch of Risso's dolphin. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

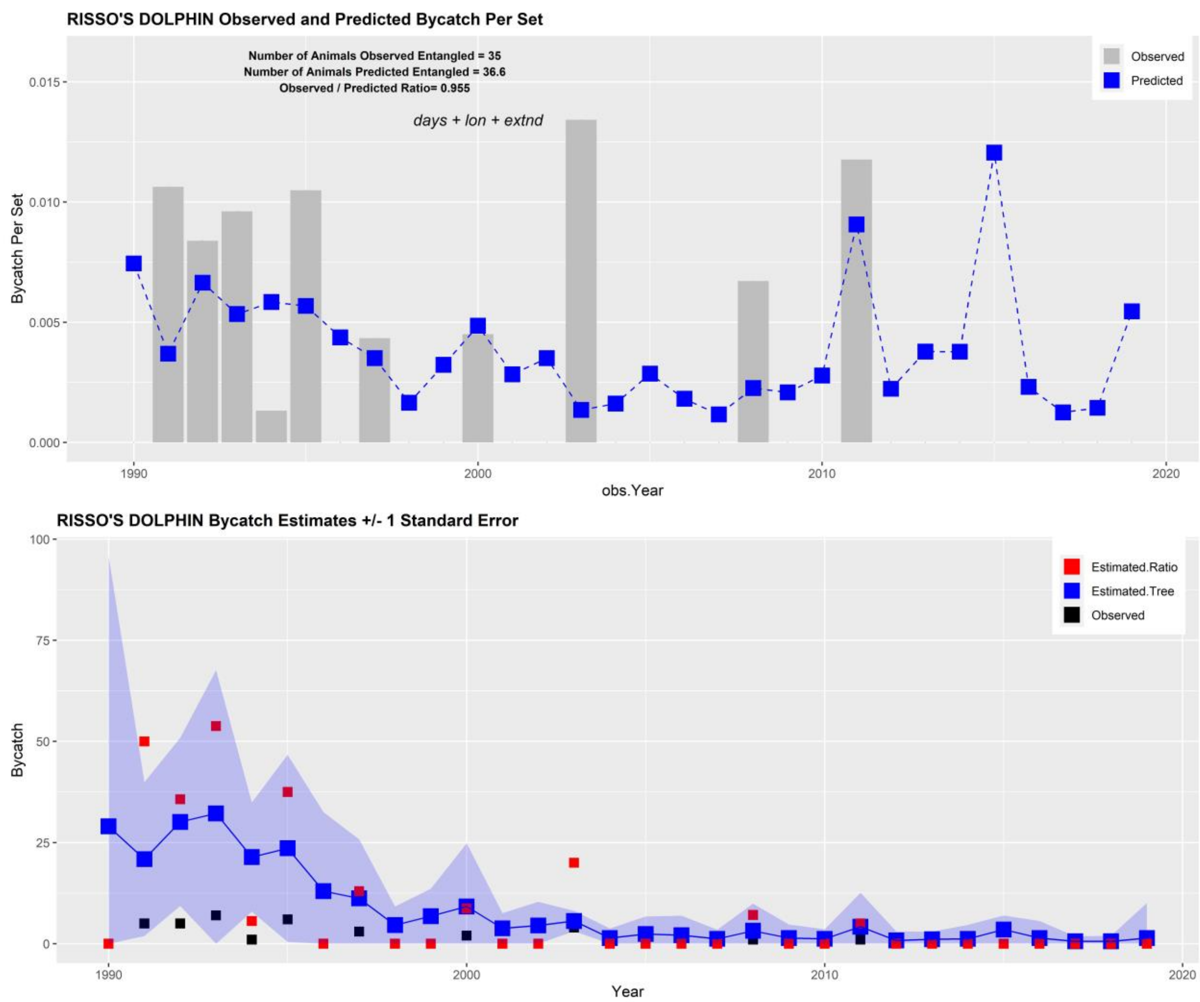

Figure 3-7. Observed and estimated bycatch of Pacific white-sided dolphin. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

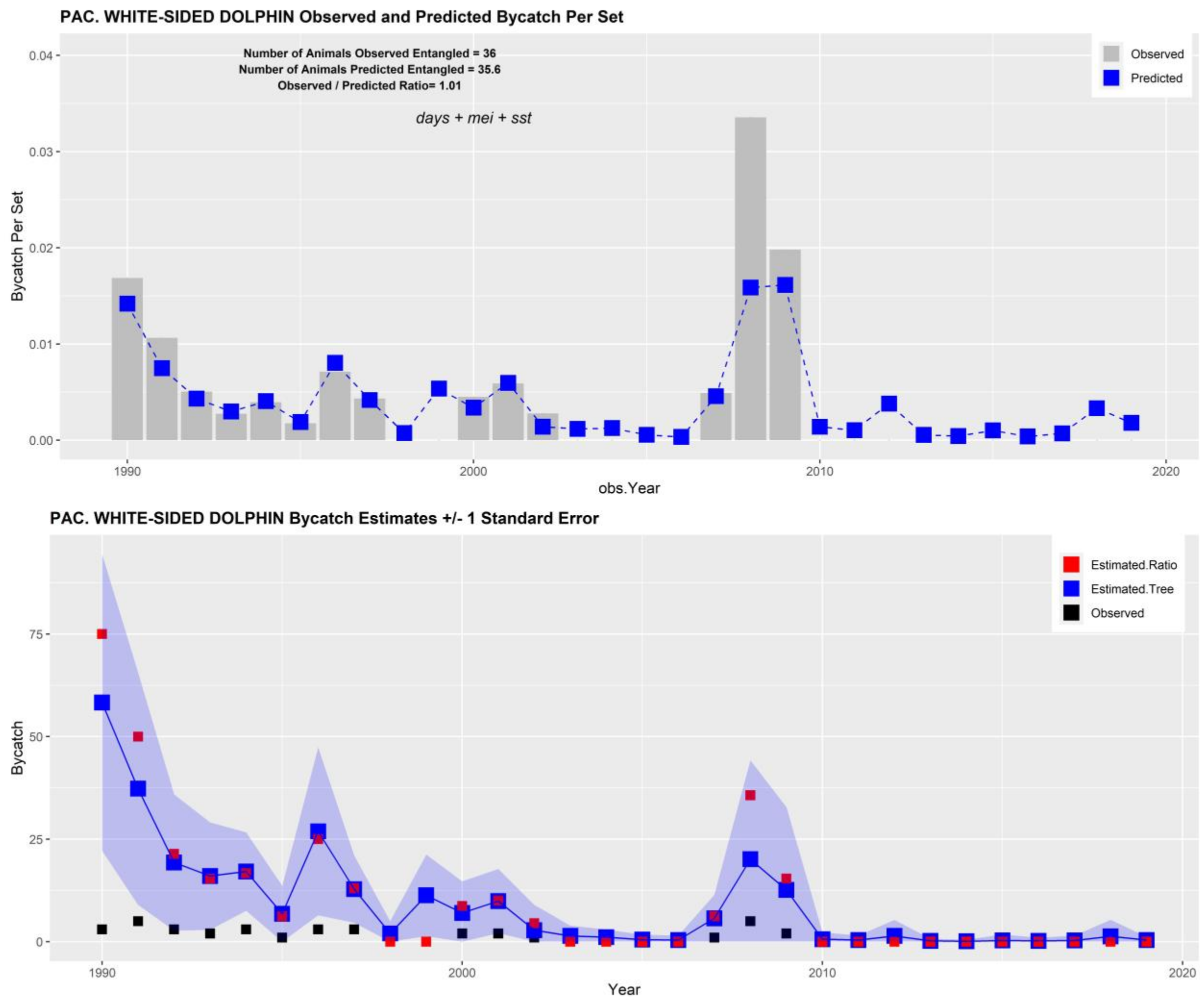

Figure 3-8. Observed and estimated bycatch of leatherback sea turtles. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

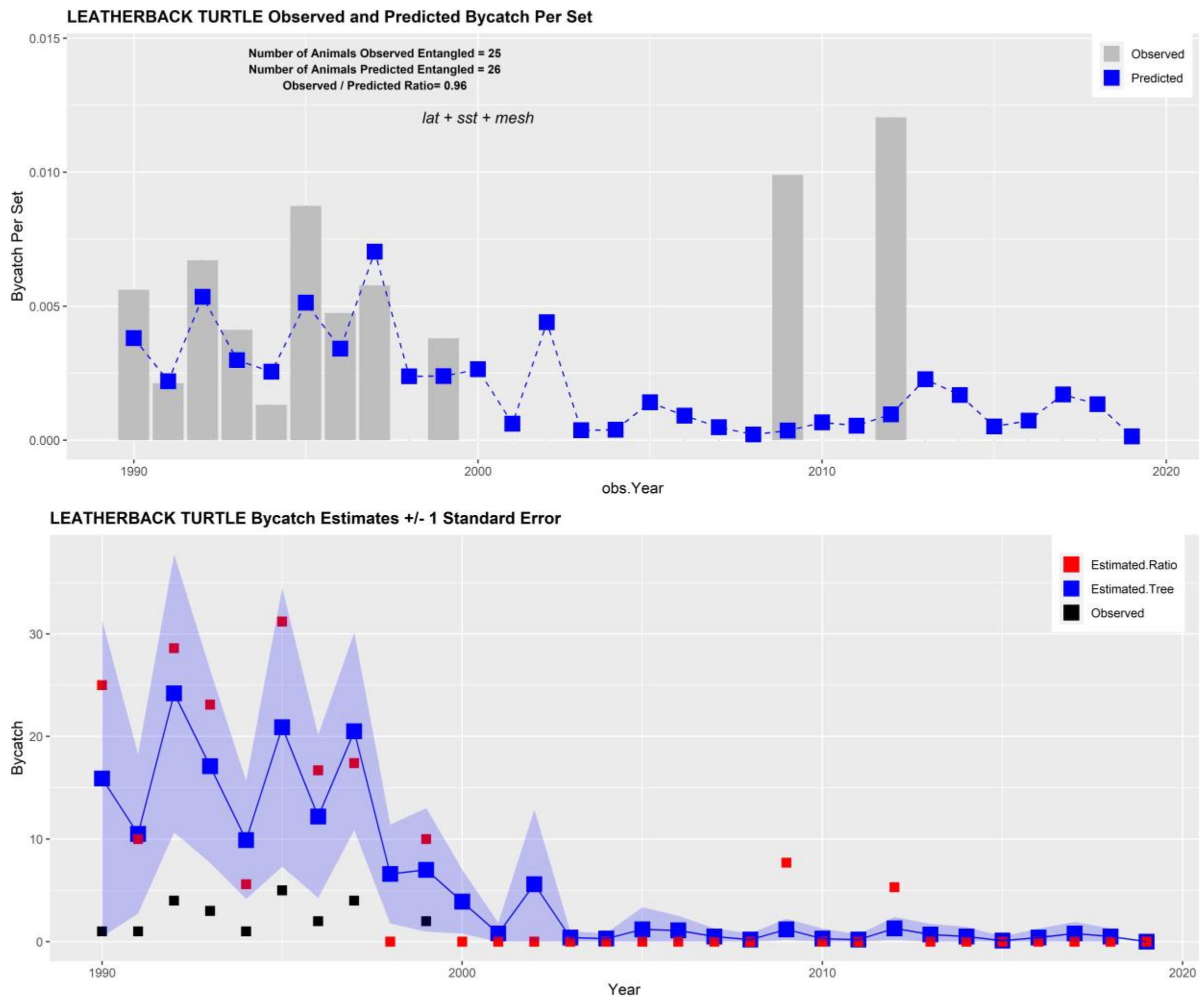

Figure 3-9. Observed and estimated bycatch of Dall's porpoise. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

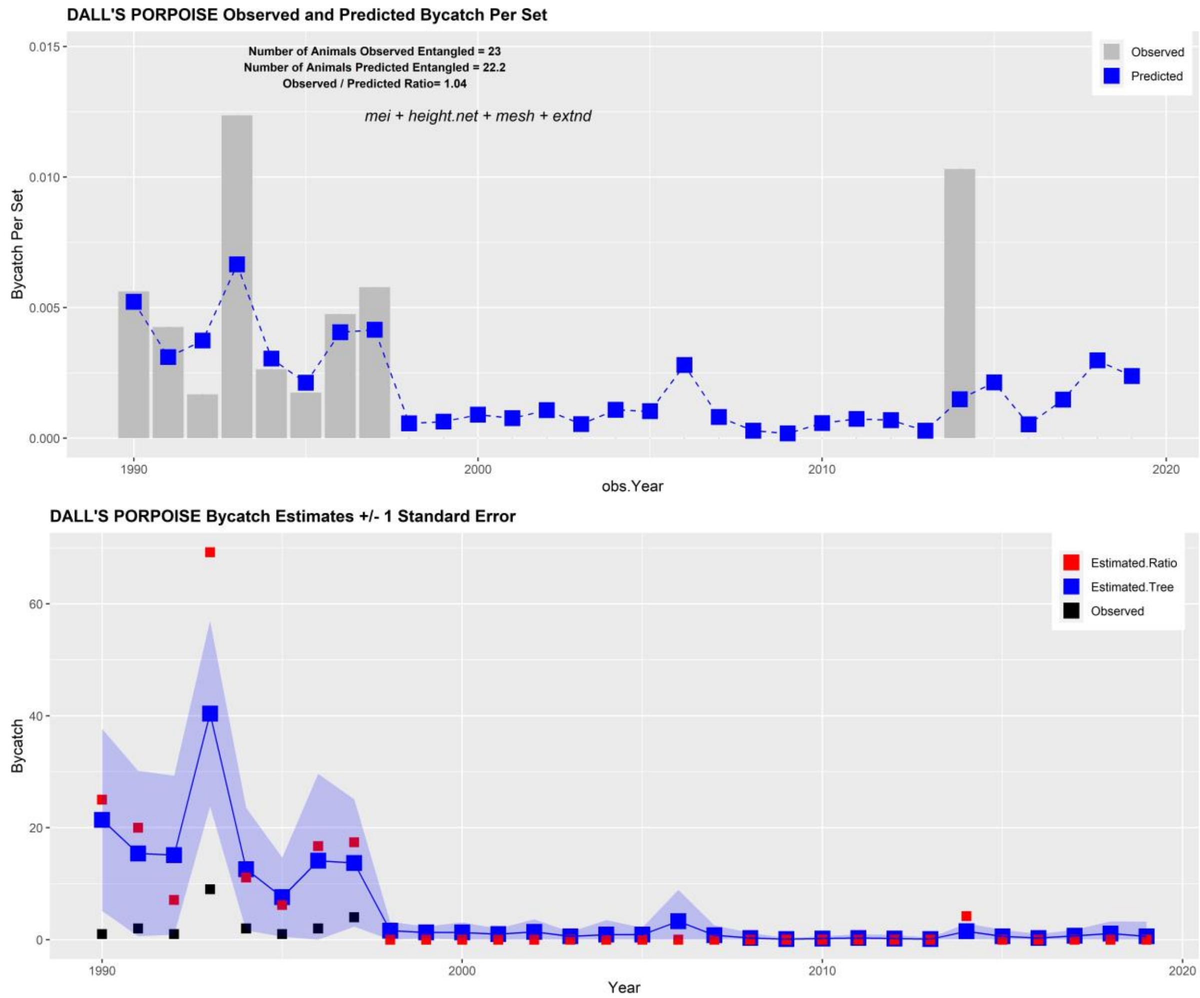

Figure 3-10. Observed and estimated bycatch of Cuvier's beaked whale. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

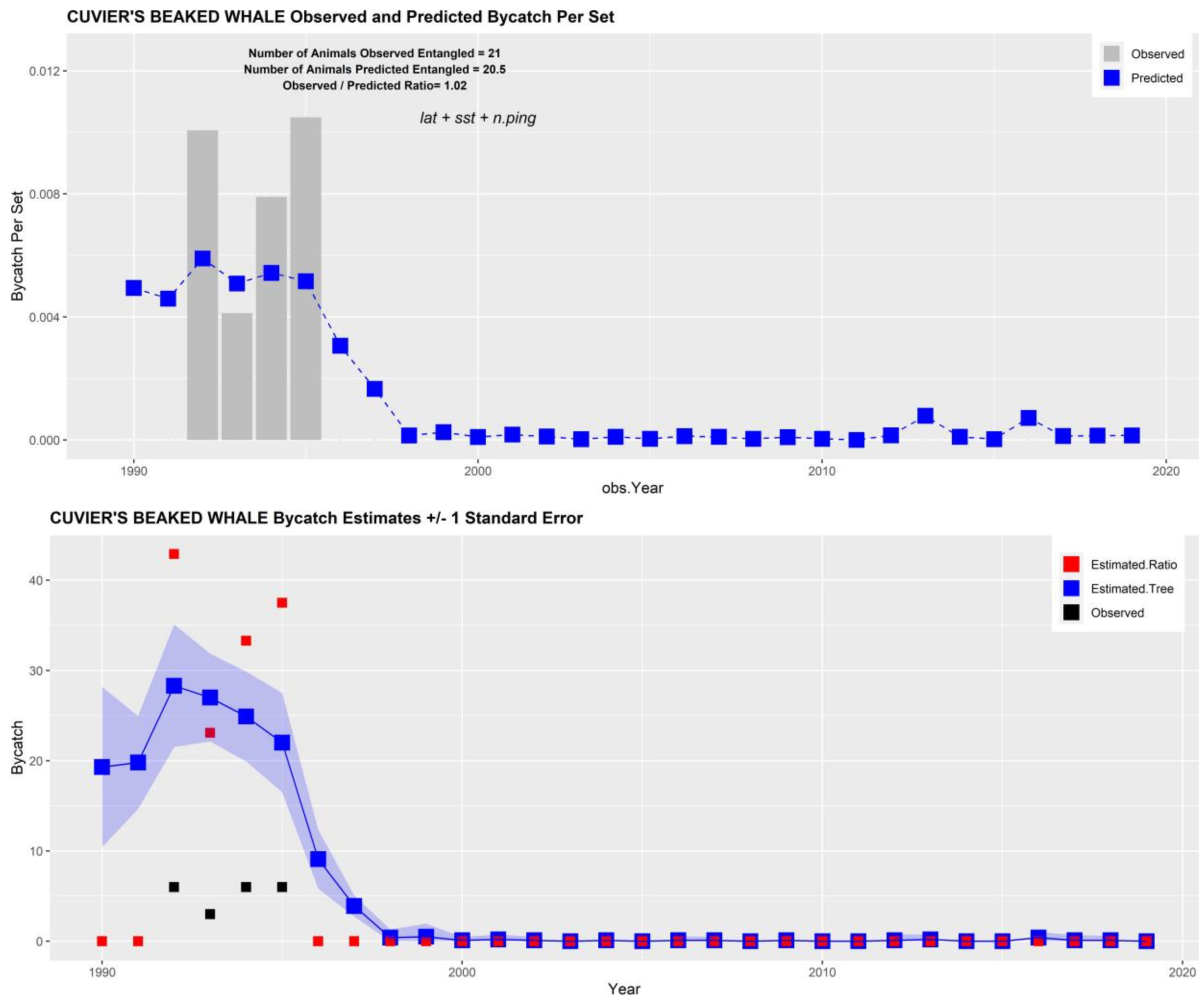

Figure 3-11. Observed and estimated bycatch of long-beaked common dolphin. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

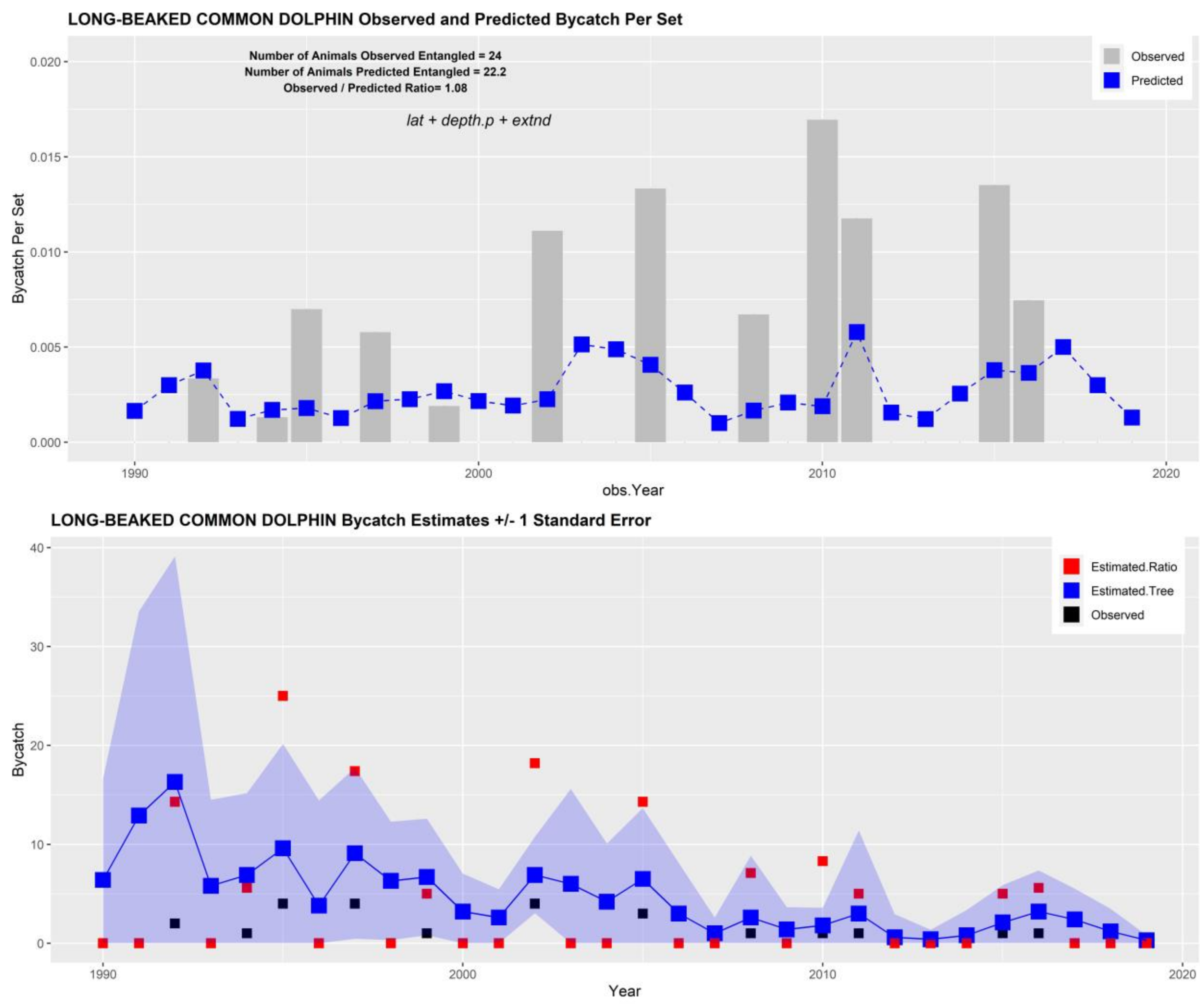

Figure 3-12. Observed and estimated bycatch of loggerhead sea turtles. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

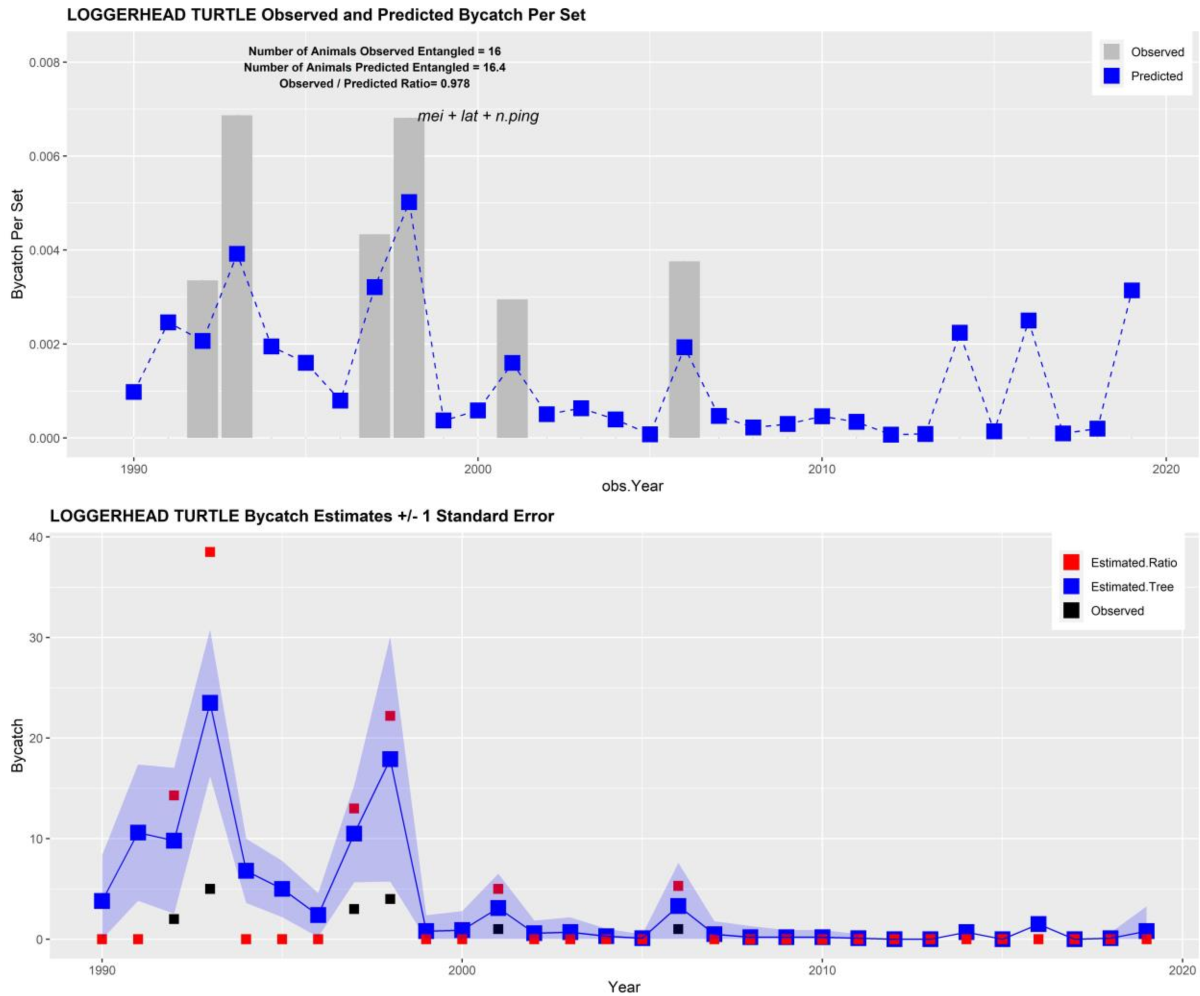

Figure 3-13. Observed and estimated bycatch of short-finned pilot whale. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

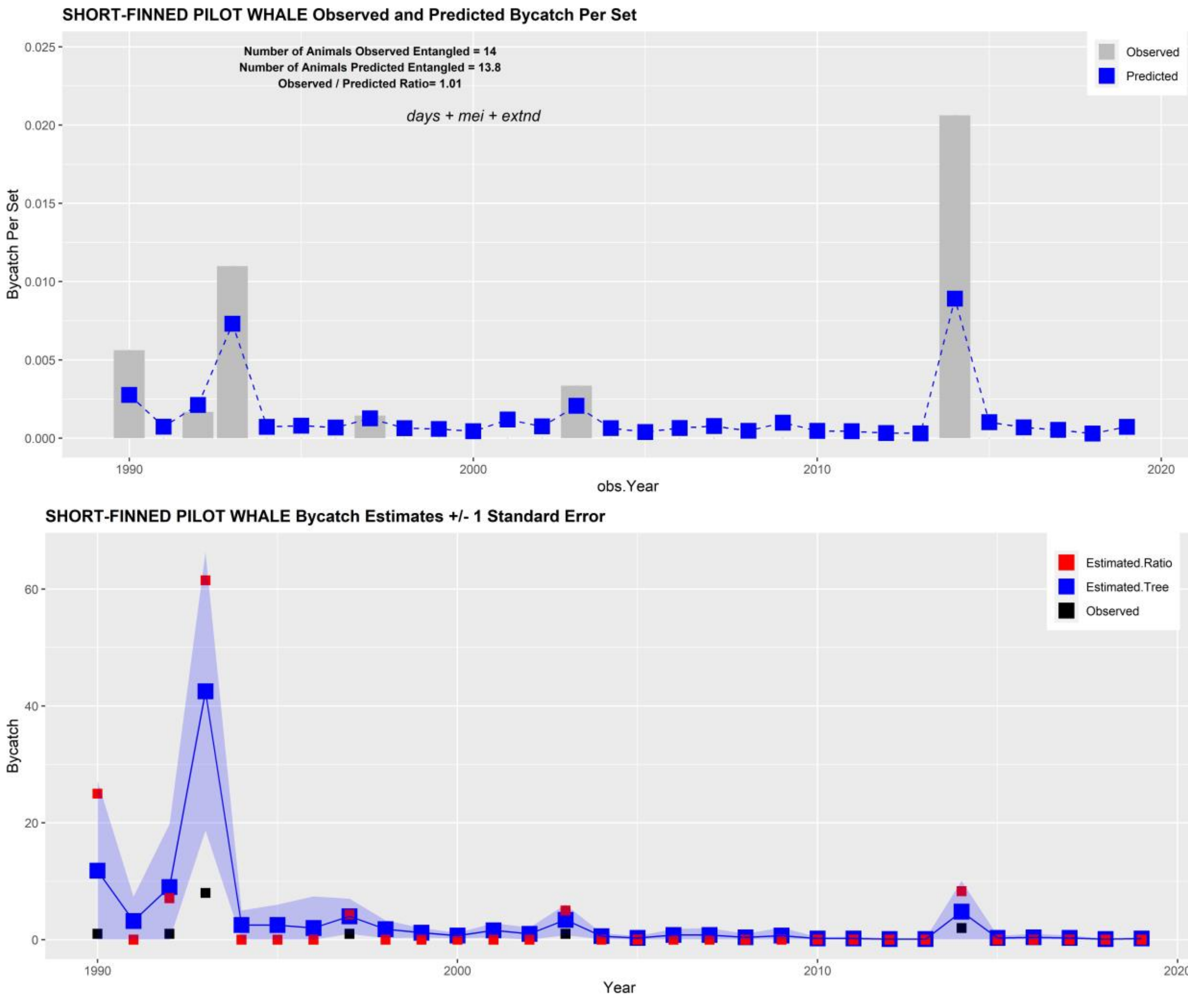

Figure 3-14. Observed and estimated bycatch of sperm whale. The top panel shows annual observed and predicted bycatch per fishing set. The ratio of observed to predicted bycatch is also shown for the cross-validated dataset of 9,158 fishing sets. Bottom panel shows observed annual bycatch and estimated total bycatch from both random forest regression trees and ratio estimates. Blue shading represents +/- 1 standard error for the random forest bycatch estimates. Variables used in each bycatch model are shown in the top panel.

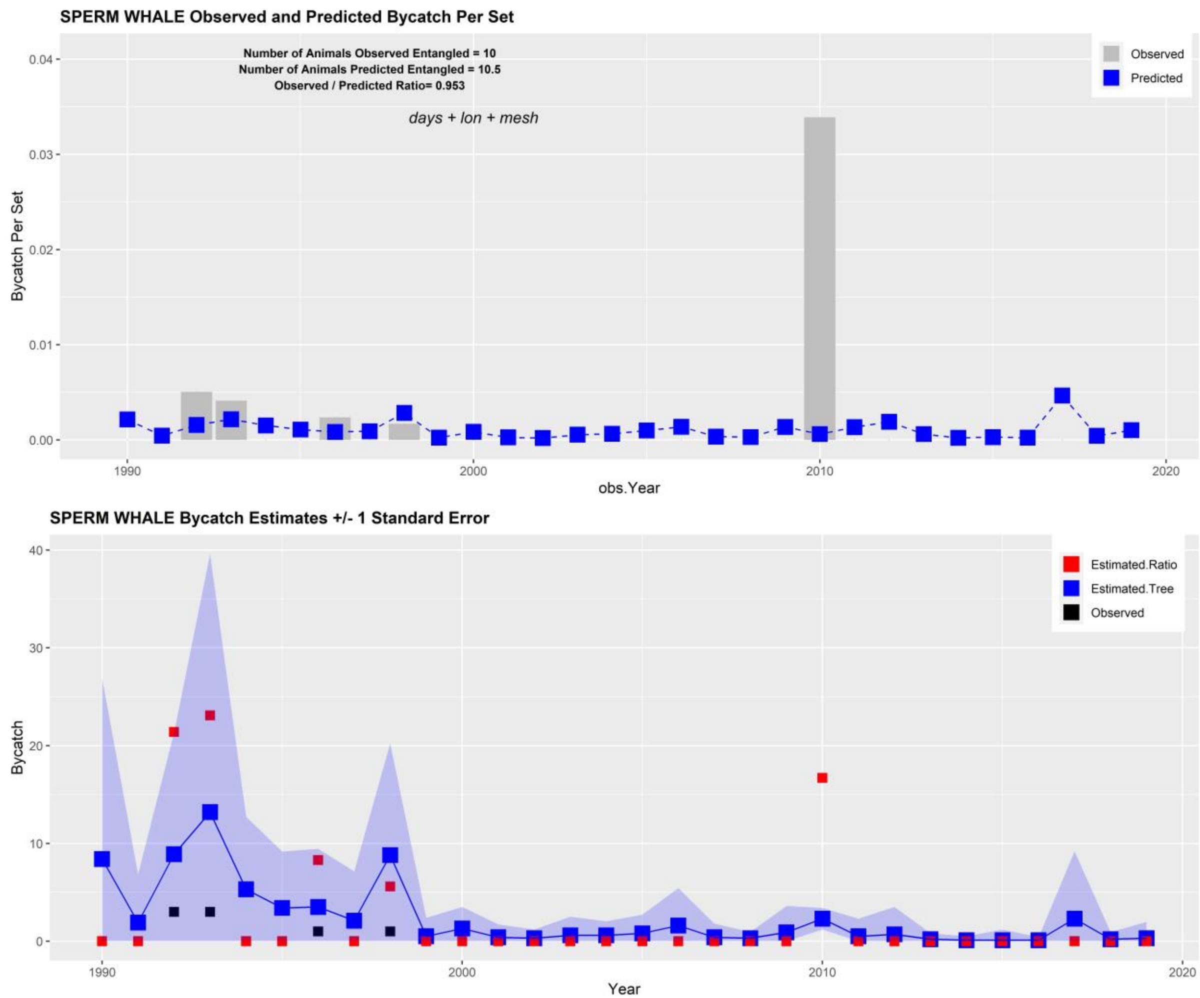

Figure 4. Observed drift gillnet fishing sets in 2019 (n=73).

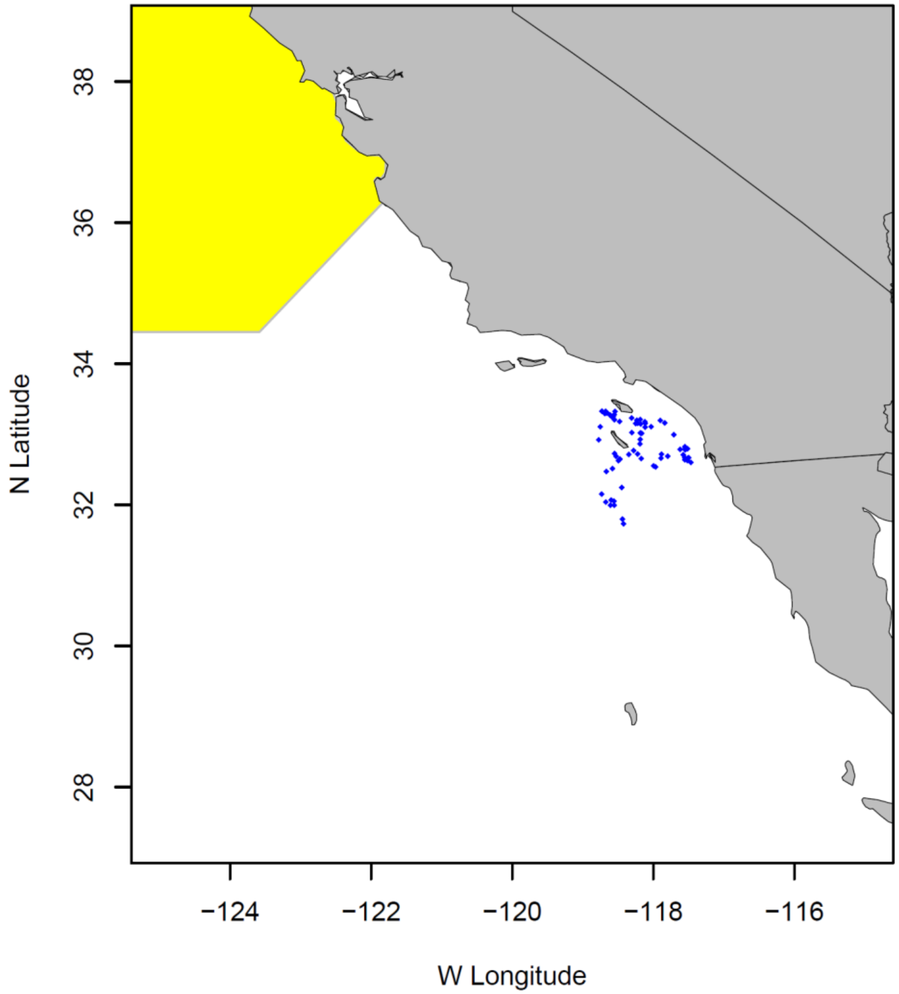

Figure 5. Selected random forest variables (*depth.p, sst, lat, days*) by year. Variables are shown to demonstrate variability of some of the commonly-used variables through the time series. Median (●), mean (●), 25th and 75th percentiles are shown.

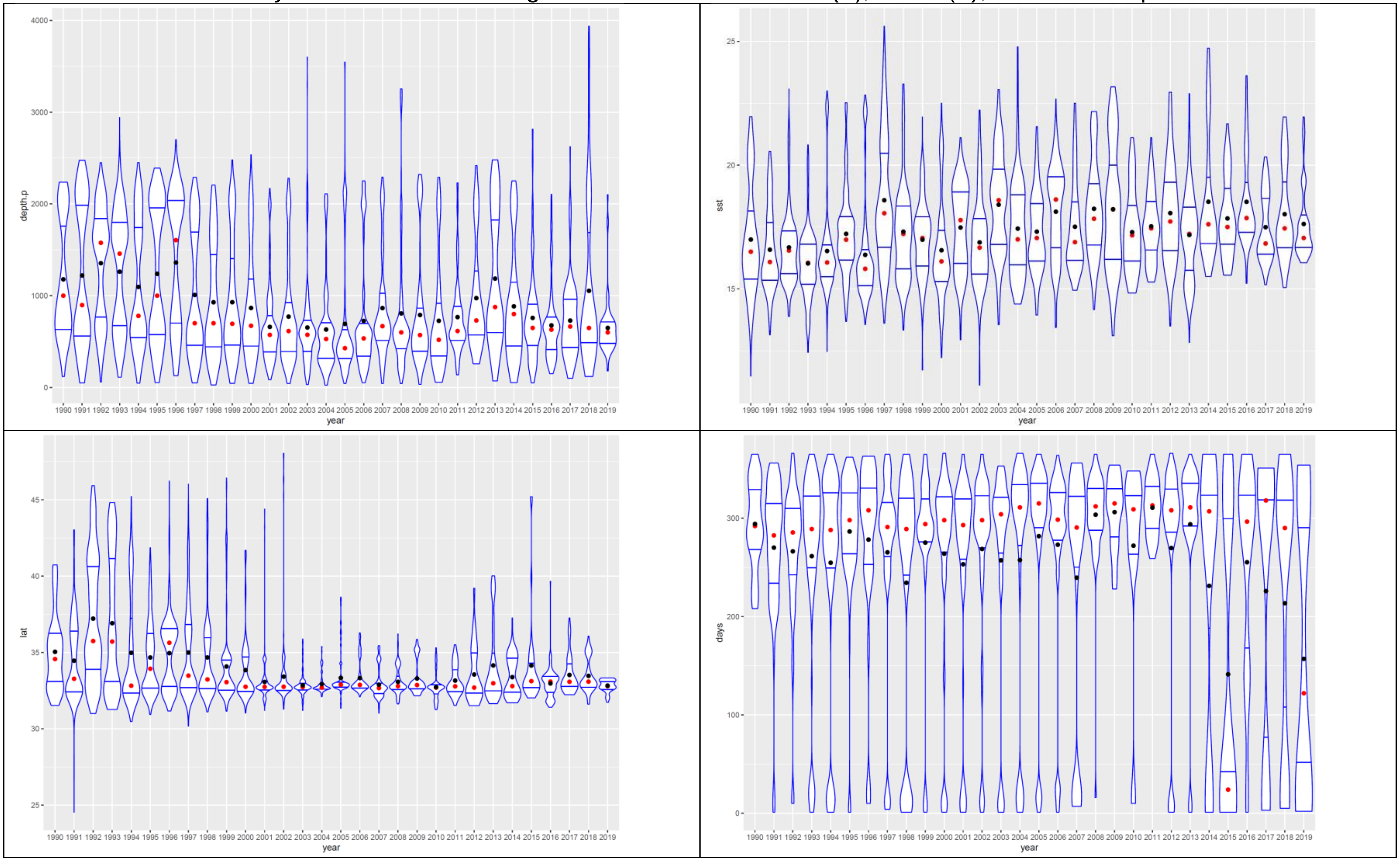

Table 1. Variables tested in random forest classification tree bycatch presence / absence models. A total of 5000 random forest (RF) models were constructed, each consisting of 5000 trees including a different set of randomly selected variables (from n=3 to all 12 variables). The bootstrap set of variables that resulted in the lowest cross-validated error rate for bycatch presence (sensitivity) were the used in a regression tree framework to estimate bycatch. In the event of a tie in cross-validated error rates, the random forest model with the fewest variables was chosen. A default set of variables (*days* + *lat* + *lon*) were used for species with <=5 observations.

Variable Name	Variable Description	Range of Values
days	Sequential day of year	1 -365
depth	water depth when net was pulled (meters)	0 - 3936
extnd	top of net depth below surface in (feet)	3 - 99
height.net	Number of meshes from top to bottom of net	14 - 300
lat	Latitude	24.5 - 48
length.net	Length of net (meters)	50 – 2000
lon	Longitude	117 - 129
mei	Multivariate El Niño index (sum of anomalies for Aug - Jan)	-13.2 to +12.6
mesh	mesh size in inches	14 - 28
n.ping	Number of acoustic pingers	0 - 76
soak	Soak time of net in hours	1 - 62
sst	Sea surface temperature (C)	11.1 – 25.6

Table 2. Variable selection results for species with >5 events. Species with <=5 events (not shown in this table) utilize a default set of variables (days + lat + lon). The number of observed and correctly classified positive bycatch events are shown, along with True Skill Statistic (TSS) scores. Dispersion indices (variance divided by mean) for observed bycatch per fishing trip are also shown.

Species	Events	Animals	Dispersion.Trip	Var.1	Var.2	Var.3	Var.4	Var.5	Var.6	Var.7	Correct.Events	Sensitivity	Specificity	Accuracy	TSS
SHORT-BEAKED COMMON DOLPHIN	345	437	2.09	days	mei	lon	depth.p	n.ping	NA	NA	257	0.745	0.641	0.645	0.386
CALIFORNIA SEA LION	179	220	3	days	mei	depth.p	soak	sst	height.net	mesh	139	0.777	0.653	0.655	0.429
NORTHERN ELEPHANT SEAL	114	118	1.2	mei	lat	n.ping	NA	NA	NA	NA	96	0.842	0.577	0.581	0.419
NORTHERN RIGHT WHALE DOLPHIN	58	80	1.9	lon	depth.p	mesh	NA	NA	NA	NA	52	0.897	0.652	0.653	0.548
ALL BEAKED WHALES	33	33	1.1	lat	sst	n.ping	NA	NA	NA	NA	33	1.000	0.682	0.683	0.682
RISSO'S DOLPHIN	27	35	1.95	days	lon	extnd	NA	NA	NA	NA	23	0.852	0.725	0.726	0.577
PACIFIC WHITE-SIDED DOLPHIN	27	36	1.59	days	mei	sst	NA	NA	NA	NA	20	0.741	0.596	0.596	0.336
LEATHERBACK SEA TURTLE	25	25	1.14	lat	sst	mesh	NA	NA	NA	NA	23	0.920	0.692	0.692	0.612
DALL'S PORPOISE	21	23	1.68	mei	height.net	mesh	extnd	NA	NA	NA	20	0.952	0.670	0.670	0.622
CUVIER'S BEAKED WHALE	21	21	0.987	lat	sst	n.ping	NA	NA	NA	NA	21	1.000	0.738	0.738	0.738
NORTHERN FULMAR	20	36	2.87	days	n.ping	height.net	NA	NA	NA	NA	20	1.000	0.713	0.714	0.713
LONG-BEAKED COMMON DOLPHIN	18	24	2.07	lat	depth.p	extnd	NA	NA	NA	NA	17	0.944	0.645	0.645	0.589
LOGGERHEAD SEA TURTLE	14	16	1.49	mei	lat	n.ping	NA	NA	NA	NA	14	1.000	0.708	0.708	0.708
SHORT-FINNED PILOT WHALE	10	14	1.99	days	mei	extnd	NA	NA	NA	NA	10	1.000	0.530	0.530	0.530
MESOPLODON SPP.	8	8	0.996	lat	sst	n.ping	NA	NA	NA	NA	8	1.000	0.753	0.753	0.753
SPERM WHALE	6	10	1.99	days	lon	mesh	NA	NA	NA	NA	6	1.000	0.620	0.620	0.620

Table 3. MINKE WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019.
Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.5) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	1.8	1.8	3	0	−	0.9	3.2
1991	470	4778	0.1	0	3.2	3.2	1.5	0	−	1.6	1.9
1992	596	4379	0.14	0	3.1	3.1	1.5	0	−	1.6	1.8
1993	728	5442	0.13	0	2.3	2.3	1.3	0	−	1.2	1.5
1994	759	4248	0.18	1	1.8	2.8	1.7	5.6	1	1.9	0.92
1995	572	3673	0.16	0	1.8	1.8	1.5	0	−	0.9	1.7
1996	421	3392	0.12	1	2	3	1.4	8.3	0.99	2.1	0.81
1997	692	3039	0.23	0	0.4	0.4	2.5	0	−	0.2	3.6
1998	587	3353	0.18	0	0.3	0.3	2.4	0	−	0.1	3.1
1999	526	2634	0.2	1	0.3	1.3	0.84	5	1	0.2	3.2
2000	444	1936	0.23	0	0.7	0.7	1.7	0	−	0.4	1.9
2001	339	1665	0.2	0	0.7	0.7	1.6	0	−	0.4	1.8
2002	360	1630	0.22	0	0.2	0.2	3.6	0	−	0.1	3.9
2003	298	1467	0.2	0	0.1	0.1	2.9	0	−	0	−
2004	223	1084	0.21	0	0	0	−	0	−	0	−
2005	225	1075	0.21	0	0.1	0.1	3	0	−	0.1	3
2006	266	1433	0.19	0	0	0	−	0	−	0	−
2007	204	1241	0.16	0	1.8	1.8	1.5	0	−	0.9	1.8
2008	149	1103	0.14	0	0.6	0.6	2.2	0	−	0.3	2.4
2009	101	761	0.13	0	0.4	0.4	2.6	0	−	0.2	2.7
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	1	0	1	0.24	5	1	0	−
2012	83	445	0.19	0	0.1	0.1	5.2	0	−	0	−
2013	175	470	0.37	0	0.3	0.3	2.5	0	−	0.1	3
2014	97	409	0.24	0	0.3	0.3	3	0	−	0.2	3
2015	74	361	0.2	0	0.1	0.1	4.2	0	−	0.1	4.2
2016	134	737	0.18	0	0.2	0.2	2.7	0	−	0.1	3.1
2017	111	598	0.19	0	0.3	0.3	2.2	0	−	0.2	2.7
2018	129	513	0.25	0	0.2	0.2	3	0	−	0.1	3.8
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0.9	0.9	1.5	0	−	0.4	1.7

Table 4. FIN WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019.
Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0.1	0.1	3.5	0	−	0.1	3.5
1991	470	4778	0.1	0	0	0	−	0	−	0	−
1992	596	4379	0.14	0	0.1	0.1	7.3	0	−	0.1	7.3
1993	728	5442	0.13	0	0.1	0.1	7.4	0	−	0.1	7.4
1994	759	4248	0.18	0	1.5	1.5	1.3	0	−	1.5	1.3
1995	572	3673	0.16	0	0.1	0.1	2.7	0	−	0.1	2.7
1996	421	3392	0.12	0	0.1	0.1	5.3	0	−	0.1	5.3
1997	692	3039	0.23	0	0.7	0.7	1.5	0	−	0.7	1.5
1998	587	3353	0.18	0	0.2	0.2	2.7	0	−	0.2	2.7
1999	526	2634	0.2	1	0.2	1.2	0.75	5	1.1	1.2	0.75
2000	444	1936	0.23	0	0.3	0.3	2.7	0	−	0.3	2.7
2001	339	1665	0.2	0	0.1	0.1	2.2	0	−	0.1	2.2
2002	360	1630	0.22	0	0	0	−	0	−	0	−
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0	0	−	0	−	0	−
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0.1	0.1	3.3	0	−	0.1	3.3
2007	204	1241	0.16	0	0.2	0.2	3.3	0	−	0.2	3.3
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0	0	−	0	−	0	−
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0.4	0.4	2.6	0	−	0.4	2.6
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0.1	0.1	2.2	0	−	0.1	2.2
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0	0	−	0	−	0	−

Table 5. GRAY WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0.4	0.4	5.4	0	−	0.4	5.4
1991	470	4778	0.1	0	1	1	1.4	0	−	1	1.4
1992	596	4379	0.14	0	0.7	0.7	1.9	0	−	0.7	1.9
1993	728	5442	0.13	0	1.3	1.3	1.4	0	−	1.3	1.4
1994	759	4248	0.18	0	0.5	0.5	1.6	0	−	0.5	1.6
1995	572	3673	0.16	0	0.4	0.4	2.3	0	−	0.4	2.3
1996	421	3392	0.12	0	1.9	1.9	1.8	0	−	1.9	1.8
1997	692	3039	0.23	0	1.5	1.5	1.2	0	−	1.5	1.2
1998	587	3353	0.18	1	2.5	3.5	0.91	5.6	1	3.5	0.91
1999	526	2634	0.2	1	1.3	2.3	1.3	5	0.93	2.3	1.3
2000	444	1936	0.23	0	0.2	0.2	2	0	−	0.2	2
2001	339	1665	0.2	0	1.3	1.3	1.3	0	−	1.3	1.3
2002	360	1630	0.22	0	1.7	1.7	1.1	0	−	1.7	1.1
2003	298	1467	0.2	0	0.9	0.9	1.1	0	−	0.9	1.1
2004	223	1084	0.21	0	1	1	1.4	0	−	1	1.4
2005	225	1075	0.21	1	0.8	1.8	0.9	4.8	1	1.8	0.9
2006	266	1433	0.19	0	0.8	0.8	1.5	0	−	0.8	1.5
2007	204	1241	0.16	0	0.5	0.5	2.5	0	−	0.5	2.5
2008	149	1103	0.14	0	0.1	0.1	4.4	0	−	0.1	4.4
2009	101	761	0.13	0	0.2	0.2	3.9	0	−	0.2	3.9
2010	59	492	0.12	0	0.5	0.5	2.7	0	−	0.5	2.7
2011	85	435	0.2	0	0.5	0.5	2.2	0	−	0.5	2.2
2012	83	445	0.19	0	0.1	0.1	5	0	−	0.1	5
2013	175	470	0.37	1	0	1	0.22	2.7	1	1	0.22
2014	97	409	0.24	0	0.1	0.1	4.1	0	−	0.1	4.1
2015	74	361	0.2	0	0.1	0.1	5.4	0	−	0.1	5.4
2016	134	737	0.18	0	0.2	0.2	3	0	−	0.2	3
2017	111	598	0.19	0	0.3	0.3	2.1	0	−	0.3	2.1
2018	129	513	0.25	1	0.1	1.1	0.49	4	1	1.1	0.49
2019	73	323	0.23	0	0.3	0.3	2.2	0	−	0.3	2.2
2015−2019	521	2532	0.21	1	0.9	1.9	1.4	4.8	1.04	1.9	1.4

Table 6. HUMPBACK WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.25) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0.1	0.1	3.7	0	−	0	−
1991	470	4778	0.1	0	1.5	1.5	2.1	0	−	0.4	3.3
1992	596	4379	0.14	0	1.2	1.2	1.9	0	−	0.3	3.5
1993	728	5442	0.13	0	0.6	0.6	2.3	0	−	0.2	2.9
1994	759	4248	0.18	1	1.6	2.6	1.1	5.6	0.97	0.4	1.6
1995	572	3673	0.16	0	0.3	0.3	2.2	0	−	0.1	3.9
1996	421	3392	0.12	0	0.2	0.2	2.8	0	−	0.1	4.8
1997	692	3039	0.23	0	0.1	0.1	3.1	0	−	0	−
1998	587	3353	0.18	0	2	2	1.1	0	−	0.5	1.8
1999	526	2634	0.2	1	0.4	1.4	0.99	5	1	0.1	3.5
2000	444	1936	0.23	0	0.2	0.2	2.3	0	−	0	−
2001	339	1665	0.2	0	0.8	0.8	1.7	0	−	0.2	2.7
2002	360	1630	0.22	0	0.7	0.7	1.7	0	−	0.2	2.6
2003	298	1467	0.2	0	0.6	0.6	2.1	0	−	0.1	3.3
2004	223	1084	0.21	1	0.1	1.1	0.32	4.8	0.97	0	−
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0.1	0.1	2.8	0	−	0	−
2007	204	1241	0.16	0	0.5	0.5	2.4	0	−	0.1	3.9
2008	149	1103	0.14	0	0.2	0.2	3.6	0	−	0	−
2009	101	761	0.13	0	0	0	−	0	−	0	−
2010	59	492	0.12	0	0.5	0.5	3.3	0	−	0.1	4.8
2011	85	435	0.2	0	0.4	0.4	2.6	0	−	0.1	3.9
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0.2	0.2	2.8	0	−	0.1	3.4
2014	97	409	0.24	0	0.3	0.3	2.5	0	−	0.1	3.8
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0.1	0.1	6.2	0	−	0	−
2017	111	598	0.19	0	0.2	0.2	3.9	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0.3	0.3	3.3	0	−	0.1	4.2

Table 7. SHORT−BEAKED COMMON DOLPHIN. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	8	262.8	270.8	0.45	200	0.46	270.8	0.45
1991	470	4778	0.1	44	334.3	378.3	0.22	440	0.19	378.3	0.22
1992	596	4379	0.14	45	259.1	304.1	0.21	321.4	0.18	304.1	0.21
1993	728	5442	0.13	28	207.7	235.7	0.24	215.4	0.28	235.7	0.24
1994	759	4248	0.18	26	165.6	191.6	0.2	144.4	0.21	191.6	0.2
1995	572	3673	0.16	38	206.2	244.2	0.23	237.5	0.23	244.2	0.23
1996	421	3392	0.12	28	195.9	223.9	0.26	233.3	0.21	223.9	0.26
1997	692	3039	0.23	22	102.5	124.5	0.24	95.7	0.23	124.5	0.24
1998	587	3353	0.18	9	78.8	87.8	0.35	50	0.33	87.8	0.35
1999	526	2634	0.2	36	138.7	174.7	0.27	180	0.23	174.7	0.27
2000	444	1936	0.23	25	87.7	112.7	0.32	108.7	0.24	112.7	0.32
2001	339	1665	0.2	7	32.8	39.8	0.54	35	0.41	39.8	0.54
2002	360	1630	0.22	7	42.3	49.3	0.48	31.8	0.41	49.3	0.48
2003	298	1467	0.2	17	60.9	77.9	0.44	85	0.32	77.9	0.44
2004	223	1084	0.21	7	40	47	0.51	33.3	0.42	47	0.51
2005	225	1075	0.21	12	39.7	51.7	0.5	57.1	0.28	51.7	0.5
2006	266	1433	0.19	7	29.1	36.1	0.64	36.8	0.49	36.1	0.64
2007	204	1241	0.16	9	54.2	63.2	0.56	56.2	0.37	63.2	0.56
2008	149	1103	0.14	8	41.5	49.5	0.68	57.1	0.46	49.5	0.68
2009	101	761	0.13	1	19.1	20.1	0.93	7.7	0.96	20.1	0.93
2010	59	492	0.12	3	23.4	26.4	1.2	25	0.74	26.4	1.2
2011	85	435	0.2	2	15.6	17.6	0.73	10	0.67	17.6	0.73
2012	83	445	0.19	5	22.3	27.3	0.96	26.3	0.57	27.3	0.96
2013	175	470	0.37	6	9.9	15.9	0.65	16.2	0.4	15.9	0.65
2014	97	409	0.24	6	19.2	25.2	0.94	25	0.44	25.2	0.94
2015	74	361	0.2	0	11.6	11.6	1.1	0	−	11.6	1.1
2016	134	737	0.18	4	20.5	24.5	0.84	22.2	0.48	24.5	0.84
2017	111	598	0.19	16	38.9	54.9	0.84	84.2	0.37	54.9	0.84
2018	129	513	0.25	2	17.3	19.3	0.82	8	0.72	19.3	0.82
2019	73	323	0.23	9	17.3	26.3	0.91	39.1	0.43	26.3	0.91
2015−2019	521	2532	0.21	31	105.2	136.2	0.43	147.6	0.26	136.2	0.43

Table 8. LONG−BEAKED COMMON DOLPHIN. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	6.4	6.4	1.6	0	−	6.4	1.6
1991	470	4778	0.1	0	12.9	12.9	1.6	0	−	12.9	1.6
1992	596	4379	0.14	2	14.3	16.3	1.4	14.3	0.67	16.3	1.4
1993	728	5442	0.13	0	5.8	5.8	1.5	0	−	5.8	1.5
1994	759	4248	0.18	1	5.9	6.9	1.2	5.6	1	6.9	1.2
1995	572	3673	0.16	4	5.6	9.6	1.1	25	0.97	9.6	1.1
1996	421	3392	0.12	0	3.8	3.8	2.8	0	−	3.8	2.8
1997	692	3039	0.23	4	5.1	9.1	0.95	17.4	0.6	9.1	0.95
1998	587	3353	0.18	0	6.3	6.3	0.95	0	−	6.3	0.95
1999	526	2634	0.2	1	5.7	6.7	0.88	5	0.99	6.7	0.88
2000	444	1936	0.23	0	3.2	3.2	1.2	0	−	3.2	1.2
2001	339	1665	0.2	0	2.6	2.6	1.1	0	−	2.6	1.1
2002	360	1630	0.22	4	2.9	6.9	0.56	18.2	0.74	6.9	0.56
2003	298	1467	0.2	0	6	6	1.6	0	−	6	1.6
2004	223	1084	0.21	0	4.2	4.2	1.4	0	−	4.2	1.4
2005	225	1075	0.21	3	3.5	6.5	1.1	14.3	0.54	6.5	1.1
2006	266	1433	0.19	0	3	3	1.7	0	−	3	1.7
2007	204	1241	0.16	0	1	1	1.6	0	−	1	1.6
2008	149	1103	0.14	1	1.6	2.6	2.4	7.1	1	2.6	2.4
2009	101	761	0.13	0	1.4	1.4	1.6	0	−	1.4	1.6
2010	59	492	0.12	1	0.8	1.8	1	8.3	1	1.8	1
2011	85	435	0.2	1	2	3	2.8	5	0.95	3	2.8
2012	83	445	0.19	0	0.6	0.6	3.9	0	−	0.6	3.9
2013	175	470	0.37	0	0.4	0.4	2.4	0	−	0.4	2.4
2014	97	409	0.24	0	0.8	0.8	3.2	0	−	0.8	3.2
2015	74	361	0.2	1	1.1	2.1	1.8	5	1	2.1	1.8
2016	134	737	0.18	1	2.2	3.2	1.3	5.6	0.98	3.2	1.3
2017	111	598	0.19	0	2.4	2.4	1.3	0	−	2.4	1.3
2018	129	513	0.25	0	1.2	1.2	1.9	0	−	1.2	1.9
2019	73	323	0.23	0	0.3	0.3	1.7	0	−	0.3	1.7
2015−2019	521	2532	0.21	2	7	9	0.76	9.5	0.68	9	0.76

Table 9. RISSO'S DOLPHIN. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	29	29	2.3	0	−	29	2.3
1991	470	4778	0.1	5	15.9	20.9	0.91	50	0.43	20.9	0.91
1992	596	4379	0.14	5	25.1	30.1	0.69	35.7	0.45	30.1	0.69
1993	728	5442	0.13	7	25.2	32.2	1.1	53.8	0.43	32.2	1.1
1994	759	4248	0.18	1	20.4	21.4	0.63	5.6	0.98	21.4	0.63
1995	572	3673	0.16	6	17.6	23.6	0.98	37.5	0.61	23.6	0.98
1996	421	3392	0.12	0	13	13	1.5	0	−	13	1.5
1997	692	3039	0.23	3	8.2	11.2	1.3	13	0.73	11.2	1.3
1998	587	3353	0.18	0	4.6	4.6	1	0	−	4.6	1
1999	526	2634	0.2	0	6.8	6.8	1	0	−	6.8	1
2000	444	1936	0.23	2	7.2	9.2	1.7	8.7	0.7	9.2	1.7
2001	339	1665	0.2	0	3.8	3.8	0.99	0	−	3.8	0.99
2002	360	1630	0.22	0	4.5	4.5	1.3	0	−	4.5	1.3
2003	298	1467	0.2	4	1.6	5.6	0.45	20	0.98	5.6	0.45
2004	223	1084	0.21	0	1.4	1.4	1.7	0	−	1.4	1.7
2005	225	1075	0.21	0	2.4	2.4	1.8	0	−	2.4	1.8
2006	266	1433	0.19	0	2.1	2.1	2.3	0	−	2.1	2.3
2007	204	1241	0.16	0	1.2	1.2	1.9	0	−	1.2	1.9
2008	149	1103	0.14	1	2.2	3.2	2.1	7.1	1.1	3.2	2.1
2009	101	761	0.13	0	1.4	1.4	2.4	0	−	1.4	2.4
2010	59	492	0.12	0	1.2	1.2	2	0	−	1.2	2
2011	85	435	0.2	1	3.2	4.2	2	5	0.98	4.2	2
2012	83	445	0.19	0	0.8	0.8	2.8	0	−	0.8	2.8
2013	175	470	0.37	0	1.1	1.1	1.7	0	−	1.1	1.7
2014	97	409	0.24	0	1.2	1.2	2.9	0	−	1.2	2.9
2015	74	361	0.2	0	3.5	3.5	1	0	−	3.5	1
2016	134	737	0.18	0	1.4	1.4	3	0	−	1.4	3
2017	111	598	0.19	0	0.6	0.6	2	0	−	0.6	2
2018	129	513	0.25	0	0.6	0.6	2.3	0	−	0.6	2.3
2019	73	323	0.23	0	1.4	1.4	6.2	0	−	1.4	6.2
2015−2019	521	2532	0.21	0	7.4	7.4	1.6	0	−	7.4	1.6

Table 10. SHORT−FINNED PILOT WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	1	10.8	11.8	1.3	25	1	11.8	1.3
1991	470	4778	0.1	0	3.2	3.2	1.3	0	−	3.2	1.3
1992	596	4379	0.14	1	8	9	1.2	7.1	0.97	9	1.2
1993	728	5442	0.13	8	34.5	42.5	0.56	61.5	0.6	42.5	0.56
1994	759	4248	0.18	0	2.5	2.5	1	0	−	2.5	1
1995	572	3673	0.16	0	2.5	2.5	1.4	0	−	2.5	1.4
1996	421	3392	0.12	0	2	2	2.7	0	−	2	2.7
1997	692	3039	0.23	1	3	4	0.75	4.3	1	4	0.75
1998	587	3353	0.18	0	1.8	1.8	0.85	0	−	1.8	0.85
1999	526	2634	0.2	0	1.2	1.2	0.68	0	−	1.2	0.68
2000	444	1936	0.23	0	0.7	0.7	0.67	0	−	0.7	0.67
2001	339	1665	0.2	0	1.6	1.6	0.77	0	−	1.6	0.77
2002	360	1630	0.22	0	1	1	1.1	0	−	1	1.1
2003	298	1467	0.2	1	2.4	3.4	0.77	5	0.97	3.4	0.77
2004	223	1084	0.21	0	0.6	0.6	0.85	0	−	0.6	0.85
2005	225	1075	0.21	0	0.3	0.3	1.1	0	−	0.3	1.1
2006	266	1433	0.19	0	0.8	0.8	1.3	0	−	0.8	1.3
2007	204	1241	0.16	0	0.8	0.8	1.5	0	−	0.8	1.5
2008	149	1103	0.14	0	0.4	0.4	1.5	0	−	0.4	1.5
2009	101	761	0.13	0	0.7	0.7	2	0	−	0.7	2
2010	59	492	0.12	0	0.2	0.2	1.2	0	−	0.2	1.2
2011	85	435	0.2	0	0.2	0.2	1.7	0	−	0.2	1.7
2012	83	445	0.19	0	0.1	0.1	1.3	0	−	0.1	1.3
2013	175	470	0.37	0	0.1	0.1	1.2	0	−	0.1	1.2
2014	97	409	0.24	2	2.8	4.8	1.1	8.3	0.69	4.8	1.1
2015	74	361	0.2	0	0.3	0.3	1.3	0	−	0.3	1.3
2016	134	737	0.18	0	0.4	0.4	1.5	0	−	0.4	1.5
2017	111	598	0.19	0	0.3	0.3	1.4	0	−	0.3	1.4
2018	129	513	0.25	0	0.1	0.1	1.1	0	−	0.1	1.1
2019	73	323	0.23	0	0.2	0.2	1.3	0	−	0.2	1.3
2015−2019	521	2532	0.21	0	1.2	1.2	0.68	0	−	1.2	0.68

Table 11. PAC. WHITE−SIDED DOLPHIN. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	3	55.3	58.3	0.62	75	0.6	58.3	0.62
1991	470	4778	0.1	5	32.3	37.3	0.76	50	0.69	37.3	0.76
1992	596	4379	0.14	3	16.3	19.3	0.86	21.4	0.76	19.3	0.86
1993	728	5442	0.13	2	14	16	0.82	15.4	0.7	16	0.82
1994	759	4248	0.18	3	14.1	17.1	0.56	16.7	0.73	17.1	0.56
1995	572	3673	0.16	1	5.8	6.8	1	6.2	0.98	6.8	1
1996	421	3392	0.12	3	23.9	26.9	0.76	25	0.74	26.9	0.76
1997	692	3039	0.23	3	9.8	12.8	0.64	13	0.58	12.8	0.64
1998	587	3353	0.18	0	2	2	1.5	0	−	2	1.5
1999	526	2634	0.2	0	11.3	11.3	0.88	0	−	11.3	0.88
2000	444	1936	0.23	2	5	7	1.1	8.7	0.74	7	1.1
2001	339	1665	0.2	2	7.9	9.9	0.79	10	0.69	9.9	0.79
2002	360	1630	0.22	1	1.8	2.8	2.2	4.5	0.99	2.8	2.2
2003	298	1467	0.2	0	1.4	1.4	1.8	0	−	1.4	1.8
2004	223	1084	0.21	0	1.1	1.1	1.7	0	−	1.1	1.7
2005	225	1075	0.21	0	0.5	0.5	2.4	0	−	0.5	2.4
2006	266	1433	0.19	0	0.4	0.4	2.8	0	−	0.4	2.8
2007	204	1241	0.16	1	4.7	5.7	1	6.2	1	5.7	1
2008	149	1103	0.14	5	15.1	20.1	1.2	35.7	0.71	20.1	1.2
2009	101	761	0.13	2	10.6	12.6	1.6	15.4	0.99	12.6	1.6
2010	59	492	0.12	0	0.6	0.6	2.8	0	−	0.6	2.8
2011	85	435	0.2	0	0.4	0.4	2.8	0	−	0.4	2.8
2012	83	445	0.19	0	1.4	1.4	2.8	0	−	1.4	2.8
2013	175	470	0.37	0	0.2	0.2	2.6	0	−	0.2	2.6
2014	97	409	0.24	0	0.1	0.1	3.9	0	−	0.1	3.9
2015	74	361	0.2	0	0.3	0.3	4.8	0	−	0.3	4.8
2016	134	737	0.18	0	0.2	0.2	4	0	−	0.2	4
2017	111	598	0.19	0	0.3	0.3	4	0	−	0.3	4
2018	129	513	0.25	0	1.3	1.3	3.1	0	−	1.3	3.1
2019	73	323	0.23	0	0.4	0.4	2	0	−	0.4	2
2015−2019	521	2532	0.21	0	3	3	2	0	−	3	2

Table 12. N. RIGHT WHALE DOLPHIN. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	41.8	41.8	1.2	0	−	41.8	1.2
1991	470	4778	0.1	7	35.6	42.6	0.66	70	0.42	42.6	0.66
1992	596	4379	0.14	2	41.3	43.3	0.55	14.3	0.73	43.3	0.55
1993	728	5442	0.13	7	40	47	0.66	53.8	0.43	47	0.66
1994	759	4248	0.18	7	39.2	46.2	0.55	38.9	0.42	46.2	0.55
1995	572	3673	0.16	9	33.9	42.9	0.68	56.2	0.64	42.9	0.68
1996	421	3392	0.12	5	17.6	22.6	0.79	41.7	0.68	22.6	0.79
1997	692	3039	0.23	5	22.1	27.1	0.69	21.7	0.45	27.1	0.69
1998	587	3353	0.18	0	23.4	23.4	0.55	0	−	23.4	0.55
1999	526	2634	0.2	3	14.2	17.2	0.67	15	0.56	17.2	0.67
2000	444	1936	0.23	11	15.3	26.3	0.7	47.8	0.51	26.3	0.7
2001	339	1665	0.2	5	10.7	15.7	0.87	25	0.52	15.7	0.87
2002	360	1630	0.22	2	14.5	16.5	0.92	9.1	0.71	16.5	0.92
2003	298	1467	0.2	1	4.4	5.4	1.2	5	0.98	5.4	1.2
2004	223	1084	0.21	1	5.3	6.3	1.9	4.8	0.96	6.3	1.9
2005	225	1075	0.21	0	1.4	1.4	1.7	0	−	1.4	1.7
2006	266	1433	0.19	0	5.1	5.1	1.5	0	−	5.1	1.5
2007	204	1241	0.16	1	9.6	10.6	1	6.2	0.98	10.6	1
2008	149	1103	0.14	1	6.6	7.6	1.3	7.1	0.99	7.6	1.3
2009	101	761	0.13	0	2.3	2.3	2.8	0	−	2.3	2.8
2010	59	492	0.12	1	1.5	2.5	2.6	8.3	1.1	2.5	2.6
2011	85	435	0.2	1	3.3	4.3	1.4	5	1	4.3	1.4
2012	83	445	0.19	1	2.4	3.4	1.6	5.3	0.99	3.4	1.6
2013	175	470	0.37	2	1.3	3.3	0.91	5.4	0.99	3.3	0.91
2014	97	409	0.24	1	2.4	3.4	1.6	4.2	0.97	3.4	1.6
2015	74	361	0.2	0	7.7	7.7	1.2	0	−	7.7	1.2
2016	134	737	0.18	5	6.2	11.2	1.2	27.8	0.69	11.2	1.2
2017	111	598	0.19	2	5.8	7.8	1.5	10.5	0.69	7.8	1.5
2018	129	513	0.25	0	7.8	7.8	1.4	0	−	7.8	1.4
2019	73	323	0.23	0	0.4	0.4	2.3	0	−	0.4	2.3
2015−2019	521	2532	0.21	7	28.6	35.6	0.7	33.3	0.53	35.6	0.7

Table 13. KILLER WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0.4	0.4	4.2	0	−	0.4	4.2
1991	470	4778	0.1	0	0.6	0.6	2.8	0	−	0.6	2.8
1992	596	4379	0.14	0	0.6	0.6	2.3	0	−	0.6	2.3
1993	728	5442	0.13	0	0.7	0.7	1.9	0	−	0.7	1.9
1994	759	4248	0.18	0	0	0	−	0	−	0	−
1995	572	3673	0.16	1	0	1	0.11	6.2	0.98	1	0.11
1996	421	3392	0.12	0	1.7	1.7	1.9	0	−	1.7	1.9
1997	692	3039	0.23	0	0.9	0.9	1.3	0	−	0.9	1.3
1998	587	3353	0.18	0	0.3	0.3	3	0	−	0.3	3
1999	526	2634	0.2	0	0	0	−	0	−	0	−
2000	444	1936	0.23	0	0	0	−	0	−	0	−
2001	339	1665	0.2	0	0	0	−	0	−	0	−
2002	360	1630	0.22	0	0	0	−	0	−	0	−
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0	0	−	0	−	0	−
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0	0	−	0	−	0	−
2007	204	1241	0.16	0	0	0	−	0	−	0	−
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0.4	0.4	3.6	0	−	0.4	3.6
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0.1	0.1	3.2	0	−	0.1	3.2
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0	0	−	0	−	0	−

Table 14. DALL'S PORPOISE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019.
Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	1	20.4	21.4	0.76	25	1	21.4	0.76
1991	470	4778	0.1	2	13.4	15.4	0.96	20	0.68	15.4	0.96
1992	596	4379	0.14	1	14.1	15.1	0.94	7.1	1	15.1	0.94
1993	728	5442	0.13	9	31.4	40.4	0.41	69.2	0.36	40.4	0.41
1994	759	4248	0.18	2	10.6	12.6	0.87	11.1	0.72	12.6	0.87
1995	572	3673	0.16	1	6.6	7.6	0.93	6.2	1	7.6	0.93
1996	421	3392	0.12	2	12.1	14.1	1.1	16.7	0.73	14.1	1.1
1997	692	3039	0.23	4	9.7	13.7	0.83	17.4	0.62	13.7	0.83
1998	587	3353	0.18	0	1.6	1.6	1	0	−	1.6	1
1999	526	2634	0.2	0	1.3	1.3	0.81	0	−	1.3	0.81
2000	444	1936	0.23	0	1.3	1.3	1.4	0	−	1.3	1.4
2001	339	1665	0.2	0	1	1	0.97	0	−	1	0.97
2002	360	1630	0.22	0	1.4	1.4	1.6	0	−	1.4	1.6
2003	298	1467	0.2	0	0.6	0.6	1.3	0	−	0.6	1.3
2004	223	1084	0.21	0	0.9	0.9	2.9	0	−	0.9	2.9
2005	225	1075	0.21	0	0.9	0.9	1.4	0	−	0.9	1.4
2006	266	1433	0.19	0	3.3	3.3	1.7	0	−	3.3	1.7
2007	204	1241	0.16	0	0.8	0.8	2.2	0	−	0.8	2.2
2008	149	1103	0.14	0	0.3	0.3	3.1	0	−	0.3	3.1
2009	101	761	0.13	0	0.1	0.1	2	0	−	0.1	2
2010	59	492	0.12	0	0.2	0.2	2.2	0	−	0.2	2.2
2011	85	435	0.2	0	0.3	0.3	2.2	0	−	0.3	2.2
2012	83	445	0.19	0	0.2	0.2	3.3	0	−	0.2	3.3
2013	175	470	0.37	0	0.1	0.1	2.7	0	−	0.1	2.7
2014	97	409	0.24	1	0.5	1.5	0.93	4.2	0.97	1.5	0.93
2015	74	361	0.2	0	0.6	0.6	2	0	−	0.6	2
2016	134	737	0.18	0	0.3	0.3	2.4	0	−	0.3	2.4
2017	111	598	0.19	0	0.7	0.7	1.5	0	−	0.7	1.5
2018	129	513	0.25	0	1.1	1.1	2	0	−	1.1	2
2019	73	323	0.23	0	0.6	0.6	4.4	0	−	0.6	4.4
2015−2019	521	2532	0.21	0	3.7	3.7	1.3	0	−	3.7	1.3

Table 15. STRIPED DOLPHIN. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0	0	−	0	−	0	−
1991	470	4778	0.1	0	0	0	−	0	−	0	−
1992	596	4379	0.14	0	0.4	0.4	1.6	0	−	0.4	1.6
1993	728	5442	0.13	0	2.6	2.6	6.8	0	−	2.6	6.8
1994	759	4248	0.18	1	1.2	2.2	6.8	5.6	1	2.2	6.8
1995	572	3673	0.16	0	0.1	0.1	6.8	0	−	0.1	6.8
1996	421	3392	0.12	0	0	0	−	0	−	0	−
1997	692	3039	0.23	0	0	0	−	0	−	0	−
1998	587	3353	0.18	0	0.1	0.1	4	0	−	0.1	4
1999	526	2634	0.2	0	0.1	0.1	4	0	−	0.1	4
2000	444	1936	0.23	0	0	0	−	0	−	0	−
2001	339	1665	0.2	0	0	0	−	0	−	0	−
2002	360	1630	0.22	0	0	0	−	0	−	0	−
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0	0	−	0	−	0	−
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0	0	−	0	−	0	−
2007	204	1241	0.16	0	0	0	−	0	−	0	−
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0	0	−	0	−	0	−
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0	0	−	0	−	0	−
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0	0	−	0	−	0	−

Table 16. BOTTLENOSE DOLPHIN. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0	0	−	0	−	0	−
1991	470	4778	0.1	0	0.6	0.6	2.2	0	−	0.6	2.2
1992	596	4379	0.14	3	11	14	3.5	21.4	1	14	3.5
1993	728	5442	0.13	0	7.4	7.4	5.4	0	−	7.4	5.4
1994	759	4248	0.18	0	0.5	0.5	6.1	0	−	0.5	6.1
1995	572	3673	0.16	0	0.3	0.3	4.4	0	−	0.3	4.4
1996	421	3392	0.12	0	0.4	0.4	5	0	−	0.4	5
1997	692	3039	0.23	0	0.4	0.4	4.3	0	−	0.4	4.3
1998	587	3353	0.18	0	0.1	0.1	3.9	0	−	0.1	3.9
1999	526	2634	0.2	0	1.5	1.5	14	0	−	1.5	14
2000	444	1936	0.23	0	0.2	0.2	8.7	0	−	0.2	8.7
2001	339	1665	0.2	0	0.2	0.2	8.7	0	−	0.2	8.7
2002	360	1630	0.22	0	0	0	−	0	−	0	−
2003	298	1467	0.2	0	0.4	0.4	4.5	0	−	0.4	4.5
2004	223	1084	0.21	0	0.2	0.2	2.2	0	−	0.2	2.2
2005	225	1075	0.21	0	1.1	1.1	3.4	0	−	1.1	3.4
2006	266	1433	0.19	0	0.6	0.6	4.2	0	−	0.6	4.2
2007	204	1241	0.16	0	0.5	0.5	4.2	0	−	0.5	4.2
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0	0	−	0	−	0	−
2010	59	492	0.12	1	0	1	2.6e−15	8.3	0.96	1	2.6e−15
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0.2	0.2	7.2	0	−	0.2	7.2
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0	0	−	0	−	0	−

Table 17. PYGMY SPERM WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.97) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	1.6	1.6	2.1	0	−	1.5	2.2
1991	470	4778	0.1	0	1	1	1.3	0	−	1	1.3
1992	596	4379	0.14	1	2.1	3.1	1.2	7.1	0.99	3	0.81
1993	728	5442	0.13	1	1.1	2.1	1	7.7	1	2.1	1
1994	759	4248	0.18	0	0.9	0.9	1.2	0	−	0.9	1.2
1995	572	3673	0.16	0	1.5	1.5	1.2	0	−	1.5	1.2
1996	421	3392	0.12	0	0.4	0.4	3.5	0	−	0.4	3.5
1997	692	3039	0.23	0	0.4	0.4	1.2	0	−	0.4	1.2
1998	587	3353	0.18	0	0	0	−	0	−	0	−
1999	526	2634	0.2	0	0	0	−	0	−	0	−
2000	444	1936	0.23	0	0.1	0.1	3.9	0	−	0.1	3.9
2001	339	1665	0.2	0	0	0	−	0	−	0	−
2002	360	1630	0.22	0	0	0	−	0	−	0	−
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0	0	−	0	−	0	−
2005	225	1075	0.21	0	0.1	0.1	5	0	−	0.1	5
2006	266	1433	0.19	0	0.7	0.7	2.1	0	−	0.6	2.1
2007	204	1241	0.16	0	0	0	−	0	−	0	−
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0	0	−	0	−	0	−
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0	0	−	0	−	0	−
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0	0	−	0	−	0	−

Table 18. BAIRD'S BEAKED WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.97) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0.2	0.2	0.46	0	−	0.2	0.46
1991	470	4778	0.1	0	0.2	0.2	0.46	0	−	0.2	0.46
1992	596	4379	0.14	0	2.7	2.7	1.2	0	−	2.6	1.2
1993	728	5442	0.13	0	0.8	0.8	1.1	0	−	0.8	1.1
1994	759	4248	0.18	1	0.7	1.7	0.88	5.6	1	1.6	0.74
1995	572	3673	0.16	0	0.3	0.3	2.8	0	−	0.3	2.8
1996	421	3392	0.12	0	0.1	0.1	0.48	0	−	0.1	0.48
1997	692	3039	0.23	0	0.1	0.1	2.3	0	−	0.1	2.3
1998	587	3353	0.18	0	0	0	−	0	−	0	−
1999	526	2634	0.2	0	0	0	−	0	−	0	−
2000	444	1936	0.23	0	0.2	0.2	4.3	0	−	0.1	4.6
2001	339	1665	0.2	0	0	0	−	0	−	0	−
2002	360	1630	0.22	0	0	0	−	0	−	0	−
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0	0	−	0	−	0	−
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0	0	−	0	−	0	−
2007	204	1241	0.16	0	0	0	−	0	−	0	−
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0	0	−	0	−	0	−
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0	0	−	0	−	0	−
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0	0	−	0	−	0	−

Table 19. HUBB'S BEAKED WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.97) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	9	9	1.4	0	−	8.8	1.4
1991	470	4778	0.1	0	3.3	3.3	0.87	0	−	3.2	0.88
1992	596	4379	0.14	3	4.9	7.9	0.62	21.4	0.58	7.7	0.38
1993	728	5442	0.13	0	4.9	4.9	0.6	0	−	4.8	0.6
1994	759	4248	0.18	2	4.2	6.2	0.64	11.1	0.71	6.1	0.44
1995	572	3673	0.16	0	3.5	3.5	0.94	0	−	3.4	0.95
1996	421	3392	0.12	0	1.6	1.6	1.1	0	−	1.5	1.1
1997	692	3039	0.23	0	1.4	1.4	0.97	0	−	1.3	0.98
1998	587	3353	0.18	0	0	0	−	0	−	0	−
1999	526	2634	0.2	0	1.4	1.4	2.4	0	−	1.3	2.4
2000	444	1936	0.23	0	0	0	−	0	−	0	−
2001	339	1665	0.2	0	0	0	−	0	−	0	−
2002	360	1630	0.22	0	2.4	2.4	2.1	0	−	2.3	2.1
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0	0	−	0	−	0	−
2005	225	1075	0.21	0	0.1	0.1	7	0	−	0.1	7
2006	266	1433	0.19	0	0	0	−	0	−	0	−
2007	204	1241	0.16	0	0	0	−	0	−	0	−
2008	149	1103	0.14	0	0.4	0.4	3.4	0	−	0.4	3.4
2009	101	761	0.13	0	0	0	−	0	−	0	−
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0	0	−	0	−	0	−
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0.1	0.1	0.86	0	−	0.1	0.86
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0.1	0.1	2.4	0	−	0.1	2.4

Table 20. STEJNEGER'S BEAKED WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.97) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0.3	0.3	0.84	0	−	0.3	0.84
1991	470	4778	0.1	0	0.3	0.3	0.42	0	−	0.2	0.46
1992	596	4379	0.14	0	1.7	1.7	2	0	−	1.7	2
1993	728	5442	0.13	0	1.8	1.8	1.6	0	−	1.8	1.6
1994	759	4248	0.18	1	0.5	1.5	0.58	5.6	0.99	1.4	0.49
1995	572	3673	0.16	0	0.1	0.1	0.5	0	−	0.1	0.5
1996	421	3392	0.12	0	0.3	0.3	4.9	0	−	0.3	4.9
1997	692	3039	0.23	0	0.1	0.1	3.3	0	−	0.1	3.3
1998	587	3353	0.18	0	0	0	−	0	−	0	−
1999	526	2634	0.2	0	0	0	−	0	−	0	−
2000	444	1936	0.23	0	0	0	−	0	−	0	−
2001	339	1665	0.2	0	0	0	−	0	−	0	−
2002	360	1630	0.22	0	0	0	−	0	−	0	−
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0	0	−	0	−	0	−
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0	0	−	0	−	0	−
2007	204	1241	0.16	0	0	0	−	0	−	0	−
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0	0	−	0	−	0	−
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0	0	−	0	−	0	−
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0	0	−	0	−	0	−

Table 21. SPERM WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.7) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	8.4	8.4	2.2	0	−	5.7	1.6
1991	470	4778	0.1	0	1.9	1.9	2.6	0	−	1.3	1.9
1992	596	4379	0.14	3	5.9	8.9	1.4	21.4	1	5.2	0.85
1993	728	5442	0.13	3	10.2	13.2	2	23.1	0.75	9.2	1.2
1994	759	4248	0.18	0	5.3	5.3	1.4	0	−	3.7	1
1995	572	3673	0.16	0	3.4	3.4	1.7	0	−	2.3	1.3
1996	421	3392	0.12	1	2.5	3.5	1.7	8.3	0.96	2.7	0.78
1997	692	3039	0.23	0	2.1	2.1	2.4	0	−	1.5	1.7
1998	587	3353	0.18	1	7.8	8.8	1.3	5.6	0.99	6.5	0.79
1999	526	2634	0.2	0	0.5	0.5	3.8	0	−	0.4	2.8
2000	444	1936	0.23	0	1.3	1.3	1.7	0	−	0.9	1.3
2001	339	1665	0.2	0	0.4	0.4	3.3	0	−	0.3	2.4
2002	360	1630	0.22	0	0.3	0.3	3	0	−	0.2	2.1
2003	298	1467	0.2	0	0.6	0.6	3.2	0	−	0.4	2.4
2004	223	1084	0.21	0	0.6	0.6	2.4	0	−	0.4	1.8
2005	225	1075	0.21	0	0.8	0.8	2.4	0	−	0.6	1.8
2006	266	1433	0.19	0	1.6	1.6	2.4	0	−	1.1	1.8
2007	204	1241	0.16	0	0.4	0.4	3.5	0	−	0.2	2.5
2008	149	1103	0.14	0	0.3	0.3	2.2	0	−	0.2	1.6
2009	101	761	0.13	0	0.9	0.9	3	0	−	0.6	2.1
2010	59	492	0.12	2	0.3	2.3	0.48	16.7	0.96	2.2	0.22
2011	85	435	0.2	0	0.5	0.5	3.6	0	−	0.3	2.5
2012	83	445	0.19	0	0.7	0.7	4	0	−	0.5	2.7
2013	175	470	0.37	0	0.2	0.2	3.1	0	−	0.1	2.3
2014	97	409	0.24	0	0.1	0.1	3.9	0	−	0	−
2015	74	361	0.2	0	0.1	0.1	11	0	−	0.1	11
2016	134	737	0.18	0	0.1	0.1	3.1	0	−	0.1	3.1
2017	111	598	0.19	0	2.3	2.3	3	0	−	1.5	2.2
2018	129	513	0.25	0	0.2	0.2	3.6	0	−	0.1	2.6
2019	73	323	0.23	0	0.3	0.3	5.6	0	−	0.2	4.1
2015−2019	521	2532	0.21	0	2.7	2.7	2.4	0	−	1.9	1.7

Table 22. CUVIER'S BEAKED WHALE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.97) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	19.3	19.3	0.46	0	−	18.7	0.46
1991	470	4778	0.1	0	19.8	19.8	0.26	0	−	19.2	0.26
1992	596	4379	0.14	6	22.3	28.3	0.24	42.9	0.41	27.6	0.19
1993	728	5442	0.13	3	24	27	0.18	23.1	0.58	26.2	0.17
1994	759	4248	0.18	6	18.9	24.9	0.2	33.3	0.4	24.4	0.15
1995	572	3673	0.16	6	16	22	0.25	37.5	0.4	20.5	0.19
1996	421	3392	0.12	0	9.1	9.1	0.36	0	−	8.8	0.37
1997	692	3039	0.23	0	3.9	3.9	0.3	0	−	3.8	0.31
1998	587	3353	0.18	0	0.4	0.4	2.3	0	−	0.4	2.3
1999	526	2634	0.2	0	0.5	0.5	2.9	0	−	0.5	2.9
2000	444	1936	0.23	0	0.1	0.1	3.7	0	−	0.1	3.7
2001	339	1665	0.2	0	0.2	0.2	2.8	0	−	0.2	2.8
2002	360	1630	0.22	0	0.1	0.1	3.8	0	−	0.1	3.8
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0.1	0.1	5.1	0	−	0.1	5.1
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0.1	0.1	4.4	0	−	0.1	4.4
2007	204	1241	0.16	0	0.1	0.1	4	0	−	0.1	4
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0.1	0.1	6	0	−	0.1	6
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0.1	0.1	6.7	0	−	0.1	6.7
2013	175	470	0.37	0	0.2	0.2	2.6	0	−	0.2	2.6
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0.4	0.4	1.6	0	−	0.4	1.6
2017	111	598	0.19	0	0.1	0.1	5.9	0	−	0.1	5.9
2018	129	513	0.25	0	0.1	0.1	4.9	0	−	0.1	4.9
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0.5	0.5	1.5	0	−	0.5	1.5

Table 23. UNID. ZIPHIID. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.97) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	1.2	1.2	0.62	0	−	1.1	0.64
1991	470	4778	0.1	0	2.5	2.5	1.1	0	−	2.4	1.1
1992	596	4379	0.14	2	5	7	0.77	14.3	0.69	6.9	0.55
1993	728	5442	0.13	0	2.7	2.7	0.81	0	−	2.6	0.81
1994	759	4248	0.18	1	1.9	2.9	0.93	5.6	1	2.8	0.62
1995	572	3673	0.16	0	1.3	1.3	1	0	−	1.2	1.1
1996	421	3392	0.12	0	1.6	1.6	1.4	0	−	1.5	1.5
1997	692	3039	0.23	0	0.4	0.4	1.9	0	−	0.4	1.9
1998	587	3353	0.18	0	0.5	0.5	2.9	0	−	0.5	2.9
1999	526	2634	0.2	0	0	0	−	0	−	0	−
2000	444	1936	0.23	0	0.1	0.1	4.9	0	−	0.1	4.9
2001	339	1665	0.2	0	0	0	−	0	−	0	−
2002	360	1630	0.22	0	0	0	−	0	−	0	−
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0	0	−	0	−	0	−
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0	0	−	0	−	0	−
2007	204	1241	0.16	0	0	0	−	0	−	0	−
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0	0	−	0	−	0	−
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0	0	−	0	−	0	−
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0.1	0.1	8	0	−	0.1	8

Table 24. CA SEA LION. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.98) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	2	59.8	61.8	1.6	50	1	60.7	0.9
1991	470	4778	0.1	4	81.1	85.1	0.71	40	0.49	83.6	0.39
1992	596	4379	0.14	9	51	60	0.98	64.3	0.33	59.1	0.48
1993	728	5442	0.13	12	79.6	91.6	0.59	92.3	0.33	89.1	0.3
1994	759	4248	0.18	5	49.2	54.2	0.6	27.8	0.46	53.3	0.31
1995	572	3673	0.16	5	48.6	53.6	0.65	31.2	0.42	51.8	0.34
1996	421	3392	0.12	4	49.7	53.7	1.3	33.3	0.5	52.8	0.67
1997	692	3039	0.23	39	84.6	123.6	0.47	169.6	0.3	121.1	0.19
1998	587	3353	0.18	23	118.1	141.1	0.48	127.8	0.22	138.9	0.23
1999	526	2634	0.2	6	71.2	77.2	0.53	30	0.4	75.9	0.28
2000	444	1936	0.23	13	49.4	62.4	0.55	56.5	0.35	61.5	0.25
2001	339	1665	0.2	2	37.1	39.1	0.83	10	0.71	38.4	0.46
2002	360	1630	0.22	18	44	62	0.71	81.8	0.24	61.2	0.29
2003	298	1467	0.2	4	28.2	32.2	0.74	20	0.5	31.7	0.37
2004	223	1084	0.21	7	32.1	39.1	0.69	33.3	0.35	37.5	0.34
2005	225	1075	0.21	1	23.4	24.4	0.76	4.8	0.98	24	0.42
2006	266	1433	0.19	12	56.7	68.7	1.2	63.2	0.35	67.7	0.58
2007	204	1241	0.16	8	19.9	27.9	1.1	50	0.4	27.6	0.46
2008	149	1103	0.14	7	35.2	42.2	0.84	50	0.4	41.5	0.4
2009	101	761	0.13	5	24	29	0.94	38.5	0.43	28.6	0.45
2010	59	492	0.12	0	10.3	10.3	1.4	0	−	10.1	0.8
2011	85	435	0.2	18	78.6	96.6	1.1	90	0.53	95.2	0.5
2012	83	445	0.19	6	18.9	24.9	1.1	31.6	0.4	24.6	0.5
2013	175	470	0.37	3	11.1	14.1	0.83	8.1	0.58	13.9	0.38
2014	97	409	0.24	3	11.3	14.3	1.2	12.5	1	14.1	0.55
2015	74	361	0.2	0	5.8	5.8	1.5	0	−	5.6	0.86
2016	134	737	0.18	0	16.2	16.2	1.6	0	−	15.9	0.93
2017	111	598	0.19	2	20.1	22.1	0.96	10.5	0.71	21.7	0.5
2018	129	513	0.25	2	10.2	12.2	1.6	8	0.72	12	0.77
2019	73	323	0.23	0	3.8	3.8	1.7	0	−	3.7	0.97
2015−2019	521	2532	0.21	4	54.7	58.7	0.69	19	0.49	57.7	0.35

Table 25. STELLER'S SEA LION. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0	0	−	0	−	0	−
1991	470	4778	0.1	0	1.3	1.3	1.8	0	−	1.3	1.8
1992	596	4379	0.14	1	2.2	3.2	1.7	7.1	0.98	3.2	1.7
1993	728	5442	0.13	0	1	1	0.96	0	−	1	0.96
1994	759	4248	0.18	1	0.9	1.9	3.4	5.6	0.98	1.9	3.4
1995	572	3673	0.16	0	0.2	0.2	2.4	0	−	0.2	2.4
1996	421	3392	0.12	0	1	1	2.4	0	−	1	2.4
1997	692	3039	0.23	0	0.4	0.4	5.2	0	−	0.4	5.2
1998	587	3353	0.18	0	0.1	0.1	2.6	0	−	0.1	2.6
1999	526	2634	0.2	0	0.4	0.4	2.6	0	−	0.4	2.6
2000	444	1936	0.23	0	0	0	−	0	−	0	−
2001	339	1665	0.2	0	0.1	0.1	1.6	0	−	0.1	1.6
2002	360	1630	0.22	0	1.3	1.3	1.6	0	−	1.3	1.6
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0.4	0.4	2.9	0	−	0.4	2.9
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0	0	−	0	−	0	−
2007	204	1241	0.16	0	0	0	−	0	−	0	−
2008	149	1103	0.14	0	0.1	0.1	3.9	0	−	0.1	3.9
2009	101	761	0.13	0	0.3	0.3	3.9	0	−	0.3	3.9
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0.2	0.2	2.2	0	−	0.2	2.2
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0.1	0.1	8	0	−	0.1	8
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0.2	0.2	4.2	0	−	0.2	4.2
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0.2	0.2	3.8	0	−	0.2	3.8

Table 26. N ELEPHANT SEAL. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	5	105.8	110.8	0.27	125	0.45	110.8	0.27
1991	470	4778	0.1	13	109.2	122.2	0.094	130	0.27	122.2	0.094
1992	596	4379	0.14	15	103.6	118.6	0.093	107.1	0.26	118.6	0.093
1993	728	5442	0.13	14	104.1	118.1	0.078	107.7	0.28	118.1	0.078
1994	759	4248	0.18	22	89.4	111.4	0.1	122.2	0.23	111.4	0.1
1995	572	3673	0.16	14	75.5	89.5	0.11	87.5	0.28	89.5	0.11
1996	421	3392	0.12	5	40.5	45.5	0.22	41.7	0.44	45.5	0.22
1997	692	3039	0.23	9	30.8	39.8	0.18	39.1	0.33	39.8	0.18
1998	587	3353	0.18	4	18.2	22.2	0.45	22.2	0.52	22.2	0.45
1999	526	2634	0.2	2	7.2	9.2	0.51	10	0.66	9.2	0.51
2000	444	1936	0.23	6	18.2	24.2	0.3	26.1	0.41	24.2	0.3
2001	339	1665	0.2	1	3.5	4.5	0.94	5	1	4.5	0.94
2002	360	1630	0.22	1	2.3	3.3	1.2	4.5	0.99	3.3	1.2
2003	298	1467	0.2	1	4.4	5.4	0.74	5	0.99	5.4	0.74
2004	223	1084	0.21	0	0.8	0.8	2.1	0	−	0.8	2.1
2005	225	1075	0.21	1	3	4	0.97	4.8	1	4	0.97
2006	266	1433	0.19	0	1	1	2.2	0	−	1	2.2
2007	204	1241	0.16	1	3.3	4.3	0.94	6.2	1	4.3	0.94
2008	149	1103	0.14	0	1.5	1.5	1.6	0	−	1.5	1.6
2009	101	761	0.13	0	0.8	0.8	2.4	0	−	0.8	2.4
2010	59	492	0.12	0	0.6	0.6	2.9	0	−	0.6	2.9
2011	85	435	0.2	0	1.3	1.3	1.5	0	−	1.3	1.5
2012	83	445	0.19	0	0.7	0.7	2.1	0	−	0.7	2.1
2013	175	470	0.37	0	0.9	0.9	1.3	0	−	0.9	1.3
2014	97	409	0.24	1	2.3	3.3	1.3	4.2	1	3.3	1.3
2015	74	361	0.2	0	0.2	0.2	3.8	0	−	0.2	3.8
2016	134	737	0.18	0	2.7	2.7	0.92	0	−	2.7	0.92
2017	111	598	0.19	3	10.2	13.2	0.82	15.8	0.56	13.2	0.82
2018	129	513	0.25	0	1.8	1.8	1.4	0	−	1.8	1.4
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	3	13.8	16.8	0.62	14.3	0.57	16.8	0.62

Table 27. LOGGERHEAD TURTLE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.25) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	3.8	3.8	1.2	0	−	0.9	1.1
1991	470	4778	0.1	0	10.6	10.6	0.64	0	−	2.6	0.72
1992	596	4379	0.14	2	7.8	9.8	0.74	14.3	0.71	2.9	0.52
1993	728	5442	0.13	5	18.5	23.5	0.31	38.5	0.45	4.6	0.49
1994	759	4248	0.18	0	6.8	6.8	0.47	0	−	1.7	0.59
1995	572	3673	0.16	0	5	5	0.56	0	−	1.2	0.63
1996	421	3392	0.12	0	2.4	2.4	0.91	0	−	0.6	0.91
1997	692	3039	0.23	3	7.5	10.5	0.46	13	0.59	2.9	0.37
1998	587	3353	0.18	4	13.9	17.9	0.68	22.2	0.81	5.5	0.46
1999	526	2634	0.2	0	0.8	0.8	2	0	−	0.2	1.9
2000	444	1936	0.23	0	0.9	0.9	2.1	0	−	0.2	2.3
2001	339	1665	0.2	1	2.1	3.1	1.1	5	0.97	0.5	1.1
2002	360	1630	0.22	0	0.6	0.6	2.1	0	−	0.2	1.7
2003	298	1467	0.2	0	0.7	0.7	2.1	0	−	0.2	2
2004	223	1084	0.21	0	0.3	0.3	2.5	0	−	0.1	2
2005	225	1075	0.21	0	0.1	0.1	3.9	0	−	0	−
2006	266	1433	0.19	1	2.3	3.3	1.3	5.3	1	0.6	1.2
2007	204	1241	0.16	0	0.5	0.5	2.6	0	−	0.1	2.3
2008	149	1103	0.14	0	0.2	0.2	5.6	0	−	0.1	5.3
2009	101	761	0.13	0	0.2	0.2	3.6	0	−	0	−
2010	59	492	0.12	0	0.2	0.2	3.6	0	−	0	−
2011	85	435	0.2	0	0.1	0.1	4.2	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0	0	−	0	−	0	−
2014	97	409	0.24	0	0.7	0.7	2.5	0	−	0.2	2.5
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	1.5	1.5	2.2	0	−	0.4	2.1
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0.1	0.1	5.6	0	−	0	−
2019	73	323	0.23	0	0.8	0.8	3.1	0	−	0.2	2.7
2015−2019	521	2532	0.21	0	2.4	2.4	1.9	0	−	0.6	1.5

Table 28. GREEN TURTLE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0	0	−	0	−	0	−
1991	470	4778	0.1	0	0.9	0.9	2.3	0	−	0.9	2.3
1992	596	4379	0.14	0	0	0	−	0	−	0	−
1993	728	5442	0.13	0	0.1	0.1	2.3	0	−	0.1	2.3
1994	759	4248	0.18	0	0.3	0.3	2.3	0	−	0.3	2.3
1995	572	3673	0.16	0	0	0	−	0	−	0	−
1996	421	3392	0.12	0	0.1	0.1	2.7	0	−	0.1	2.7
1997	692	3039	0.23	0	0.1	0.1	2.7	0	−	0.1	2.7
1998	587	3353	0.18	0	0	0	−	0	−	0	−
1999	526	2634	0.2	1	0.4	1.4	2.5	5	1	1.4	2.5
2000	444	1936	0.23	0	0.3	0.3	4.2	0	−	0.3	4.2
2001	339	1665	0.2	0	0.1	0.1	2.7	0	−	0.1	2.7
2002	360	1630	0.22	0	0.2	0.2	1.9	0	−	0.2	1.9
2003	298	1467	0.2	0	0.4	0.4	1.9	0	−	0.4	1.9
2004	223	1084	0.21	0	0	0	−	0	−	0	−
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0	0	−	0	−	0	−
2007	204	1241	0.16	0	0	0	−	0	−	0	−
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0.2	0.2	3.5	0	−	0.2	3.5
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0.4	0.4	3	0	−	0.4	3
2012	83	445	0.19	0	0.2	0.2	3	0	−	0.2	3
2013	175	470	0.37	0	0	0	−	0	−	0	−
2014	97	409	0.24	0	0.3	0.3	2	0	−	0.3	2
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0.1	0.1	4.9	0	−	0.1	4.9
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0.1	0.1	4.9	0	−	0.1	4.9

Table 29. LEATHERBACK TURTLE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.68) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	1	14.9	15.9	0.97	25	0.98	11	0.84
1991	470	4778	0.1	1	9.5	10.5	0.74	10	1	6.5	0.72
1992	596	4379	0.14	4	20.2	24.2	0.56	28.6	0.47	15.8	0.47
1993	728	5442	0.13	3	14.1	17.1	0.55	23.1	0.58	12.6	0.41
1994	759	4248	0.18	1	8.9	9.9	0.58	5.6	1	6	0.56
1995	572	3673	0.16	5	15.9	20.9	0.65	31.2	0.45	14.9	0.46
1996	421	3392	0.12	2	10.2	12.2	0.65	16.7	0.7	8.9	0.48
1997	692	3039	0.23	4	16.5	20.5	0.47	17.4	0.5	13.1	0.39
1998	587	3353	0.18	0	6.6	6.6	0.73	0	−	4.5	0.7
1999	526	2634	0.2	2	5	7	0.86	10	0.72	3.4	0.83
2000	444	1936	0.23	0	3.9	3.9	0.8	0	−	2.7	0.75
2001	339	1665	0.2	0	0.8	0.8	1.3	0	−	0.6	1.1
2002	360	1630	0.22	0	5.6	5.6	1.3	0	−	3.8	1.2
2003	298	1467	0.2	0	0.4	0.4	1.5	0	−	0.3	1.4
2004	223	1084	0.21	0	0.3	0.3	1.8	0	−	0.2	1.7
2005	225	1075	0.21	0	1.2	1.2	1.8	0	−	0.8	1.7
2006	266	1433	0.19	0	1.1	1.1	1.3	0	−	0.7	1.3
2007	204	1241	0.16	0	0.5	0.5	1.6	0	−	0.3	1.5
2008	149	1103	0.14	0	0.2	0.2	3.1	0	−	0.1	2.9
2009	101	761	0.13	1	0.2	1.2	0.86	7.7	0.97	0.2	3.4
2010	59	492	0.12	0	0.3	0.3	3.3	0	−	0.2	3.1
2011	85	435	0.2	0	0.2	0.2	2.6	0	−	0.1	2.6
2012	83	445	0.19	1	0.3	1.3	0.86	5.3	0.96	0.2	2.3
2013	175	470	0.37	0	0.7	0.7	1.5	0	−	0.5	1.5
2014	97	409	0.24	0	0.5	0.5	1.9	0	−	0.4	1.8
2015	74	361	0.2	0	0.1	0.1	4.3	0	−	0.1	4.3
2016	134	737	0.18	0	0.4	0.4	2.2	0	−	0.3	2.1
2017	111	598	0.19	0	0.8	0.8	1.4	0	−	0.6	1.4
2018	129	513	0.25	0	0.5	0.5	1.6	0	−	0.3	1.5
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	2	2	1	0	−	1.3	0.93

Table 30. OLIVE RIDLEY TURTLE. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0.1	0.1	3.3	0	−	0	−
1991	470	4778	0.1	0	0	0	−	0	−	0	−
1992	596	4379	0.14	0	0	0	−	0	−	0	−
1993	728	5442	0.13	0	0.7	0.7	2.1	0	−	0	−
1994	759	4248	0.18	0	1	1	1.4	0	−	0	−
1995	572	3673	0.16	0	0	0	−	0	−	0	−
1996	421	3392	0.12	0	0.2	0.2	2.9	0	−	0	−
1997	692	3039	0.23	0	0	0	−	0	−	0	−
1998	587	3353	0.18	0	0.1	0.1	2.3	0	−	0	−
1999	526	2634	0.2	1	0.3	1.3	0.73	5	0.99	0	−
2000	444	1936	0.23	0	0.1	0.1	2.9	0	−	0	−
2001	339	1665	0.2	0	0	0	−	0	−	0	−
2002	360	1630	0.22	0	0.1	0.1	2.2	0	−	0	−
2003	298	1467	0.2	0	0.1	0.1	3.9	0	−	0	−
2004	223	1084	0.21	0	0.1	0.1	2.9	0	−	0	−
2005	225	1075	0.21	0	0.2	0.2	2.7	0	−	0	−
2006	266	1433	0.19	0	0	0	−	0	−	0	−
2007	204	1241	0.16	0	0	0	−	0	−	0	−
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0.1	0.1	5.5	0	−	0	−
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0.1	0.1	2.3	0	−	0	−
2014	97	409	0.24	0	0.1	0.1	3	0	−	0	−
2015	74	361	0.2	0	0.4	0.4	2.5	0	−	0	−
2016	134	737	0.18	0	0.3	0.3	2.5	0	−	0	−
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0.1	0.1	3.9	0	−	0	−
2019	73	323	0.23	0	0.1	0.1	3	0	−	0	−
2015−2019	521	2532	0.21	0	0.8	0.8	1.6	0	−	0	−

Table 31. UNID. CORMORANT. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (1) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	0	0	−	0	−	0	−
1991	470	4778	0.1	0	0.6	0.6	3.1	0	−	0.6	3.1
1992	596	4379	0.14	0	0.6	0.6	5	0	−	0.6	5
1993	728	5442	0.13	0	0.3	0.3	5.1	0	−	0.3	5.1
1994	759	4248	0.18	0	0.3	0.3	2.6	0	−	0.3	2.6
1995	572	3673	0.16	0	0.3	0.3	2.6	0	−	0.3	2.6
1996	421	3392	0.12	0	0	0	−	0	−	0	−
1997	692	3039	0.23	0	0	0	−	0	−	0	−
1998	587	3353	0.18	0	0	0	−	0	−	0	−
1999	526	2634	0.2	0	0.5	0.5	4.7	0	−	0.5	4.7
2000	444	1936	0.23	0	0.1	0.1	4.7	0	−	0.1	4.7
2001	339	1665	0.2	0	0	0	−	0	−	0	−
2002	360	1630	0.22	0	0.1	0.1	0.025	0	−	0.1	0.025
2003	298	1467	0.2	1	0	1	2.4	5	0.98	1	2.4
2004	223	1084	0.21	0	0.4	0.4	2.4	0	−	0.4	2.4
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0.2	0.2	2.4	0	−	0.2	2.4
2007	204	1241	0.16	0	0	0	−	0	−	0	−
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0.3	0.3	3.4	0	−	0.3	3.4
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0	0	−	0	−	0	−
2014	97	409	0.24	0	0.2	0.2	2.5	0	−	0.2	2.5
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0.1	0.1	6	0	−	0.1	6

Table 32. NORTHERN FULMAR. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.14) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	0	1.6	1.6	3.1	0	−	0.2	1.9
1991	470	4778	0.1	0	2.6	2.6	2.6	0	−	0.4	1.5
1992	596	4379	0.14	0	1.7	1.7	2.1	0	−	0.2	1.4
1993	728	5442	0.13	0	1.9	1.9	1.5	0	−	0.3	1
1994	759	4248	0.18	0	1.4	1.4	2.1	0	−	0.2	1.5
1995	572	3673	0.16	0	1.1	1.1	2.1	0	−	0.2	1.4
1996	421	3392	0.12	0	6	6	1.1	0	−	0.8	0.79
1997	692	3039	0.23	0	9.5	9.5	1.4	0	−	1.3	1
1998	587	3353	0.18	0	13.5	13.5	1.2	0	−	1.9	0.85
1999	526	2634	0.2	0	21.2	21.2	0.63	0	−	2.9	0.58
2000	444	1936	0.23	16	14.8	30.8	0.52	69.6	0.37	5	0.26
2001	339	1665	0.2	0	8.2	8.2	0.8	0	−	1.1	0.68
2002	360	1630	0.22	1	10.2	11.2	0.68	4.5	0.97	1.4	0.57
2003	298	1467	0.2	14	7.4	21.4	0.41	70	0.41	3.1	0.24
2004	223	1084	0.21	0	8	8	1.5	0	−	1.1	1
2005	225	1075	0.21	5	4.3	9.3	0.6	23.8	0.79	0.6	0.74
2006	266	1433	0.19	0	10.4	10.4	1.3	0	−	1.5	0.86
2007	204	1241	0.16	0	4	4	1.2	0	−	0.5	0.86
2008	149	1103	0.14	0	7.9	7.9	1.1	0	−	1.1	0.82
2009	101	761	0.13	0	2.6	2.6	1.9	0	−	0.4	1.3
2010	59	492	0.12	0	0.8	0.8	2.8	0	−	0.1	2
2011	85	435	0.2	0	3.2	3.2	1.9	0	−	0.4	1.3
2012	83	445	0.19	0	3.5	3.5	1.4	0	−	0.5	0.93
2013	175	470	0.37	0	1.4	1.4	1.2	0	−	0.2	0.94
2014	97	409	0.24	0	1	1	1.9	0	−	0.1	1.4
2015	74	361	0.2	0	2.4	2.4	1.5	0	−	0.3	1
2016	134	737	0.18	0	2.8	2.8	2.1	0	−	0.4	1.5
2017	111	598	0.19	0	1.6	1.6	1.6	0	−	0.2	1.1
2018	129	513	0.25	0	1.1	1.1	1.2	0	−	0.2	0.86
2019	73	323	0.23	0	0.9	0.9	2.2	0	−	0.1	1.4
2015−2019	521	2532	0.21	0	8.7	8.7	0.88	0	−	1.2	0.64

Table 33. MESOPLODON. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019.
Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.97) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	1	6.9	7.9	0.55	25	0.99	6.7	0.57
1991	470	4778	0.1	0	7.6	7.6	0.28	0	−	7.4	0.28
1992	596	4379	0.14	4	8.6	12.6	0.32	28.6	0.51	8.3	0.32
1993	728	5442	0.13	0	11.9	11.9	0.37	0	−	11.5	0.37
1994	759	4248	0.18	3	6.2	9.2	0.28	16.7	0.59	6	0.29
1995	572	3673	0.16	0	5.5	5.5	0.22	0	−	5.3	0.23
1996	421	3392	0.12	0	3.4	3.4	0.23	0	−	3.3	0.23
1997	692	3039	0.23	0	1.5	1.5	0.44	0	−	1.5	0.44
1998	587	3353	0.18	0	0.2	0.2	1.3	0	−	0.2	1.3
1999	526	2634	0.2	0	0.1	0.1	1.9	0	−	0.1	1.9
2000	444	1936	0.23	0	0.1	0.1	3	0	−	0.1	3
2001	339	1665	0.2	0	0	0	−	0	−	0	−
2002	360	1630	0.22	0	0	0	−	0	−	0	−
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0	0	−	0	−	0	−
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0	0	−	0	−	0	−
2007	204	1241	0.16	0	0.1	0.1	2.9	0	−	0.1	2.9
2008	149	1103	0.14	0	0.2	0.2	5.1	0	−	0.1	5.3
2009	101	761	0.13	0	0	0	−	0	−	0	−
2010	59	492	0.12	0	0.1	0.1	6.2	0	−	0.1	6.2
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0	0	−	0	−	0	−
2014	97	409	0.24	0	0	0	−	0	−	0	−
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0	0	−	0	−	0	−
2017	111	598	0.19	0	0	0	−	0	−	0	−
2018	129	513	0.25	0	0	0	−	0	−	0	−
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0.1	0.1	1.9	0	−	0.1	1.9

Table 34. ALL BEAKED WHALES. Observed Sets, total sets, observer coverage, observed and estimated bycatch from 1990−2019. Unobserved bycatch estimated with regression trees ('Tree.Est') and total bycatch ('Bycatch.Tot') are shown. Ratio estimates ('Ratio.Est') are shown for comparison. Total mortality and serious injury (MSI) is based on prorating Bycatch.Tot by the fraction of observations (0.97) resulting in death or serious injury. Precision for all estimates are given as coefficients of variation (CV).

Year	Obs.Sets	Tot.Sets	Obs.Cov	Obs.Bycatch	Tree.Est	Bycatch.Tot	CV.Bycatch.Tot	Ratio.Est	CV.Ratio.Est	MSI	CV.MSI
1990	178	4078	0.04	1	39	40	0.42	25	0.97	38.9	0.39
1991	470	4778	0.1	0	29.1	29.1	0.19	0	−	28.2	0.18
1992	596	4379	0.14	12	37.9	49.9	0.19	85.7	0.3	48.8	0.14
1993	728	5442	0.13	3	39.8	42.8	0.15	23.1	0.58	41.6	0.13
1994	759	4248	0.18	11	29.5	40.5	0.15	61.1	0.3	39.6	0.11
1995	572	3673	0.16	6	23	29	0.21	37.5	0.41	27.3	0.16
1996	421	3392	0.12	0	13.7	13.7	0.24	0	−	13.3	0.23
1997	692	3039	0.23	0	6.3	6.3	0.26	0	−	6.1	0.25
1998	587	3353	0.18	0	0.9	0.9	1.7	0	−	0.9	1.7
1999	526	2634	0.2	0	1.4	1.4	2.2	0	−	1.4	2.2
2000	444	1936	0.23	0	0.2	0.2	3.7	0	−	0.2	3.7
2001	339	1665	0.2	0	0.2	0.2	3.3	0	−	0.2	3.3
2002	360	1630	0.22	0	1.9	1.9	2.3	0	−	1.8	2.2
2003	298	1467	0.2	0	0	0	−	0	−	0	−
2004	223	1084	0.21	0	0.1	0.1	6.1	0	−	0.1	6.1
2005	225	1075	0.21	0	0	0	−	0	−	0	−
2006	266	1433	0.19	0	0.1	0.1	5.7	0	−	0.1	5.7
2007	204	1241	0.16	0	0.1	0.1	3.5	0	−	0.1	3.5
2008	149	1103	0.14	0	0	0	−	0	−	0	−
2009	101	761	0.13	0	0.2	0.2	5.1	0	−	0.2	5.1
2010	59	492	0.12	0	0	0	−	0	−	0	−
2011	85	435	0.2	0	0	0	−	0	−	0	−
2012	83	445	0.19	0	0	0	−	0	−	0	−
2013	175	470	0.37	0	0.1	0.1	3.7	0	−	0.1	3.7
2014	97	409	0.24	0	0.1	0.1	3.9	0	−	0.1	3.9
2015	74	361	0.2	0	0	0	−	0	−	0	−
2016	134	737	0.18	0	0.5	0.5	1.5	0	−	0.5	1.5
2017	111	598	0.19	0	0.1	0.1	4.4	0	−	0.1	4.4
2018	129	513	0.25	0	0.1	0.1	5.3	0	−	0.1	5.3
2019	73	323	0.23	0	0	0	−	0	−	0	−
2015−2019	521	2532	0.21	0	0.7	0.7	1.5	0	−	0.6	1.4