ESTIMATES OF MARINE MAMMAL, SEA TURTLE, AND SEABIRD BYCATCH IN THE CALIFORNIA LARGE-MESH DRIFT GILLNET FISHERY: 1990-2023.

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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 2023 is estimated with random forest classification and regression trees. Tree estimates are compared with annual ratio estimates using the same observer data. Biases associated with ratio estimators (systematic under- and overestimation of bycatch) are notable when observed bycatch is rare, when each annual bycatch estimate is informed only by data from the same year, and observer coverage is low. Tree methods provide 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 address 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 (hereafter, 'the fishery') began in the 1970s as an experimental fishery targeting pelagic sharks. By the mid-1980s, the fishery included over 200 vessels and annual effort was approximately 10,000 fishing sets (Hanan *et al.* 1993, Holts *et al.* 1998). Fishing effort has declined since, with mean annual effort of 215.2 sets during 2019 - 2023. From 1990 to 2023, trained fishery observers aboard vessels observed 9,311 sets from an estimated 57,947 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 1990-2022 (Carretta 2023). In this report, updated estimates of bycatch are summarized for the period 1990 - 2023. 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 suffer from 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, especially 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 only and when these conditions exist (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 (*Dermochelys coriacea*). Random forest (RF) classification and regression trees (Breiman *et al.* 1984, 2001a, 2001b) are used for variable selection and bycatch estimation (respectively) for all species observed entangled in this fishery, with a secondary emphasis on comparing tree estimates to annual ratio estimates derived from within-year data.

Methods

Modeling approach

Bycatch models are constructed in a two-step process, first, using RF classification trees for variable selection with bycatch presence / absence data (see Variable Selection). Although variable importance can be assessed with either classification or regression trees, the rarity of bycatch events in the fishery necessitates oversampling fishing sets with observed bycatch to address signal-to-noise ratio issues common to zero-inflated data (Xie *et al.* 2009, Lin and Chen 2013). This strategy is implemented in RF by treating the response (bycatch or no bycatch) as a factor (or class) to be predicted, rather than a numeric response to be estimated. Variables selected for inclusion are then used in a regression tree RF to estimate the bycatch rate in unobserved fishing sets (see Bycatch Estimation).

Variable selection (classification trees)

Variable selection was implemented with RF classification trees (Breiman *et al.* 1984, Breiman 2001a, 2001b, Liaw and Wiener 2002) in the R-package *rfPermute* (Archer 2021), which implements the R-package *randomForest* (Liaw and Wiener 2002), but *rfPermute* additionally provides statistical significance measures for each variable. Variables evaluated for bycatch models included a suite of fishing gear, oceanographic, and location variables described in Table 1.

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 resulting in the greatest homogenization (= information gain) of the response variable in subsequent daughter nodes is selected to split the data. 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 known response variable in the OOB data, providing a direct measure of model error and 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 RF variable selection model consists of classification trees, where the response to be classified is the presence or absence of bycatch in an observed fishing set. Evaluation of the RF model is based on cross-validated classification accuracy: how often is the presence and absence of observed bycatch in OOB data correctly classified? The number of RF trees (n = 1000) is based on the approximate number 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 presence/absence fishing sets. All RF analyses in this analysis were implemented in the programming language R, version 4.3 (R Core Team 2023).

Observed bycatch in the fishery is a rare event. The species that is most frequently observed entangled (short-beaked common dolphin) occurs in only 3.7% of all observed fishing sets, while some species such as sperm whales have been observed in 0.064% 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.

The variable selection strategy for zero-inflated data is to boost the signal-to-noise ratio by oversampling fishing sets with bycatch. The strategy 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 this case, fishing sets with observed bycatch. RF models included 1000 individual classification trees, each constructed from equal numbers of sets (n=1/2 of smaller class size) with and without bycatch. Fishing sets used in construction of each classification tree are sampled without replacement. The relative importance of predictors in classifications of the RF model is assessed by permuting each predictor, and the resulting decreases in classification accuracy are measured. Important variables will result in the largest decreases in classification accuracy, while unimportant variables result in negligible decreases. For each predictor, an importance 'score' is defined as the mean decrease in classification accuracy (number of additional cases misclassified) across all trees when it was permuted. Statistical p-values for each variable are obtained by permuting the *response variable* (observed bycatch presence or absence in a set) 200 times, which yields a null distribution of variable importance scores, which is compared to the importance score from the unpermuted responses to calculate a p-value. Variables with p-values less than a 0.05 alpha-level threshold are selected for inclusion in estimation models, based on the feature 'Mean Decrease in Gini Index', a measure of how each variable contributes to the homogeneity of the nodes and leaves in the random forest. This is the method applied to simulated rare-event bycatch data by Carretta *et al.* (2017). In cases where no variables are identified as 'significant', a default set of variables are used (*days* + *lat* + *lon* + *sst*). Ideally, RF models should include at least 2 variables, as use of 1 variable over many trees is simply equivalent to bootstrap aggregating, or 'bagging'. Therefore, where only one significant variable is identified, it is pooled with the default set of variables.

In a bycatch presence / absence context (was bycatch observed?), 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	c
Absence	b	d

where

Overall Accuracy = $(a + d)/(a + b + c + d)$;

Sensitivity = $a/(a + c)$;

Specificity = $d/(b + d)$;

and

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 chance (Allouche *et al.* 2006). The focus here is on 'sensitivity', because a primary goal is to correctly predict bycatch occurrence / risk. 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 as an assessment tool is consistent with approaches used to estimate the strength of presence / absence models (Allouche *et al.* 2006).

Bycatch Estimation (regression trees)

Variables for each species / taxon bycatch model were identified using the balanced RF classification tree procedure described above and bycatch models were generated with RF 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. For all species where the number of observed bycatch events <=5, a default set of variables (*lat* + *lon* + *days* + *sst*) is used in regression tree models, in recognition that most species in the California Current show seasonal and spatial movements within the region in response to prevailing oceanographic conditions (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: 'all beaked whales + *Kogia*'. This is done in recognition that these species are known to be sensitive to anthropogenic sound (Barlow and Gisiner 2006, Tyack *et al.* 2011) and whose bycatch has apparently been absent in this fishery since the introduction 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. RF regression trees (*n* = 1,000) 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 an RF model with all data, except one fishing trip is omitted for cross-validation. Individual vessel trips averaged 5.7 sets fished (range = 1 – 19). The resulting RF of 1,000 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 1,000 summed bycatch predictions for all 9,311 observed sets.

For species s in year y, mean annual predicted bycatch per set $\overline{b}_{s,y}$, is the mean predicted bycatch for all observed sets in year y, where RF trees are constructed using all years of data. Mean annual estimates of bycatch from regression trees $\overline{T}_{s,y}$, are calculated as the product of $\overline{b}_{s,y}$ and the number of unobserved sets in year y (u_y), plus the sum of observed bycatch $o_{s,y}$ that year:

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

The approach of extrapolating predicted bycatch rates to unobserved fishing effort u_y reflects an assumption that observer data are representative of the fishery. The variance of each bycatch estimate is calculated as:

$$(2)\ \ var\left(\overline{T}_{s,y}\right) = var\left(\overline{b}_{s,y} * u_{s,y}\right) * d_s * fpc^2$$

where

$var\left(\overline{b}_{s,y} * u_{s,y}\right)$ = the variance of 1,000 individual bycatch predictions (one for each tree) summed across observed sets in year y and d_s = the dispersion index of observed bycatch per fishing trip for species s, calculated as the ratio of the variance to mean of the number of observed bycatch events (o), per fishing trip (t), across all 1,624 observed fishing trips from 1990-2023:

$$(3)\ \ d_s = \sum_{t=1}^{n} N \frac{var\left(o_{s,t}\right)}{\overline{o}_{s,t}}$$

The dispersion index is required to reflect uncertainty in the bycatch process (Curtis and Carretta 2020), because $var(\overline{b}_{s,y})$ alone reflects only the uncertainty in estimating mean bycatch rates. For many species, the bycatch process is not Poisson (variance to mean ratio >> 1, see Table 2) and without a dispersion factor term, the overall variance of the bycatch estimate may be underestimated. Finally, the variance also includes a finite population correction (*fpc*) (Snedecor and Cochran 1967) to account for incomplete observer coverage:

$$(4)\ fpc = \sqrt{\frac{\text{total effort - observed effort}}{\text{total effort - 1}}}$$

For all bycatch estimates, the value of *fpc* = 0.916 (total effort = 57,947 sets, observed effort = 9,311 sets). Coefficients of variation (CV) for all estimates were calculated as:

$$(5)\ \ CV(T_{s,y}) = \frac{\sqrt{var(\overline{T}_{s,y})}}{\overline{T}_{s,y}}$$

In addition to total entanglements, estimated mortality and serious injury (MSI) levels are estimated for all species, using the fraction of observed entanglements recorded as dead, injured, or 'unknown' (*f*), 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 $\overline{b}_{s,y} * u_y$ 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 5. 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 $\overline{T}_{s,y}$, with the associated CV of $\overline{T}_{s,y}$. In this report, MSI for all species is calculated with *f* = 1, except for olive ridley sea turtle (0), Northern fulmar (0.138), humpback whale (0.20), loggerhead sea turtle (0.25), minke whale (0.50), leatherback sea turtle (0.68), sperm whale (0.70), Cuvier's beaked whale (0.952), all beaked whales + *Kogia* (0.969), and California sea lion (0.982). The value of *f* used for humpback whales (0.20) is similar to that used by Martin *et al*. (2015), or 0.25.

Estimates from regression trees 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.

From 1990-1999, there were 21 'unidentified common dolphin' (*Delphinus sp.*) entanglements observed in the fishery, out of a total of 481 observed common dolphin entanglements. The generic species ID was due to a lack of genetic samples and/or taxonomic uncertainty regarding short- and long-beaked forms of common dolphin at the time (Heyning and Perrin 1994, Rosel *et al*. 1994). However, these two forms are currently recognized as distinct species, *Delphinus delphis* and *D. bairdii*, respectively (Jefferson *et al*. 2024). In this analysis, these unidentified animals were prorated to species, based on noted differences in depth distributions of the two *Delphinus* species caught in the fishery. This proration resulted in 16/21 animals being classified as long-beaked common dolphin (*D. bairdii*) and 5/21 as short-beaked common dolphin, *D. delphis*.

Results

Variables identified as important predictors for each species / taxonomic group are summarized in Table 2. Model performance measures (variables selected, sensitivity, selectivity, TSS metrics) for selected species with sample size >=6 are given in Table 2. Estimates of total bycatch and mortality and serious injury are summarized 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 34 years of observer data in tree construction and estimation of mean bycatch rates based on variables. This contrasts with the use of ratio estimates that rely on one year of data for estimating mean bycatch rates. In sum, the information contained in the full dataset provides a better estimate of true bycatch rates and variable 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 estimates can also be poor, a consequence of fewer observations from which to predict the mean annual bycatch per set $\bar{b}_{s,y}$. Regression tree estimate CVs also reflect the diversity of predictions from the RF, which depends upon the variability in fishing set characteristics in year y used to extrapolate bycatch to unobserved fishing activity. In the extreme, if all observed sets in year y had identical set characteristics (location, date, depth, etc.), then a RF 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 18). In contrast, the regression tree estimate of bycatch for 2010 is approximately 2.1 whales (2 observed + 0.1 whales estimated in 433 unobserved sets). Given observed sperm whale bycatch rates in this fishery over 34 years (~ 1 animal for every 1,000 sets), it is highly unlikely that total 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, 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 18), 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 9 sperm whales, which is more realistic, given the level of fishing effort. 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 a 'significant' variable (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 variables in addition to pingers, also influence current estimates (Figure 3-5 and Table 7).

Absolute California sea lion bycatch levels declined from 1990-2023, which largely reflects declining fishing effort (Table 4, Figure 2). However, observed and estimated sea lion bycatch per fishing set *increased* during a large portion of this time frame (Fig. 3-2), coincident with 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 fishery effort to southern waters closer to sea lion breeding rookeries where at-sea abundance is highest. Observed and predicted bycatch per set has been highly-variable in recent years, as the size of the sea lion population has declined and fewer vessels participate in the fishery.

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 (~170 entanglements, ~123 estimated deaths, Table 11) are similar. In both studies, estimated leatherback entanglements decline each year, reaching low levels after PLCA implementation in 2001 (Fig. 1, Figure 3-9). 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 has been negligible, which reflects PLCA effectiveness, declining fishing effort, and a decline in North Pacific leatherback abundance (Tapilatu *et al.* 2013, Benson *et al.* 2020). Prior to the PLCA (1990-2000), the observed leatherback bycatch rate was 23 turtles in 5,973 fishing sets. Since the closure has been in place (2001-2023), the observed bycatch rate is 2 turtles in 3,338 fishing sets. Individual leatherback entanglements in 2009 and 2012 give a false impression of a high bycatch rate in those years, but the rates are artifacts of the small number of sets observed (Fig. 3-8). Our leatherback bycatch model included the variables *lat* + *lon* + *depth*. Latitude and latitude collectively are proxy variables for the PLCA (Fig. 1), where fishing effort is now rare since the seasonal closure began.

The bycatch dataset includes 9,311 observed fishing sets spanning 34 years, and while it might be considered ‘data rich’ by some standards, bycatch for many species is represented by fewer than 5 observed entanglements. The uncertainty in bycatch estimates for rarely-entangled species will always be large, but compared to intra-annual ratio estimates, the precision of model-based estimates is typically superior. 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 dispersion index term reflecting individual fishing trip variance in observed bycatch. 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 impacts due to low observer coverage (Curtis and Carretta 2020). 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 RF or other models with a default set of variables can provide a 'null model' that mirrors the mean observed 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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Data Availability

Annual bycatch estimates are available by species / taxa group as CSV files on Github. Filenames are of the format [Species Code] + ".All.Estimates.csv". Species codes can be found in the SpeciesLookup.csv file in the main branch.

Estimates for 1990 to the most-recent year of data available are updated annually. Estimates are model-based, so that individual year estimates may change slightly with the addition of new data. This repository holds the most-recent published estimates. Email jim.carretta@noaa.gov with questions.

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Figure 1. Observed fishing sets, 1990−2023.

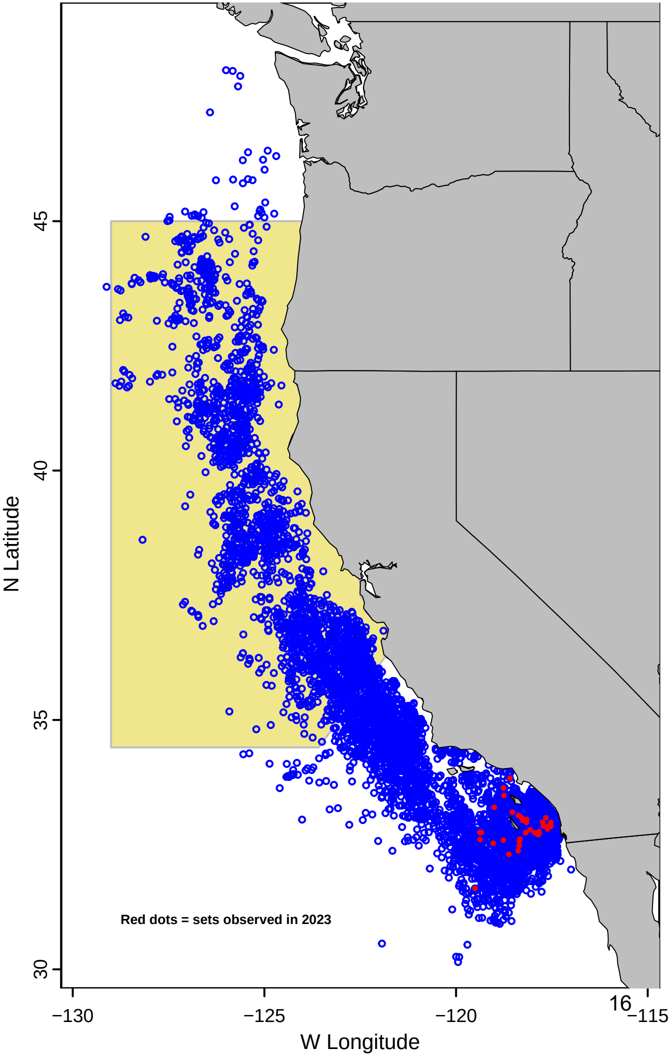


Figure 2. CA thresher shark and swordfish drift gillnet observer coverage by year.

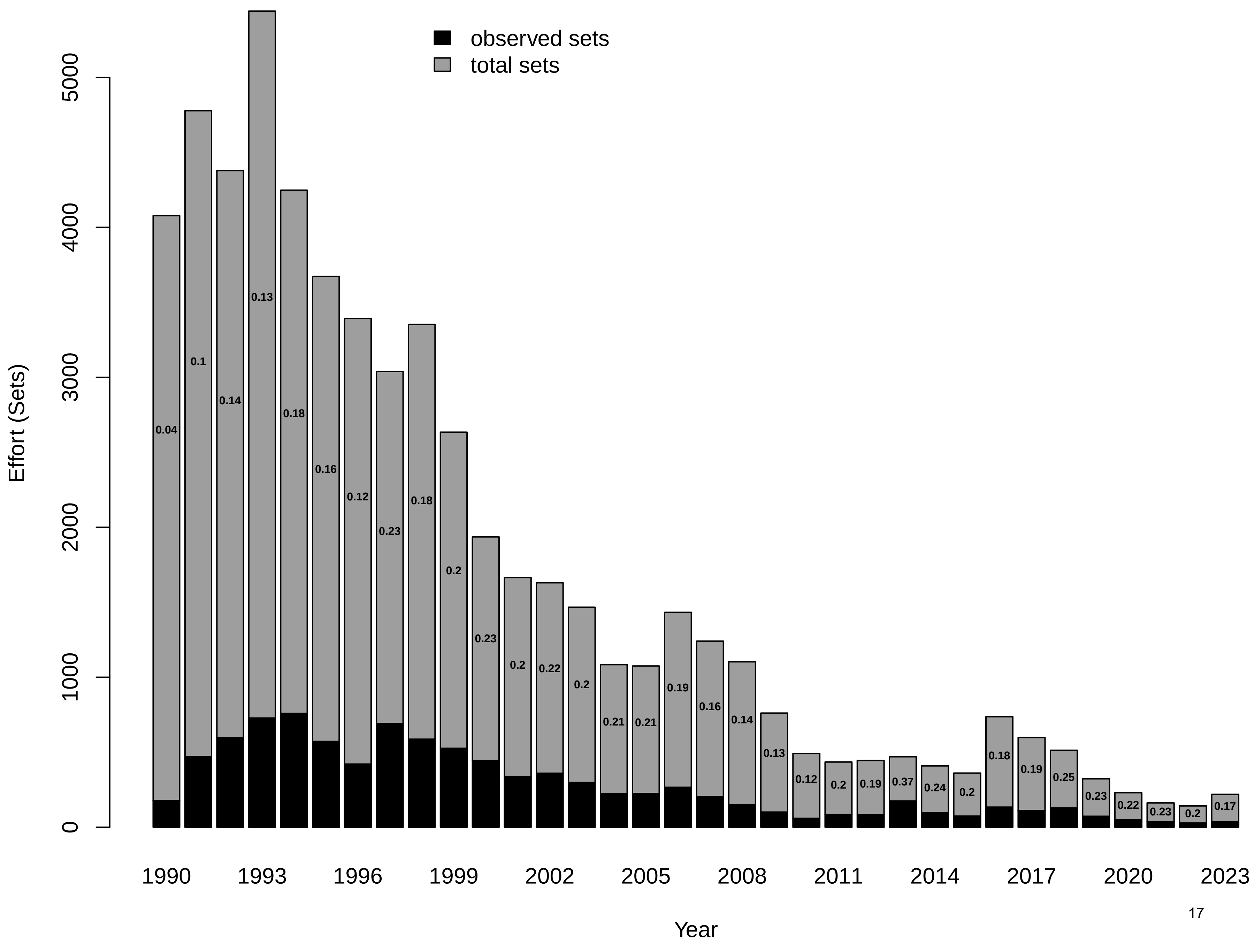
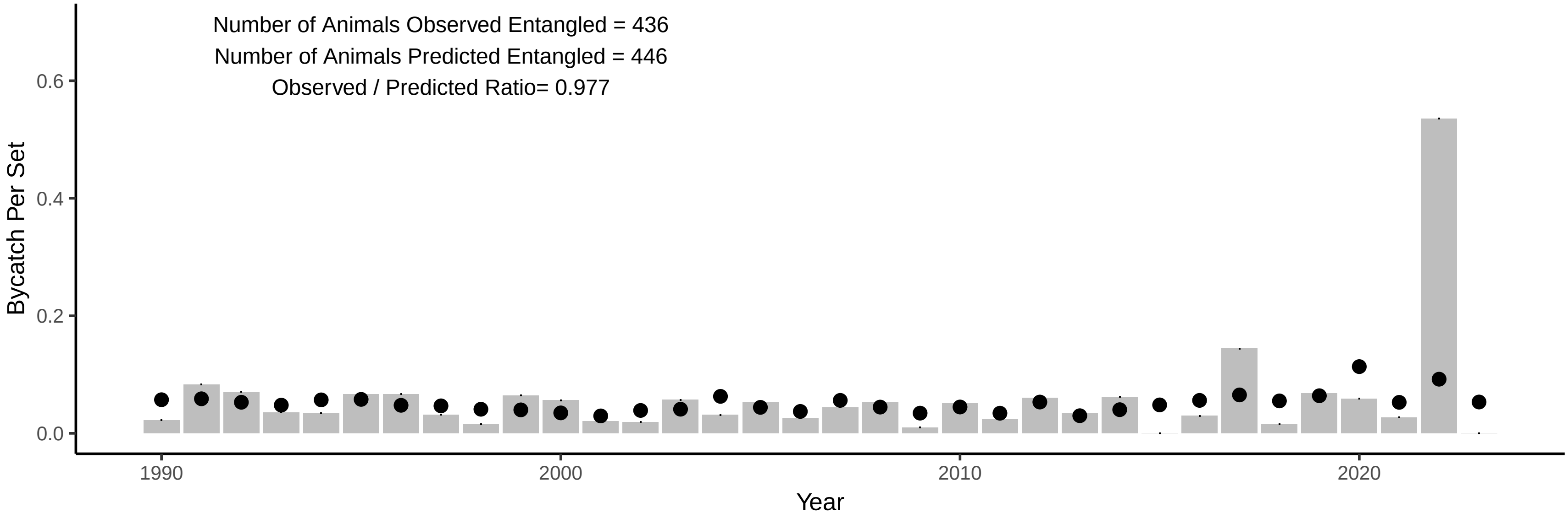


Figure 3−1. COMMON DOLPHIN, SHORT−BEAKED Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: n.ping + lon + days



COMMON DOLPHIN, SHORT−BEAKED Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

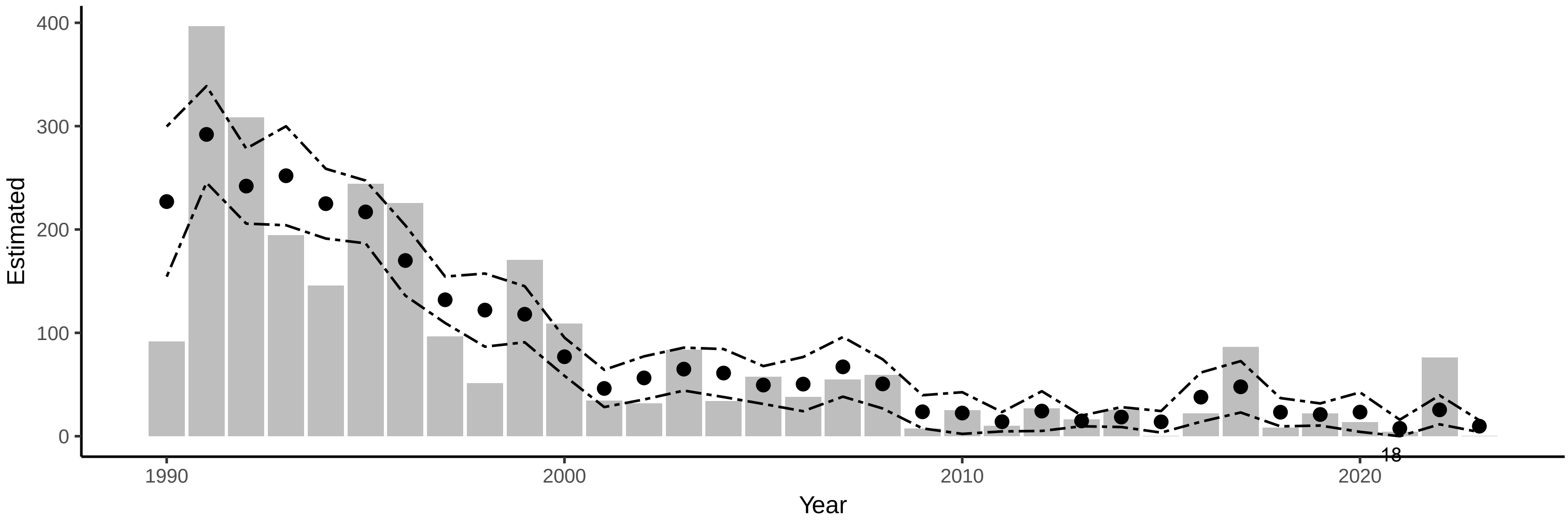
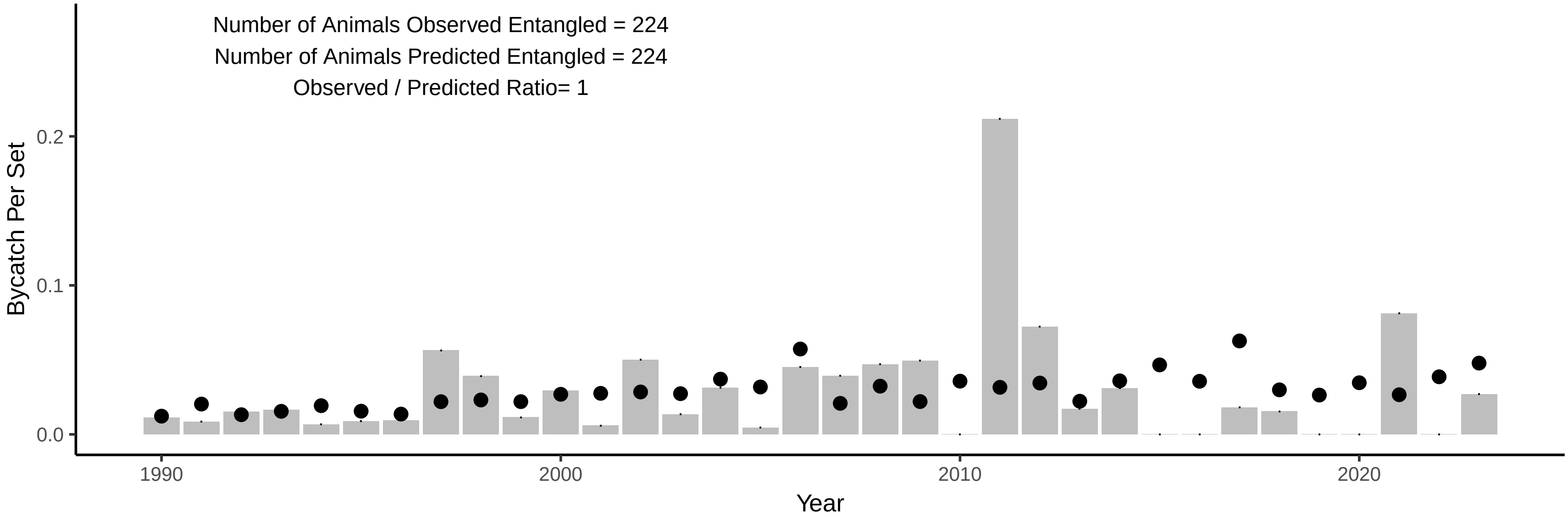


Figure 3−2. CA SEA LION Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: depth.p + mesh



CA SEA LION Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

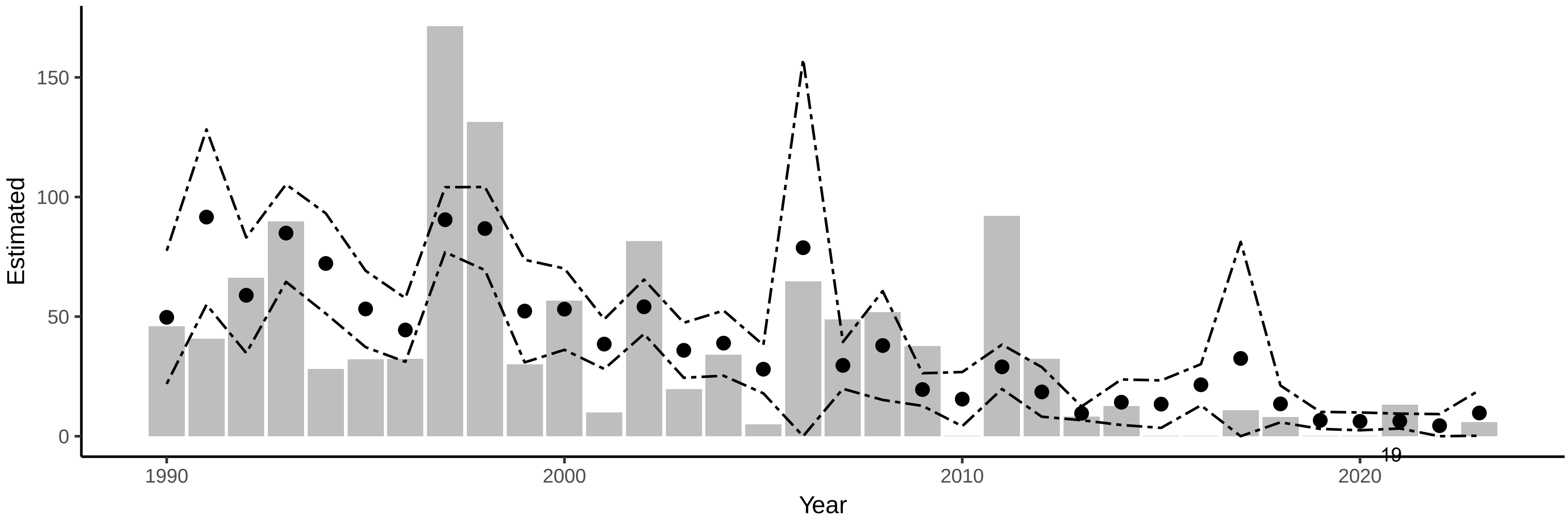
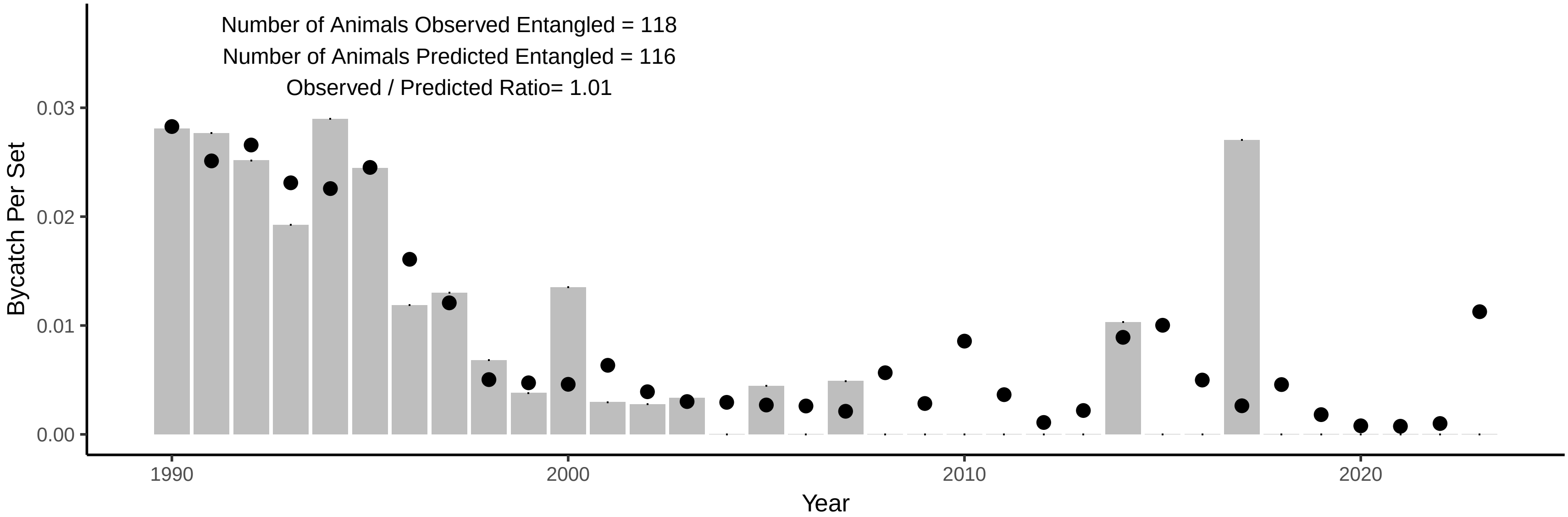


Figure 3−3. N ELEPHANT SEAL Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: n.ping + lon



N ELEPHANT SEAL Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

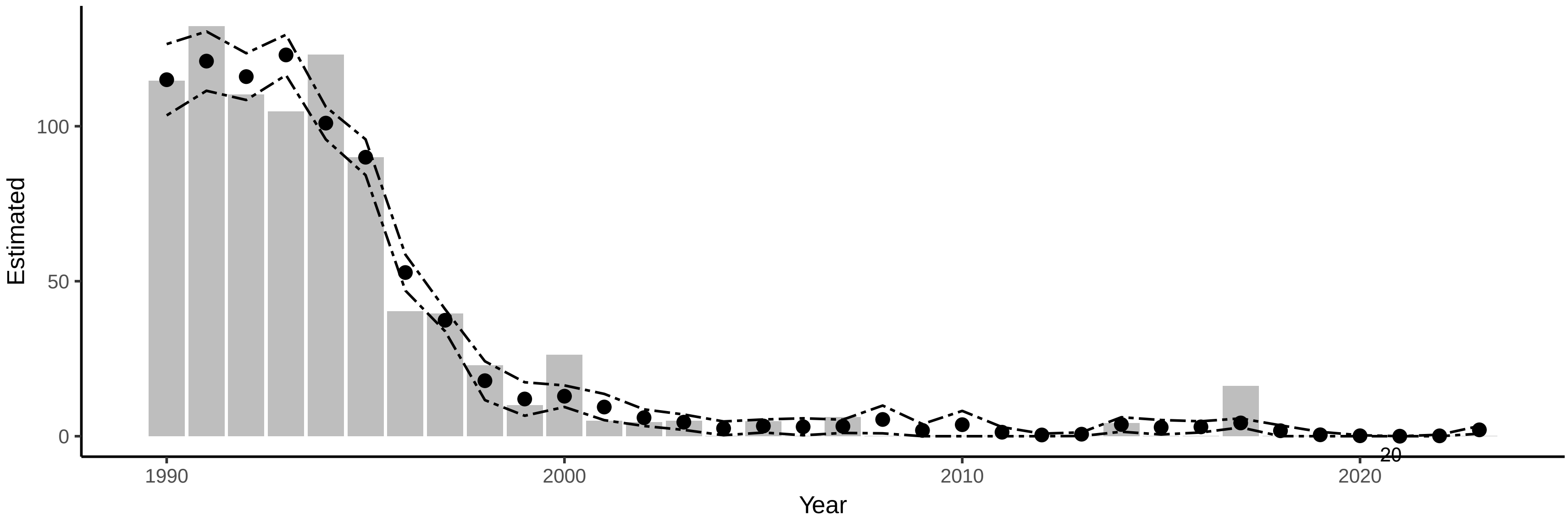
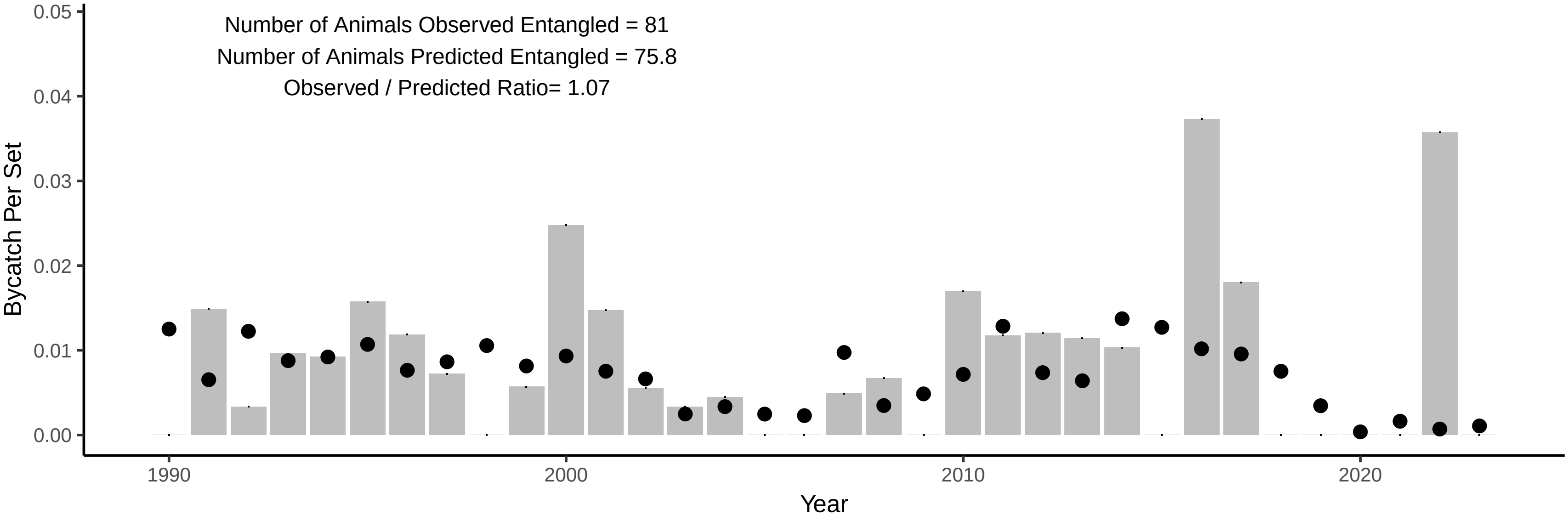


Figure 3−4. N RIGHT WHALE DOLPHIN Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: depth.p + lon



N RIGHT WHALE DOLPHIN Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

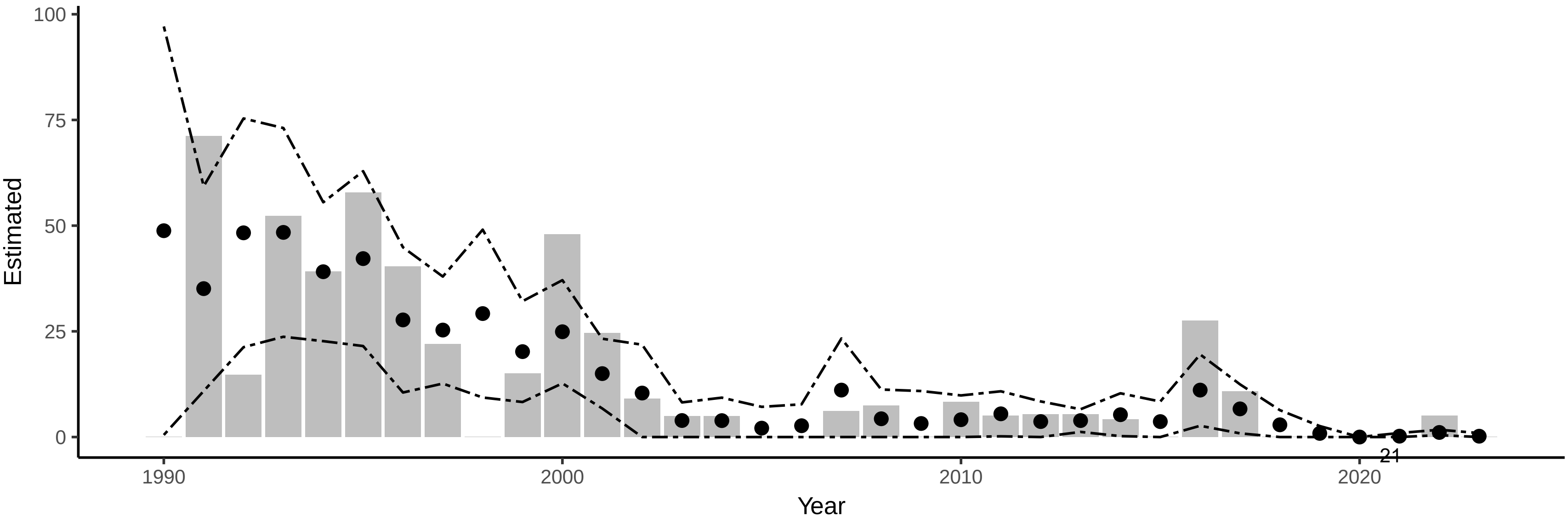
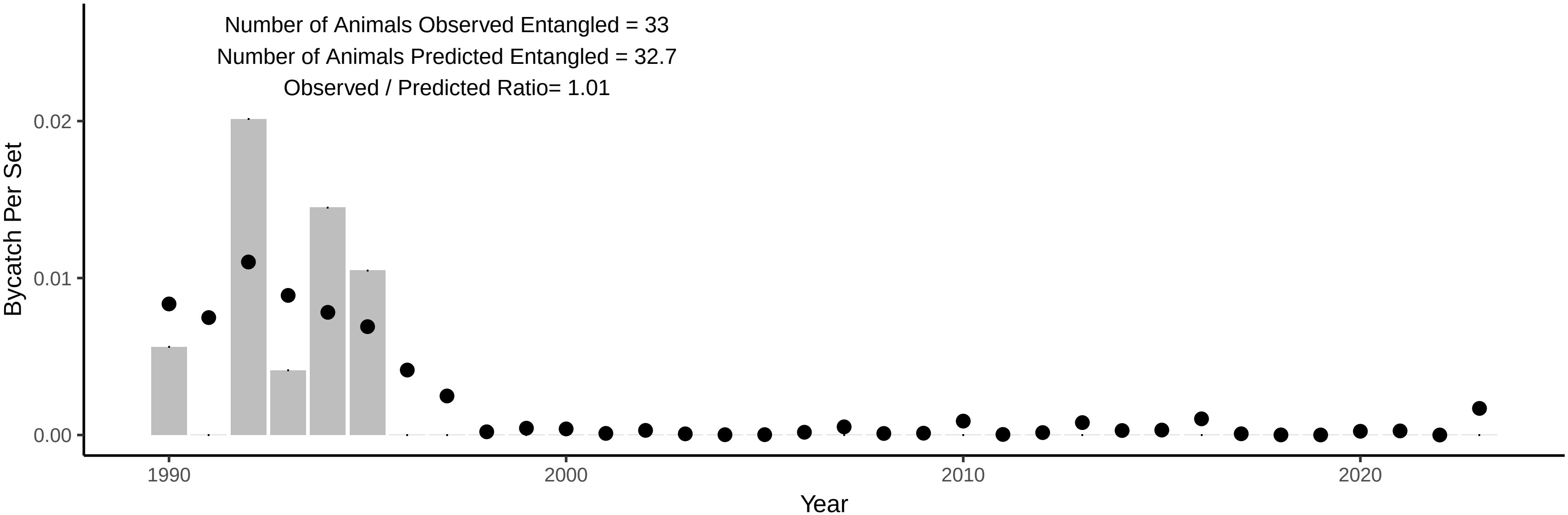


Figure 3−5. BEAKED WHALES Bycatch Per Set: Observed (bars) and Predicted (points).
Model Variables: depth.p + lon + n.ping



BEAKED WHALES Bycatch Estimates: Ratio (bars) and Tree (points).
Dashed lines = Tree Estimate +/− 1 SE.

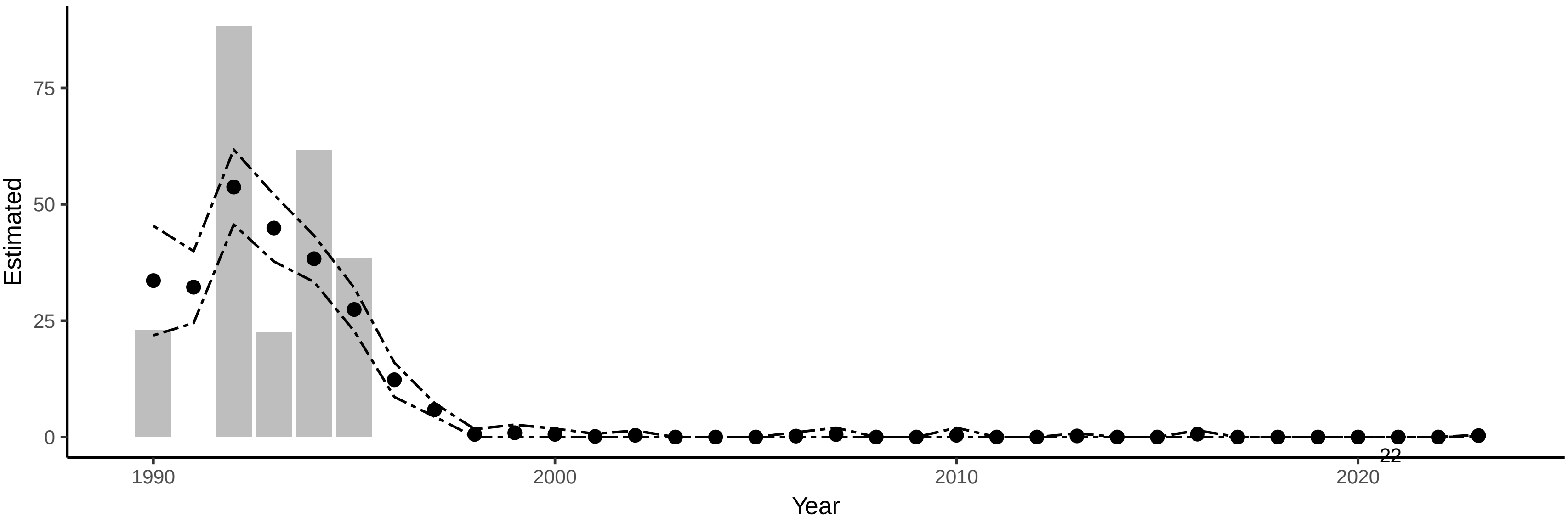
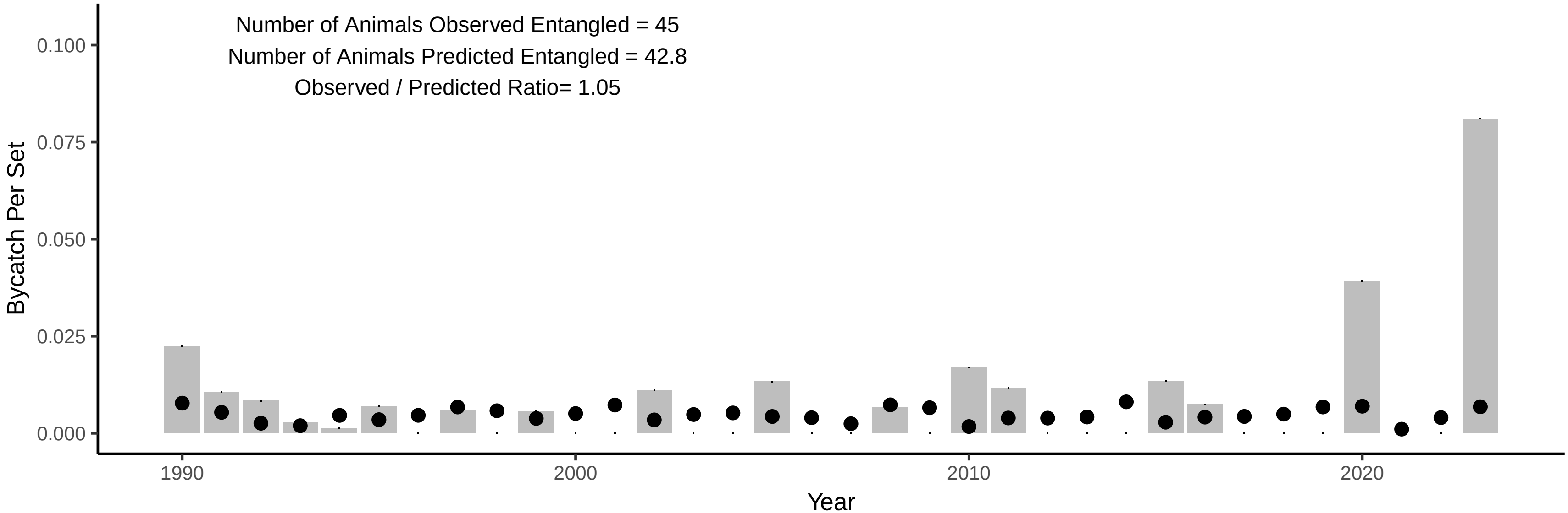


Figure 3−6. COMMON DOLPHIN, LONG−BEAKED Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: lat + lon + depth.p



COMMON DOLPHIN, LONG−BEAKED Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

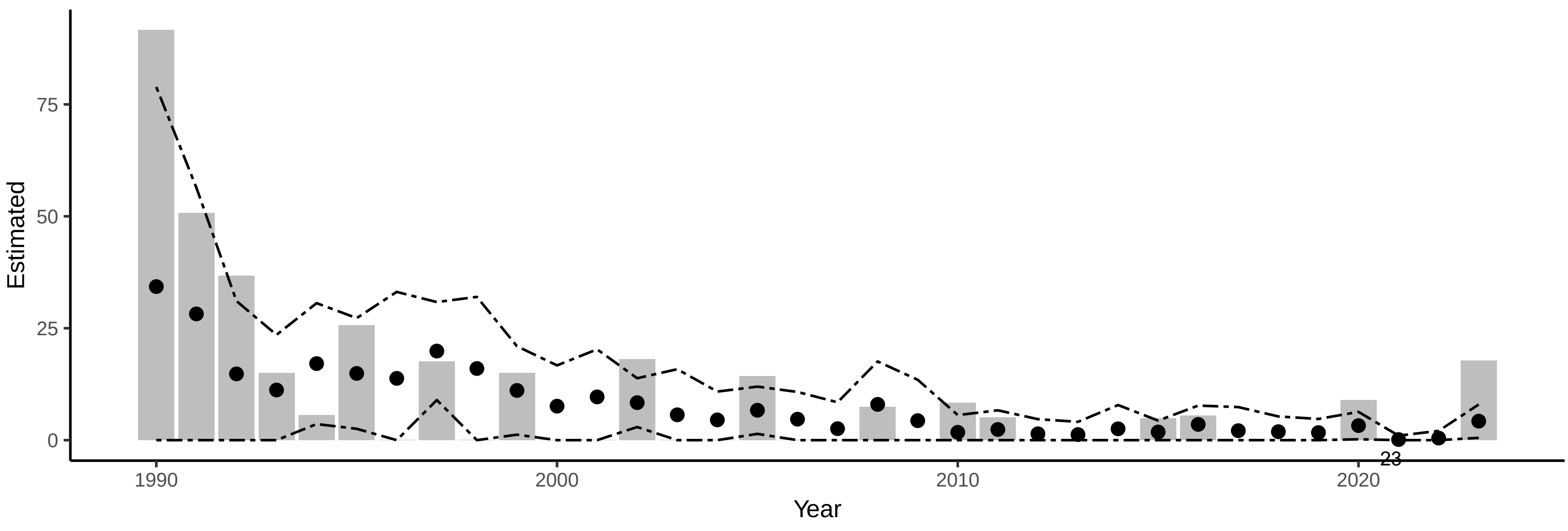
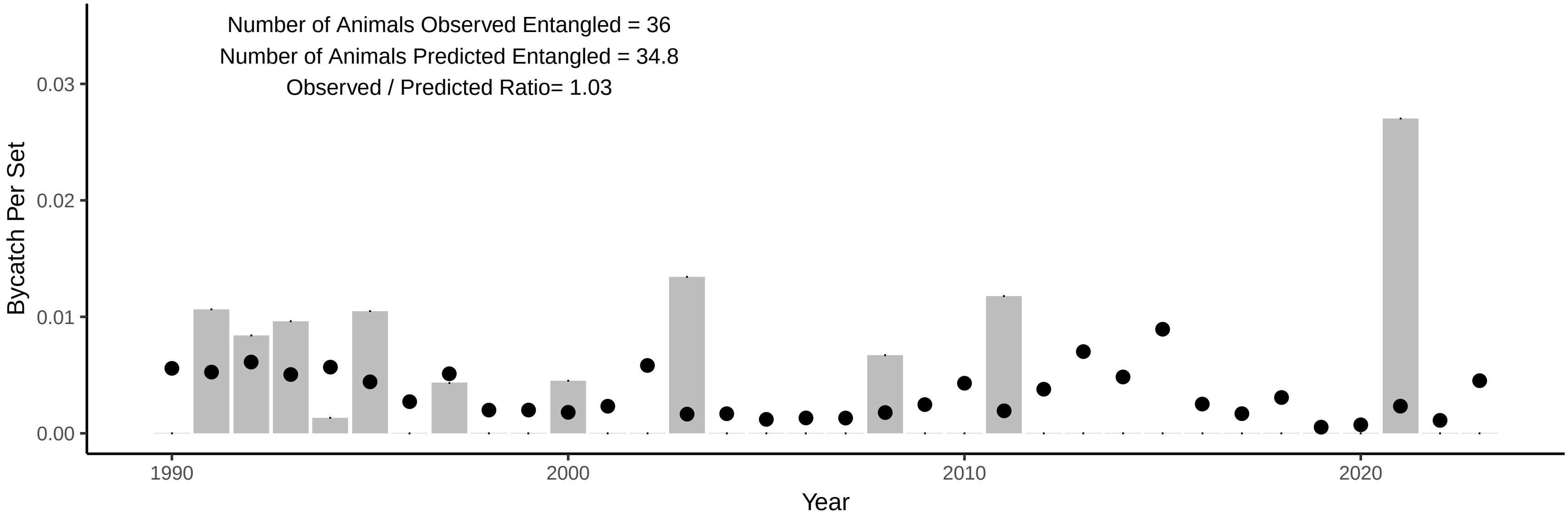


Figure 3−7. RISSO'S DOLPHIN Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: lon + mei



RISSO'S DOLPHIN Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

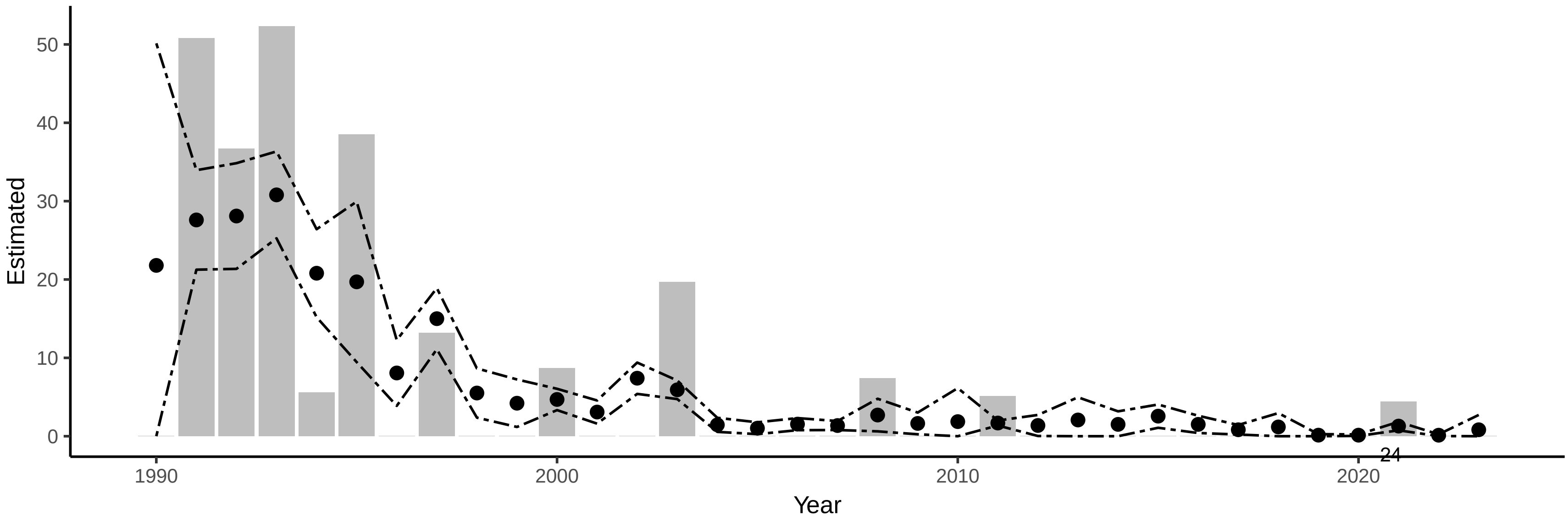
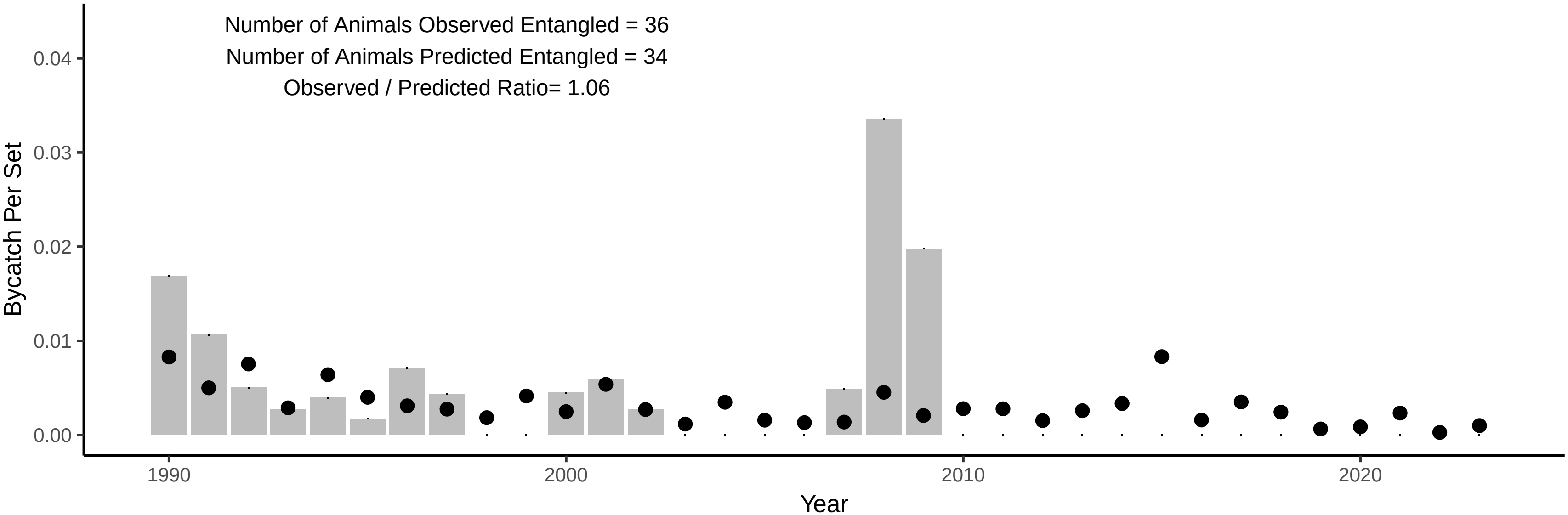


Figure 3−8. PACIFIC WHITE−SIDED DOLPHIN Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: days + lat + lon + sst



PACIFIC WHITE−SIDED DOLPHIN Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

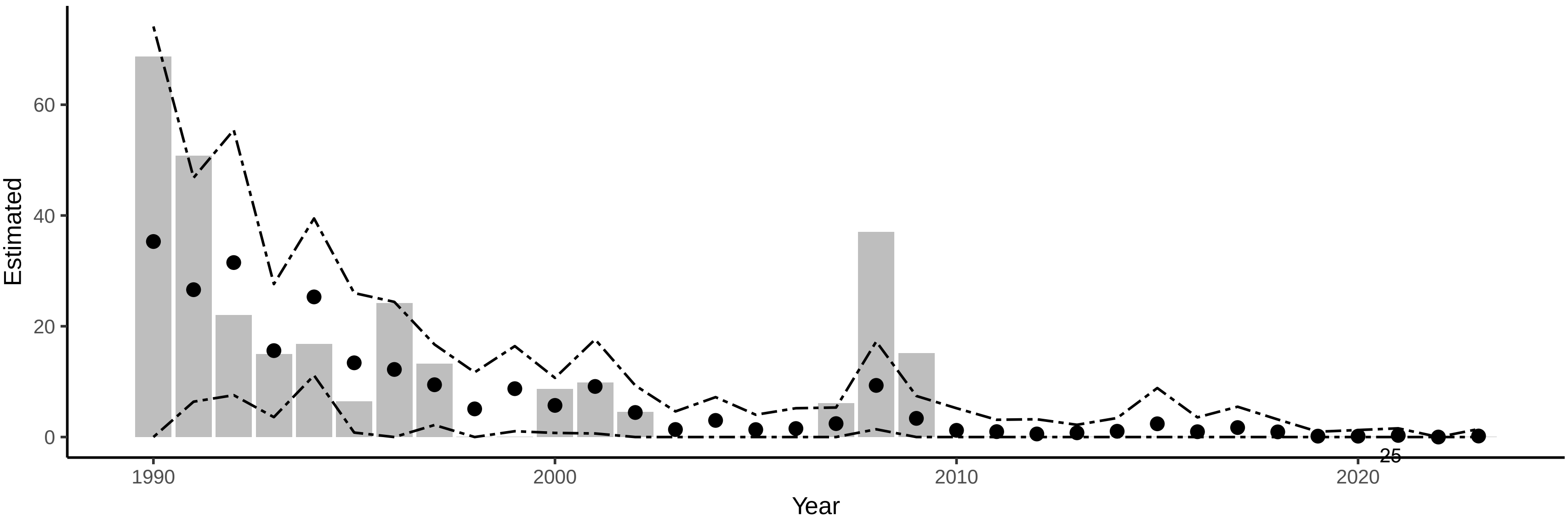
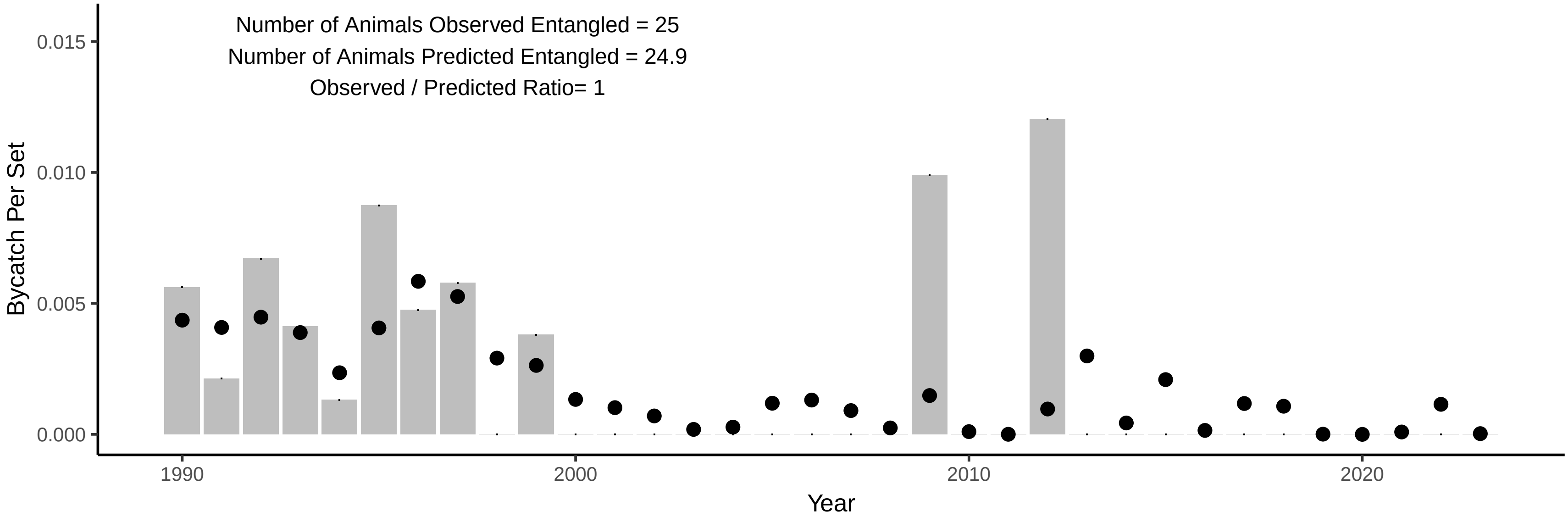


Figure 3−9. LEATHERBACK TURTLE Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: depth.p + lat + lon



LEATHERBACK TURTLE Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

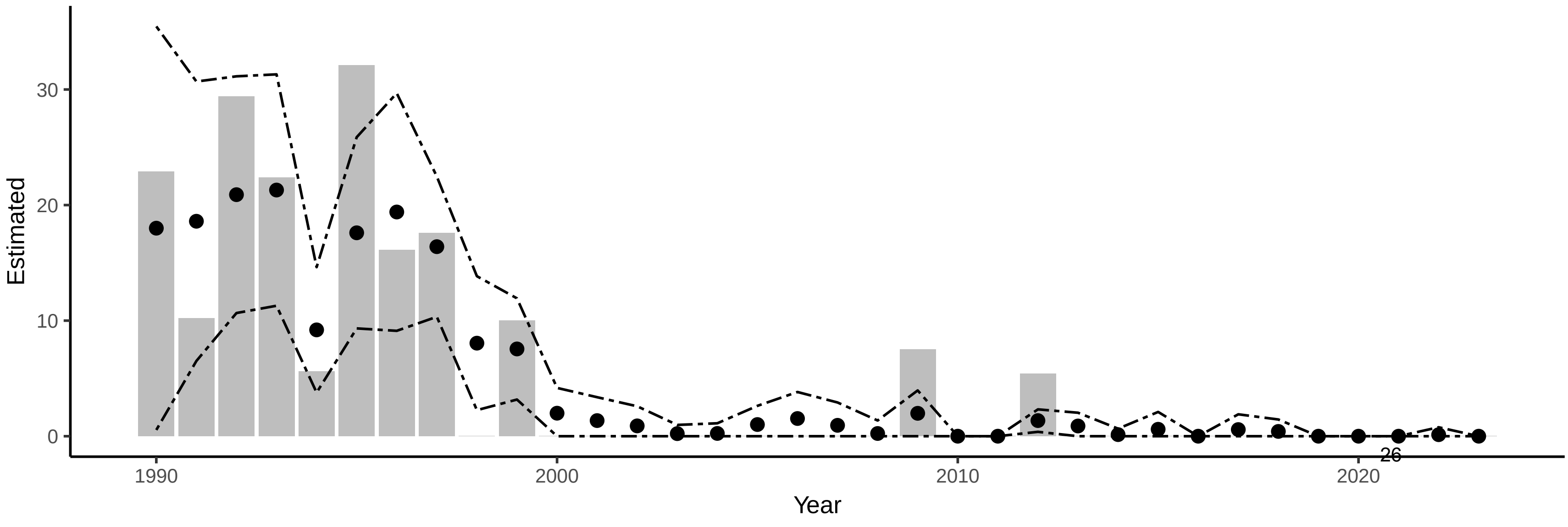
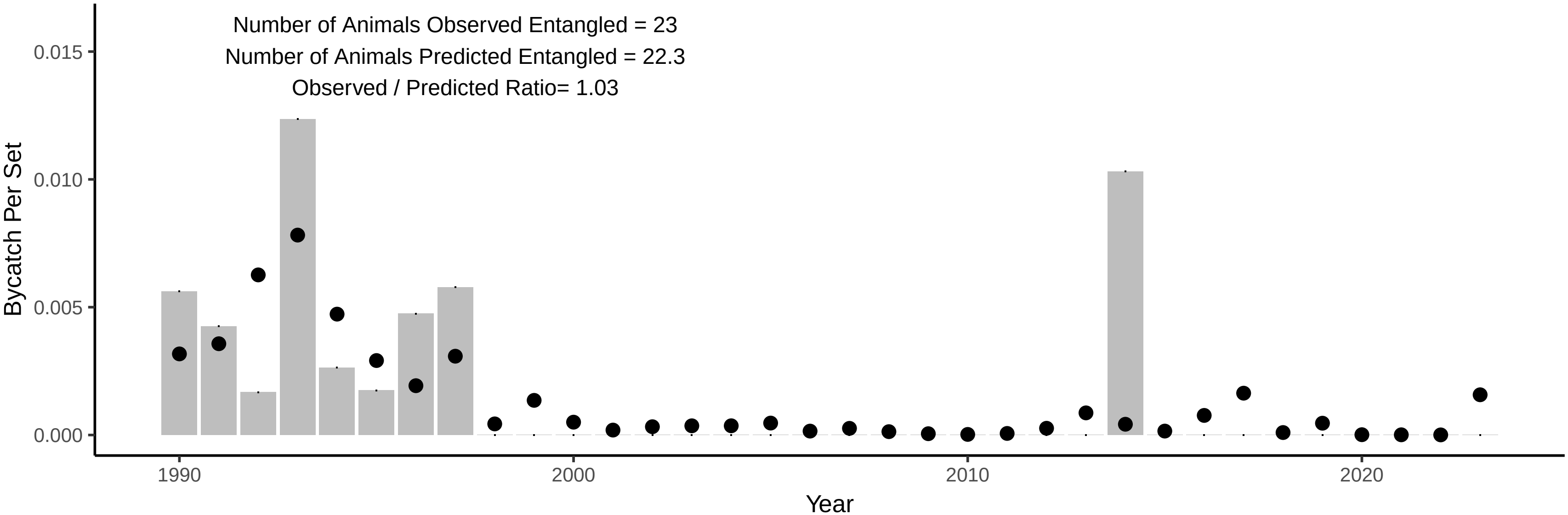


Figure 3−10. DALL'S PORPOISE Bycatch Per Set: Observed (bars) and Predicted (points).
Model Variables: lat + lon + n.ping



DALL'S PORPOISE Bycatch Estimates: Ratio (bars) and Tree (points).
Dashed lines = Tree Estimate +/− 1 SE.

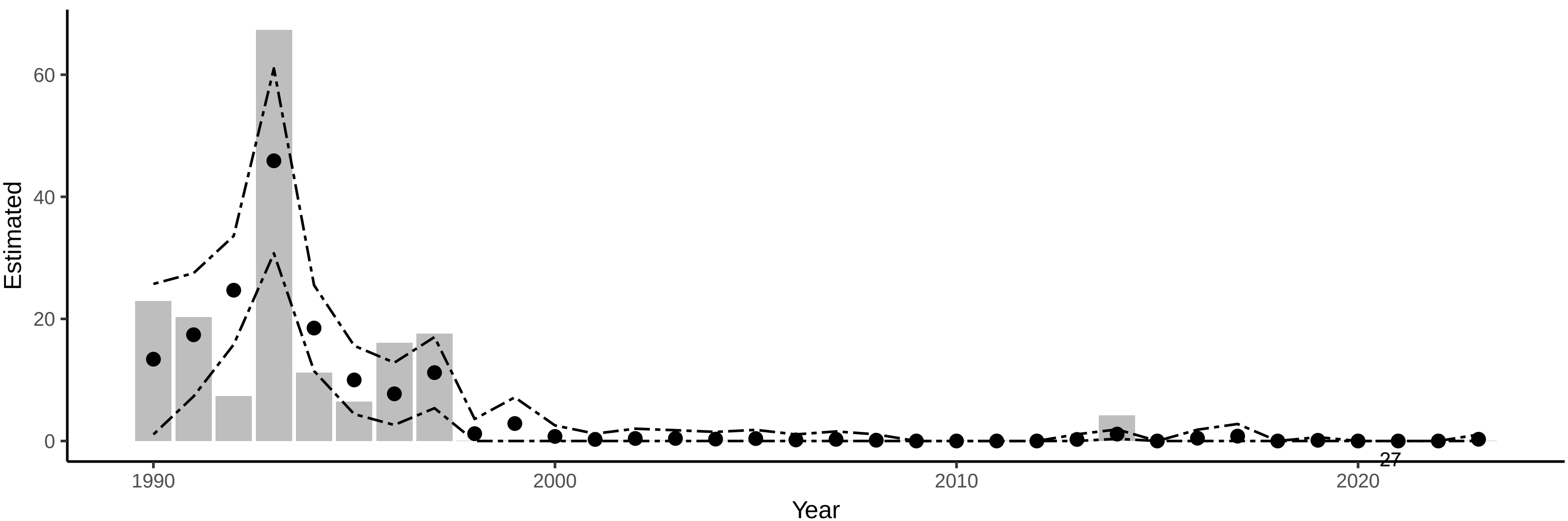
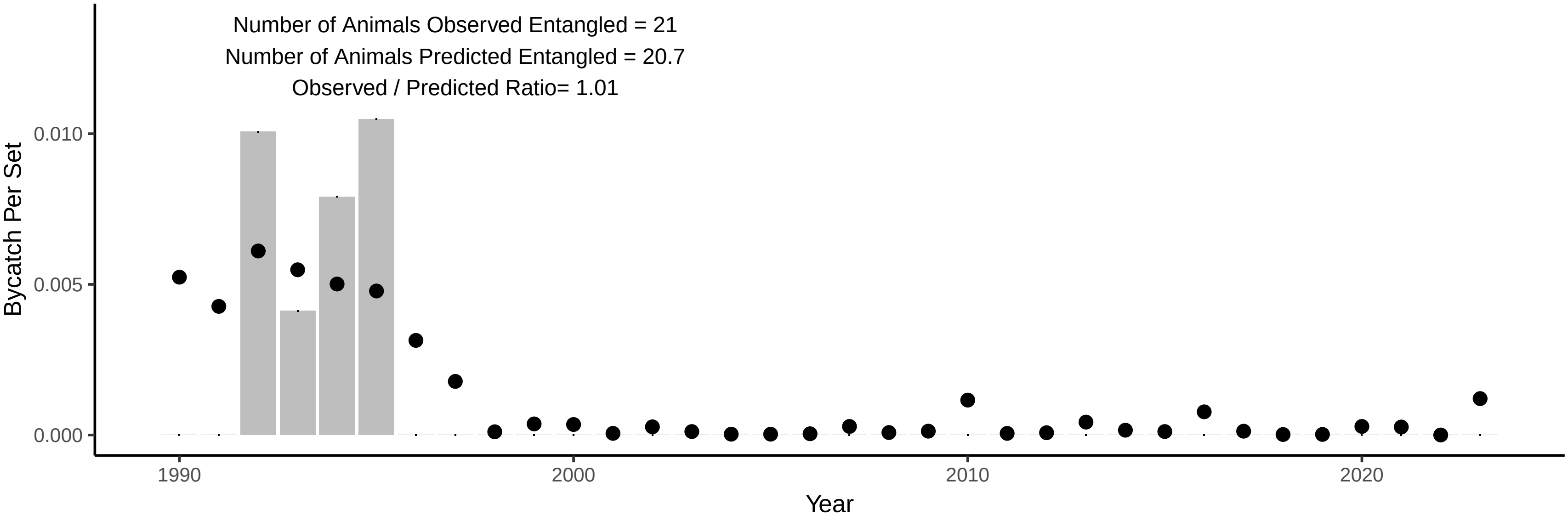


Figure 3−11. CUVIER'S BEAKED WHALE Bycatch Per Set: Observed (bars) and Predicted (points).
Model Variables: depth.p + lon + n.ping



CUVIER'S BEAKED WHALE Bycatch Estimates: Ratio (bars) and Tree (points).
Dashed lines = Tree Estimate +/− 1 SE.

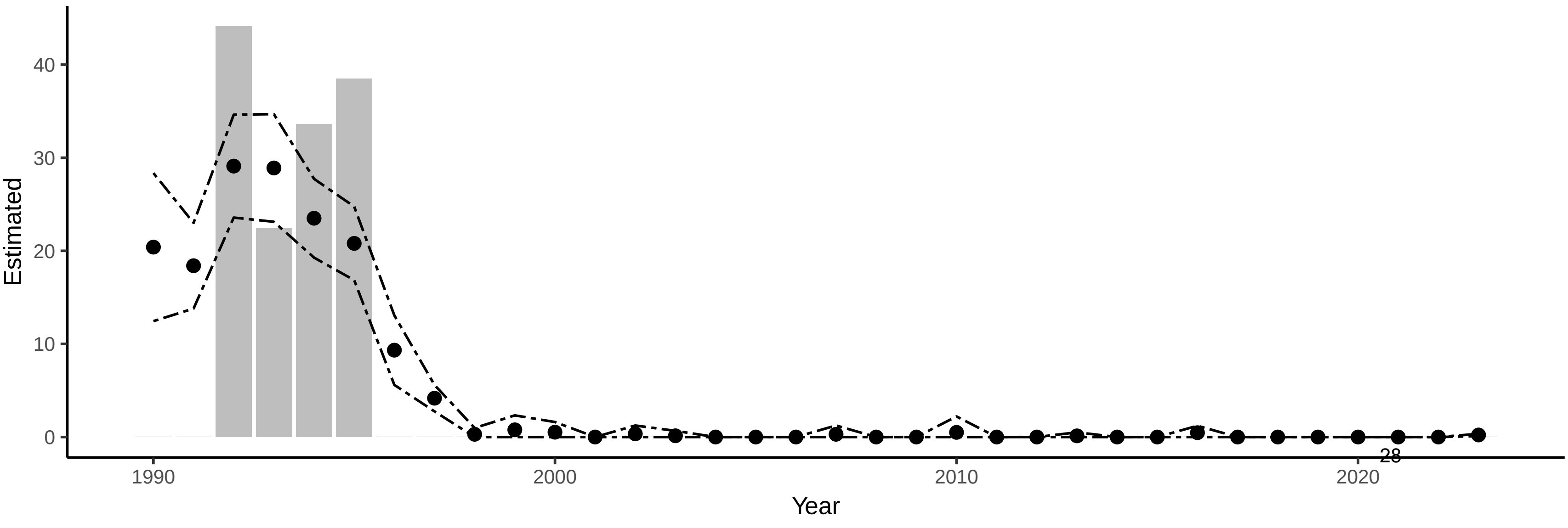
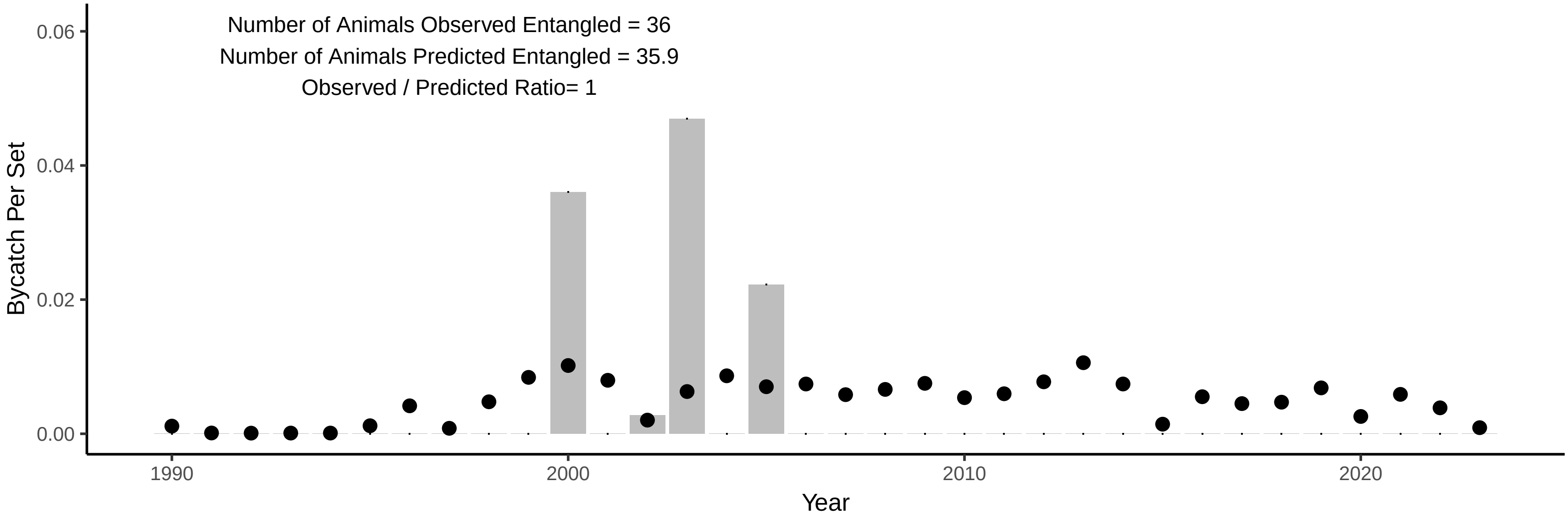


Figure 3−12. N. FULMAR Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: n.ping + mei + days



N. FULMAR Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

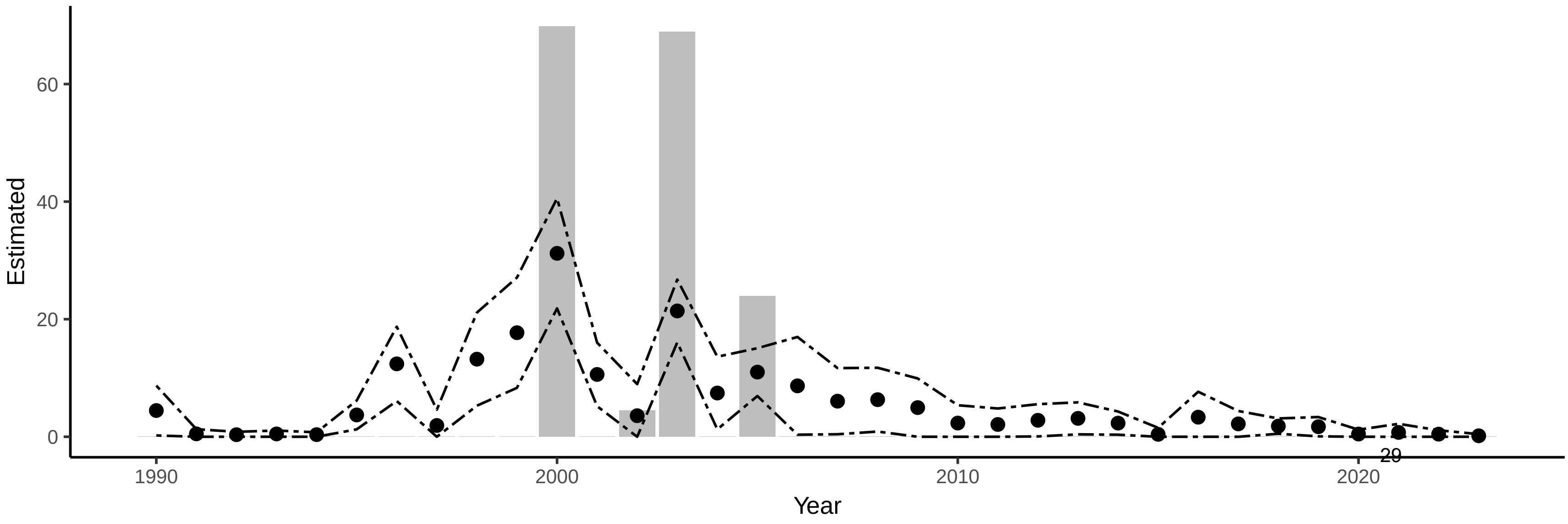
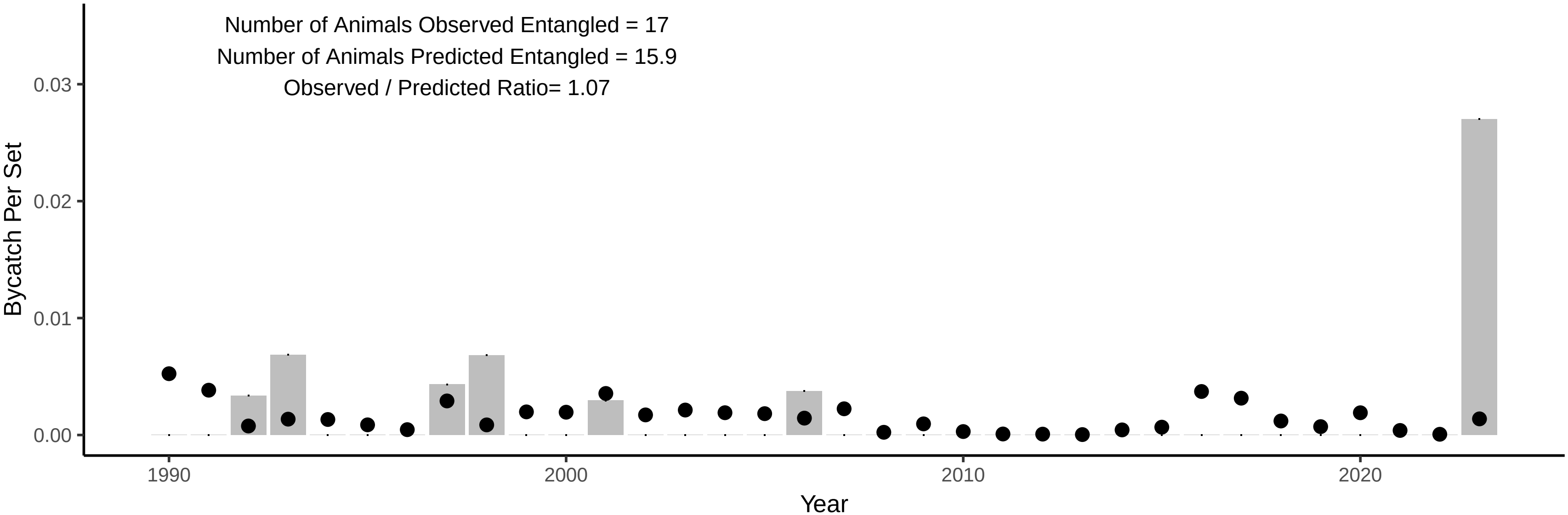


Figure 3−13. LOGGERHEAD TURTLE Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: days + lat



LOGGERHEAD TURTLE Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

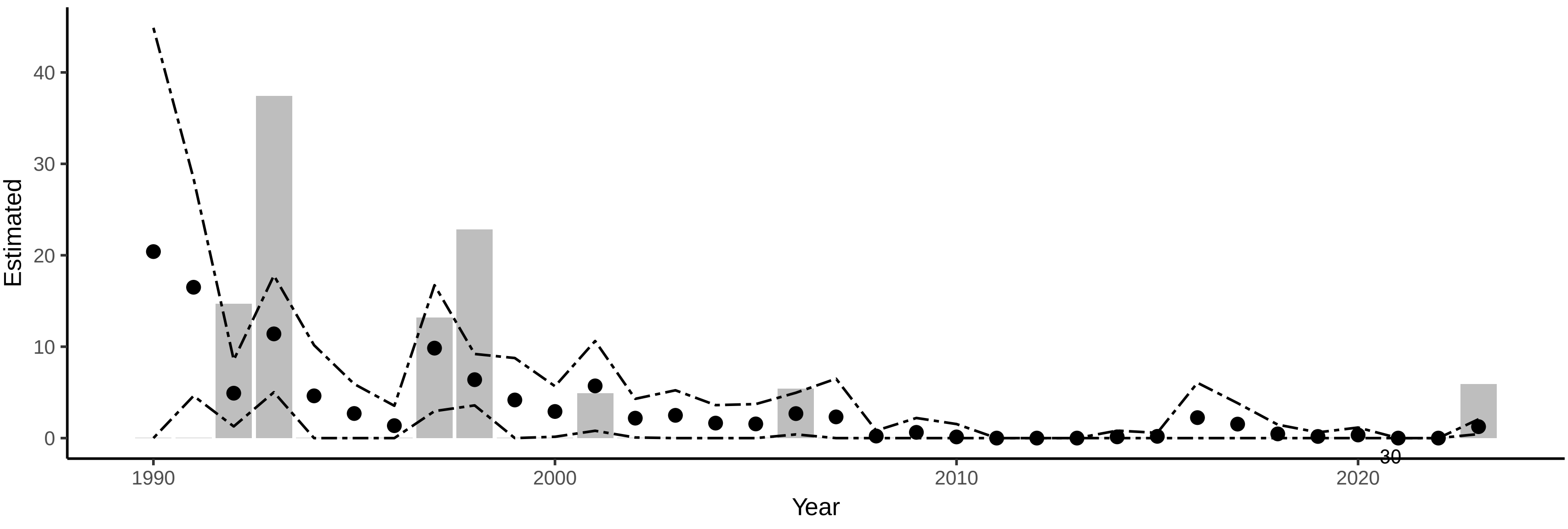
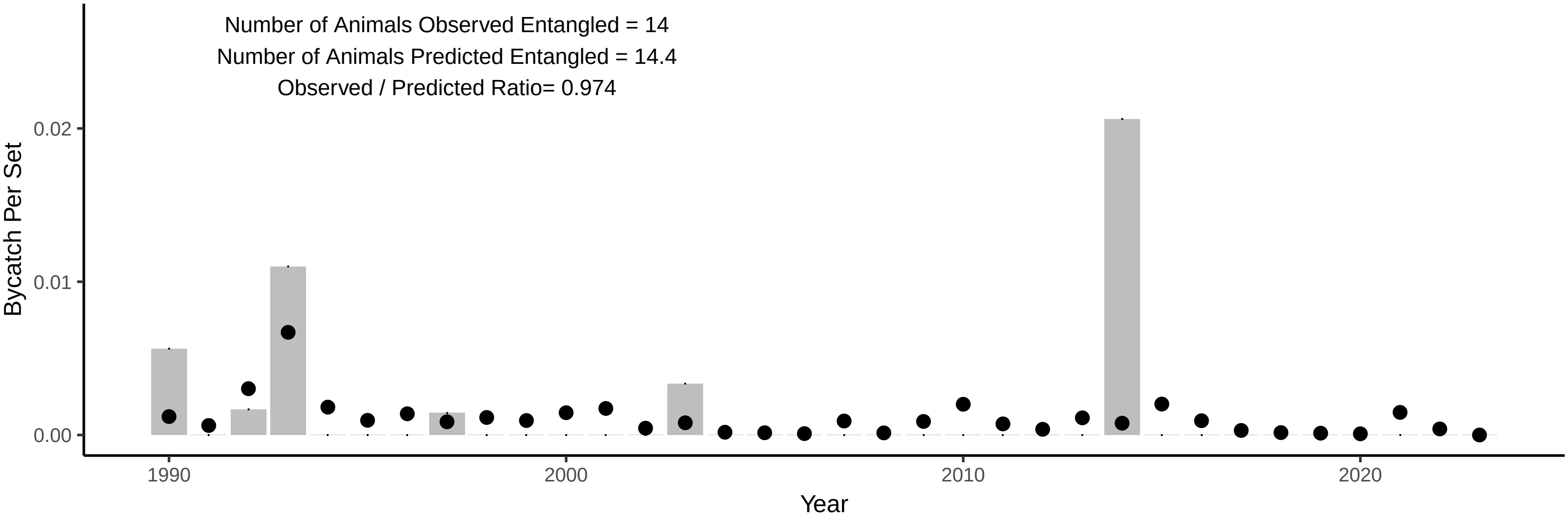


Figure 3−14. PILOT WHALE Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: depth.p + lon + days



PILOT WHALE Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

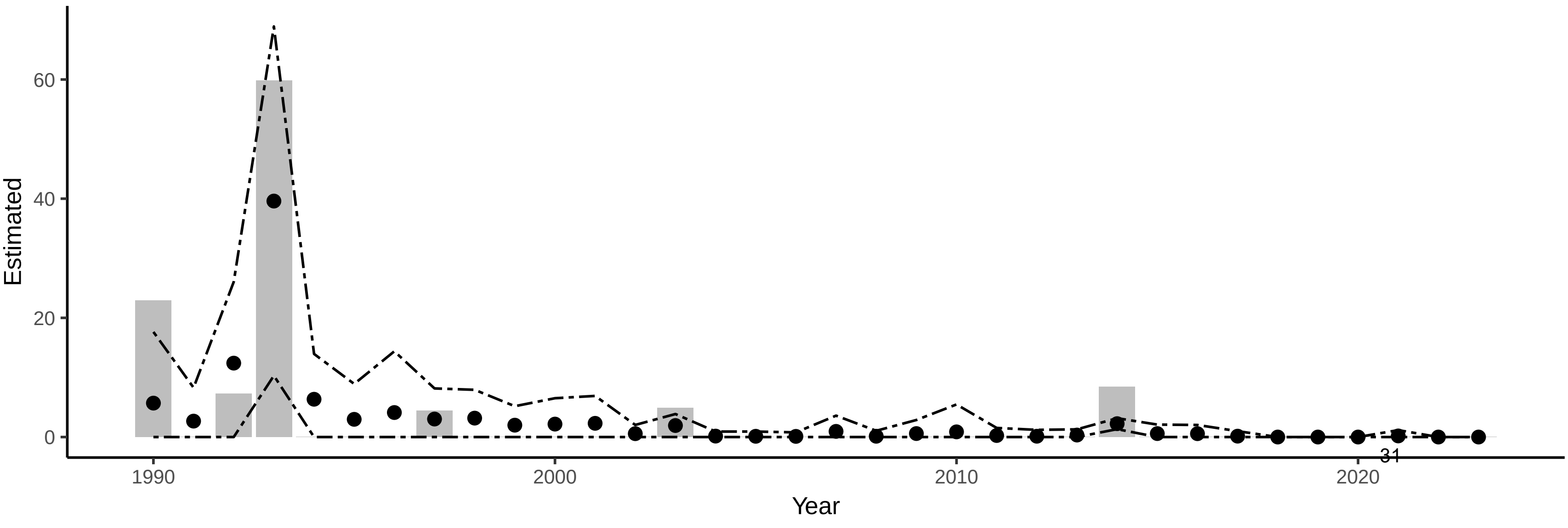
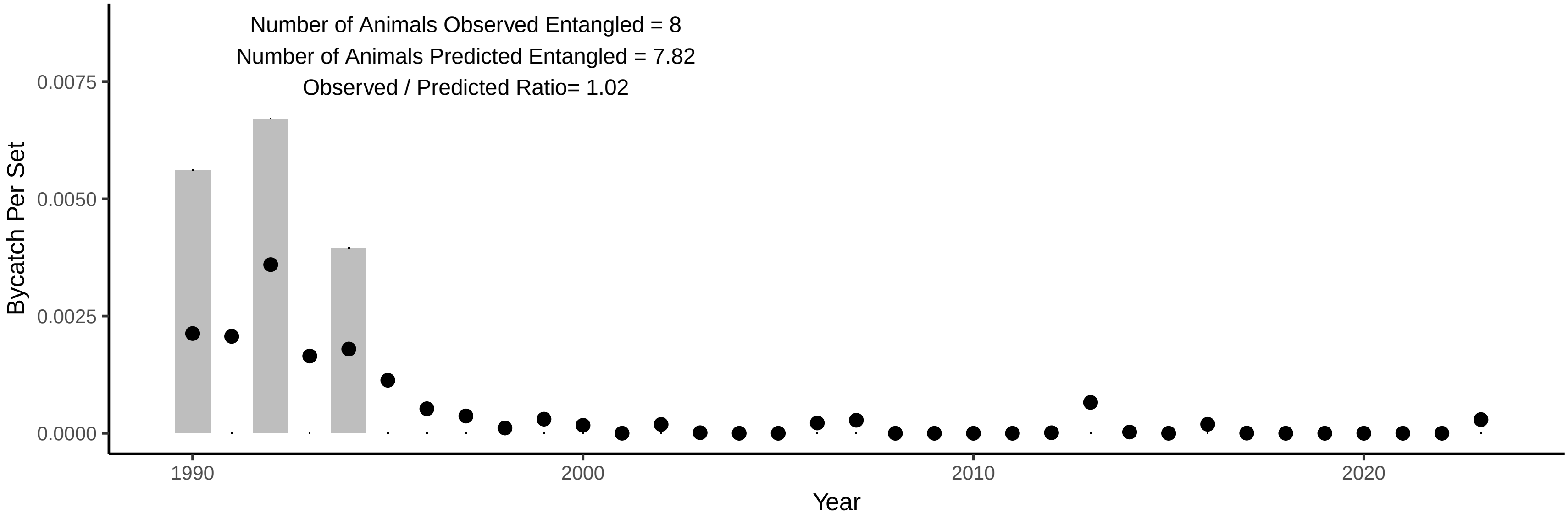


Figure 3−15. MESOPLODON Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: depth.p + lon + n.ping



MESOPLODON Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

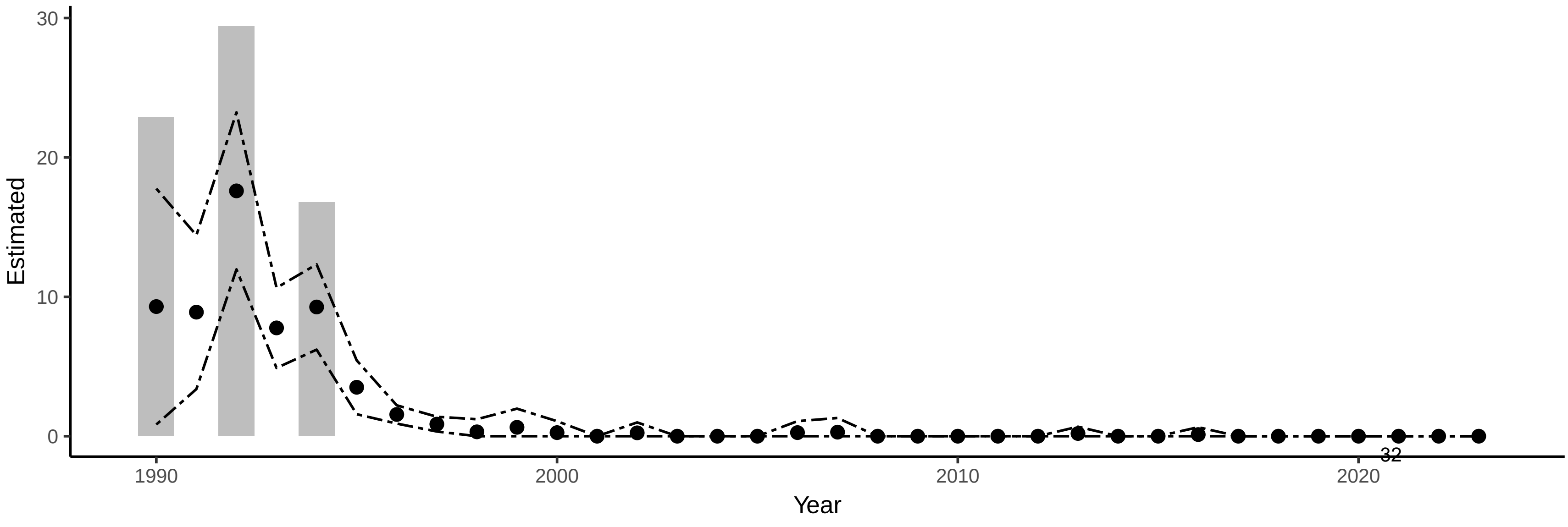
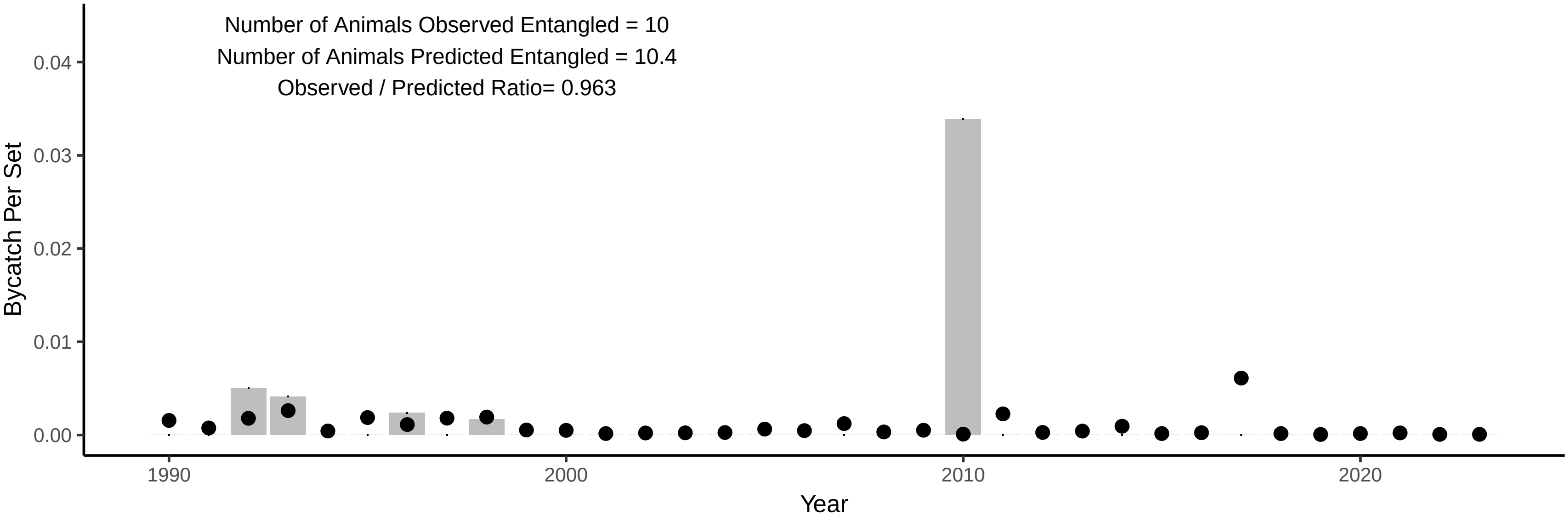


Figure 3−16. SPERM WHALE Bycatch Per Set: Observed (bars) and Predicted (points).

Model Variables: lon + days



SPERM WHALE Bycatch Estimates: Ratio (bars) and Tree (points).

Dashed lines = Tree Estimate +/− 1 SE.

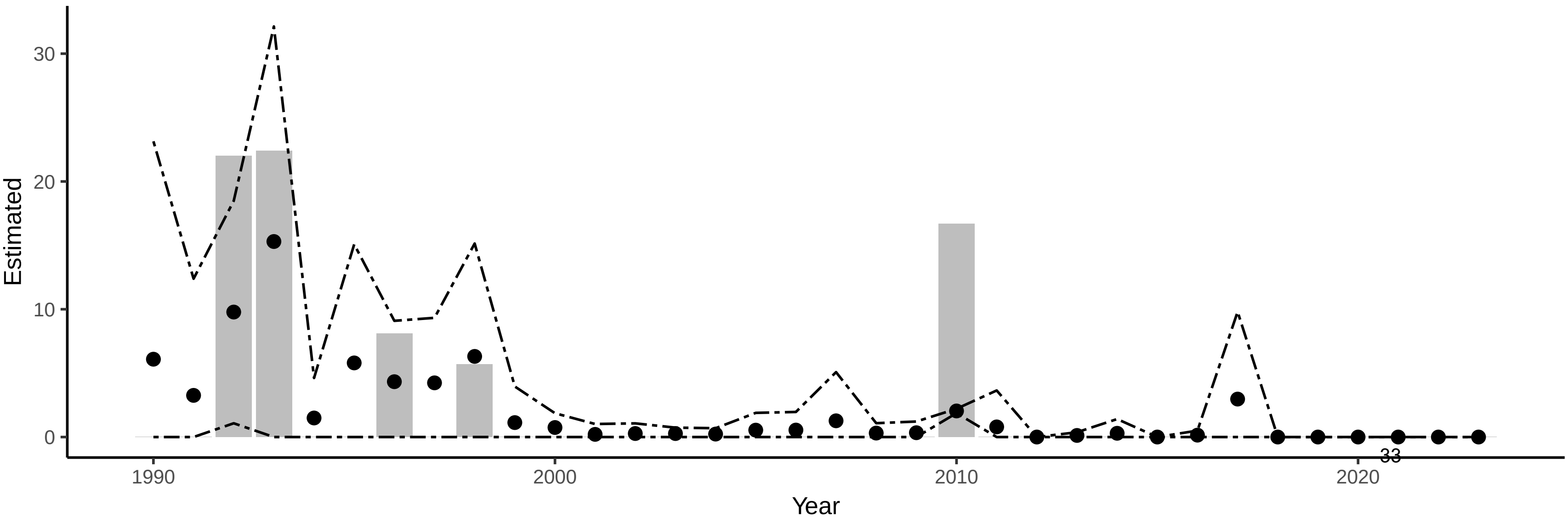


Table 1. Variables tested in random forest classification tree bycatch presence / absence models. Variables with p-values less than a 0.05 alpha-level threshold are selected for inclusion in species-specific estimation models, based on the feature 'Mean Decrease in Gini Index', a measure of how each variable contributes to the homogeneity of the nodes and leaves in the random forest. In cases where no variables are identified as 'significant', a default set of variables are used (*days* + *lat* + *lon* + *sst*). In cases where only one significant variable is identified, it was pooled with the set of default variables.

Variable.Name	Variable.Description	Range.of.Values
days	Sequential Day of Year	1 to 366
depth.p	Depth (meters) net pull	14 to 4678
extnd	Top of net depth below surface (in feet)	3 to 99
height.net	Height of net (number of meshes)	14 to 300
lat	Latitude	24.5 to 48.02
length.net	Length of net (meters)	91.4 to 2194.5
lon	Longitude	-117.0 to -129.1
mei	Multivariate El Niño index ('Cold', 'Normal', 'Warm'). Categorical variable based on mean of bimonthy ENSO anomalies for Jan + Aug – Dec of each calendar year, corresponding to fishing activity. 'Cold' <= -0.5; 'Normal' > -0.5 and < 0.5; 'Warm' = >0.5)	Factor: 'Cold', 'Normal', 'Warm'
mesh	mesh size (in)	14.0 to 31.0
n.ping	number of acoustic pingers	0 to 76
soak	soak time of net (hours)	0 to 62
sst	sea surface temperature (C)	11.1 to 25.6

Table 2. Variable selection results. 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 with ≤ 5 bycatch events (not shown in this table) utilize a default set of variables (*days* + *lat* + *lon* + *sst*).

Species	Events	Animals	Var.1	Var.2	Var.3	Var.4	Dispersion.Trip	Correct.Events	Sensitivity	Specificity	Accuracy	TSS
COMMON DOLPHIN, SHORT-BEAKED	345	436	n.ping	lon	days		2.100	261	0.757	0.524	0.533	0.281
CA SEA LION	183	224	depth.p	mesh			2.970	128	0.699	0.618	0.620	0.317
N ELEPHANT SEAL	114	118	n.ping	lon			1.200	88	0.772	0.654	0.655	0.426
N RIGHT WHALE DOLPHIN	59	81	depth.p	lon			1.890	48	0.814	0.671	0.672	0.485
BEAKED WHALES	33	33	depth.p	lon	n.ping		1.100	31	0.939	0.708	0.709	0.647
COMMON DOLPHIN, LONG-BEAKED	32	45	lat	lon	depth.p		2.260	22	0.688	0.661	0.661	0.349
RISSO'S DOLPHIN	28	36	lon	mei			1.920	17	0.607	0.612	0.612	0.219
PACIFIC WHITE-SIDED DOLPHIN	27	36	days	lat	lon	sst	1.590	16	0.593	0.659	0.659	0.252
LEATHERBACK TURTLE	25	25	depth.p	lat	lon		1.150	20	0.800	0.665	0.665	0.465
DALL'S PORPOISE	21	23	lat	lon	n.ping		1.680	16	0.762	0.724	0.724	0.486
CUVIER'S BEAKED WHALE	21	21	depth.p	lon	n.ping		0.988	19	0.905	0.689	0.690	0.594
N. FULMAR	20	36	n.ping	mei	days		2.870	19	0.950	0.700	0.701	0.650
LOGGERHEAD TURTLE	15	17	days	lat			1.460	12	0.800	0.724	0.724	0.524
PILOT WHALE	10	14	depth.p	lon	days		1.990	9	0.900	0.683	0.683	0.583
MESOPLODON	8	8	depth.p	lon	n.ping		0.996	8	1.000	0.767	0.767	0.767
SPERM WHALE	6	10	lon	days			2.000	6	1.000	0.728	0.728	0.728

Table 3. COMMON DOLPHIN, SHORT−BEAKED. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	4	178	4078	0.044	91.6	0.49	227	0.32	226	0.32
1991	39	470	4778	0.098	396.5	0.2	292	0.16	291	0.16
1992	42	596	4379	0.136	308.6	0.21	242	0.15	241	0.15
1993	26	728	5442	0.134	194.4	0.3	252	0.19	252	0.19
1994	26	759	4248	0.179	145.5	0.21	225	0.15	224	0.15
1995	38	572	3673	0.156	244	0.31	217	0.14	217	0.14
1996	28	421	3392	0.124	225.6	0.25	170	0.2	169	0.2
1997	22	692	3039	0.228	96.6	0.29	132	0.17	131	0.17
1998	9	587	3353	0.175	51.4	0.36	122	0.29	122	0.29
1999	34	526	2634	0.2	170.3	0.26	118	0.23	118	0.23
2000	25	444	1936	0.229	109	0.27	76.9	0.24	76.7	0.24
2001	7	339	1665	0.204	34.4	0.43	46.2	0.39	46.1	0.39
2002	7	360	1630	0.221	31.7	0.45	56.4	0.37	56.3	0.37
2003	17	298	1467	0.203	83.7	0.29	64.9	0.32	64.8	0.32
2004	7	223	1084	0.206	34	0.49	61.1	0.38	61	0.38
2005	12	225	1075	0.209	57.3	0.29	49.5	0.37	49.4	0.37
2006	7	266	1433	0.186	37.7	0.49	50.4	0.52	50.3	0.52
2007	9	204	1241	0.164	54.8	0.39	67.1	0.43	67	0.43
2008	8	149	1103	0.135	59.2	0.41	50.6	0.47	50.5	0.47
2009	1	101	761	0.133	7.5	0.97	23.6	0.68	23.6	0.68
2010	3	59	492	0.12	25	0.69	22.4	0.9	22.3	0.9
2011	2	85	435	0.195	10.2	0.66	14	0.67	13.9	0.67
2012	5	83	445	0.187	26.8	0.66	24.3	0.79	24.2	0.79
2013	6	175	470	0.372	16.1	0.43	14.8	0.35	14.8	0.35
2014	6	97	409	0.237	25.3	0.4	18.5	0.52	18.5	0.52
2015	0	74	361	0.205	0	NA	13.9	0.75	13.8	0.75
2016	4	134	737	0.182	22	0.57	37.8	0.63	37.7	0.63
2017	16	111	598	0.186	86.2	0.39	47.8	0.52	47.7	0.52
2018	2	129	513	0.251	8	0.67	23.2	0.59	23.1	0.59
2019	5	73	323	0.226	22.1	0.46	21	0.51	20.9	0.51
2020	3	51	230	0.222	13.5	0.7	23.3	0.82	23.3	0.82
2021	1	37	162	0.228	4.4	0.93	7.59	1.1	7.57	1.1
2022	15	28	142	0.197	76.1	0.5	25.5	0.55	25.5	0.55
2023	0	37	219	0.169	0	NA	9.69	0.59	9.67	0.59

Table 4. CA SEA LION. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	2	178	4078	0.044	45.8	1.01	49.7	0.56	48.4	0.56
1991	4	470	4778	0.098	40.7	0.61	91.6	0.4	89.2	0.4
1992	9	596	4379	0.136	66.1	0.34	58.9	0.41	57.5	0.41
1993	12	728	5442	0.134	89.7	0.4	84.9	0.24	82.9	0.24
1994	5	759	4248	0.179	28	0.43	72.2	0.29	70.4	0.29
1995	5	572	3673	0.156	32.1	0.43	53.2	0.3	51.9	0.3
1996	4	421	3392	0.124	32.2	0.47	44.4	0.3	43.3	0.3
1997	39	692	3039	0.228	171.3	0.31	90.5	0.15	89.1	0.15
1998	23	587	3353	0.175	131.4	0.26	86.8	0.2	85.1	0.2
1999	6	526	2634	0.2	30	0.38	52.3	0.41	51.1	0.4
2000	13	444	1936	0.229	56.7	0.4	53.1	0.32	52	0.32
2001	2	339	1665	0.204	9.8	0.69	38.5	0.27	37.5	0.27
2002	18	360	1630	0.221	81.5	0.26	54.1	0.21	53.2	0.2
2003	4	298	1467	0.203	19.7	0.48	35.9	0.32	35.1	0.32
2004	7	223	1084	0.206	34	0.4	38.9	0.35	38	0.35
2005	1	225	1075	0.209	4.8	0.99	28	0.36	27.3	0.36
2006	12	266	1433	0.186	64.6	0.42	78.8	1	77	1
2007	8	204	1241	0.164	48.7	0.63	29.6	0.33	29	0.33
2008	7	149	1103	0.135	51.8	0.52	37.9	0.6	37	0.6
2009	5	101	761	0.133	37.7	0.78	19.5	0.35	19.1	0.35
2010	0	59	492	0.12	0	NA	15.5	0.73	15	0.73
2011	18	85	435	0.195	92.1	0.85	29	0.32	28.8	0.31
2012	6	83	445	0.187	32.2	0.57	18.5	0.56	18.1	0.56
2013	3	175	470	0.372	8.1	0.69	9.56	0.3	9.38	0.3
2014	3	97	409	0.237	12.6	1	14.2	0.67	13.9	0.67
2015	0	74	361	0.205	0	NA	13.4	0.74	13	0.74
2016	0	134	737	0.182	0	NA	21.5	0.4	20.9	0.4
2017	2	111	598	0.186	10.8	0.67	32.5	1.5	31.7	1.5
2018	2	129	513	0.251	8	0.69	13.5	0.57	13.2	0.57
2019	0	73	323	0.226	0	NA	6.6	0.54	6.42	0.54
2020	0	51	230	0.222	0	NA	6.2	0.6	6.03	0.6
2021	3	37	162	0.228	13.1	0.69	6.32	0.49	6.24	0.48
2022	0	28	142	0.197	0	NA	4.4	1.1	4.29	1.1
2023	1	37	219	0.169	5.9	0.93	9.7	0.98	9.47	0.98

Table 5. N ELEPHANT SEAL. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	5	178	4078	0.044	114.6	0.42	115	0.1	114	0.1
1991	13	470	4778	0.098	132.2	0.28	121	0.079	120	0.08
1992	15	596	4379	0.136	110.2	0.25	116	0.065	115	0.065
1993	14	728	5442	0.134	104.7	0.29	123	0.053	122	0.054
1994	22	759	4248	0.179	123.1	0.26	101	0.052	100	0.052
1995	14	572	3673	0.156	89.9	0.29	90	0.064	89.4	0.064
1996	5	421	3392	0.124	40.3	0.5	52.8	0.11	52.4	0.11
1997	9	692	3039	0.228	39.5	0.32	37.4	0.095	37.1	0.095
1998	4	587	3353	0.175	22.8	0.47	17.9	0.35	17.8	0.35
1999	2	526	2634	0.2	10	0.68	12	0.45	11.9	0.45
2000	6	444	1936	0.229	26.2	0.38	12.9	0.27	12.8	0.27
2001	1	339	1665	0.204	4.9	1	9.41	0.45	9.34	0.45
2002	1	360	1630	0.221	4.5	1.02	5.97	0.45	5.93	0.45
2003	1	298	1467	0.203	4.9	1	4.52	0.55	4.49	0.55
2004	0	223	1084	0.206	0	NA	2.53	0.88	2.51	0.88
2005	1	225	1075	0.209	4.8	0.97	3.29	0.64	3.27	0.64
2006	0	266	1433	0.186	0	NA	3.04	0.9	3.01	0.9
2007	1	204	1241	0.164	6.1	1	3.2	0.67	3.18	0.67
2008	0	149	1103	0.135	0	NA	5.4	0.83	5.35	0.83
2009	0	101	761	0.133	0	NA	1.87	1.1	1.85	1.1
2010	0	59	492	0.12	0	NA	3.71	1.2	3.68	1.2
2011	0	85	435	0.195	0	NA	1.28	1.3	1.27	1.3
2012	0	83	445	0.187	0	NA	0.396	1.1	0.392	1.1
2013	0	175	470	0.372	0	NA	0.646	0.91	0.641	0.91
2014	1	97	409	0.237	4.2	1.01	3.78	0.62	3.76	0.62
2015	0	74	361	0.205	0	NA	2.88	0.81	2.85	0.81
2016	0	134	737	0.182	0	NA	3.01	0.6	2.98	0.61
2017	3	111	598	0.186	16.2	0.73	4.28	0.34	4.27	0.34
2018	0	129	513	0.251	0	NA	1.76	0.99	1.74	0.98
2019	0	73	323	0.226	0	NA	0.453	2.1	0.449	2.1
2020	0	51	230	0.222	0	NA	0.141	1.2	0.139	1.2
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0.114	3.2	0.113	3.2
2023	0	37	219	0.169	0	NA	2.05	0.61	2.03	0.61

Table 6. N RIGHT WHALE DOLPHIN. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	48.8	0.99	48.8	0.99
1991	7	470	4778	0.098	71.2	0.4	35.1	0.69	35.1	0.69
1992	2	596	4379	0.136	14.7	0.72	48.3	0.56	48.3	0.56
1993	7	728	5442	0.134	52.3	0.42	48.4	0.51	48.4	0.51
1994	7	759	4248	0.179	39.2	0.48	39.1	0.42	39.1	0.42
1995	9	572	3673	0.156	57.8	0.67	42.2	0.49	42.2	0.49
1996	5	421	3392	0.124	40.3	0.65	27.7	0.62	27.7	0.62
1997	5	692	3039	0.228	22	0.43	25.3	0.5	25.3	0.5
1998	0	587	3353	0.175	0	NA	29.2	0.68	29.2	0.68
1999	3	526	2634	0.2	15	0.74	20.2	0.59	20.2	0.59
2000	11	444	1936	0.229	48	0.51	24.9	0.49	24.9	0.49
2001	5	339	1665	0.204	24.6	0.59	15	0.55	15	0.55
2002	2	360	1630	0.221	9.1	0.72	10.4	1.1	10.4	1.1
2003	1	298	1467	0.203	4.9	0.96	3.9	1.1	3.9	1.1
2004	1	223	1084	0.206	4.9	1	3.88	1.4	3.88	1.4
2005	0	225	1075	0.209	0	NA	2.1	2.4	2.1	2.4
2006	0	266	1433	0.186	0	NA	2.67	1.9	2.67	1.9
2007	1	204	1241	0.164	6.1	0.95	11.1	1.1	11.1	1.1
2008	1	149	1103	0.135	7.4	0.96	4.32	1.6	4.32	1.6
2009	0	101	761	0.133	0	NA	3.2	2.4	3.2	2.4
2010	1	59	492	0.12	8.3	0.96	4.1	1.4	4.1	1.4
2011	1	85	435	0.195	5.1	0.95	5.49	0.97	5.49	0.97
2012	1	83	445	0.187	5.4	0.94	3.66	1.3	3.66	1.3
2013	2	175	470	0.372	5.4	0.97	3.89	0.69	3.89	0.69
2014	1	97	409	0.237	4.2	0.97	5.28	0.96	5.28	0.96
2015	0	74	361	0.205	0	NA	3.65	1.3	3.65	1.3
2016	5	134	737	0.182	27.5	0.68	11.1	0.76	11.1	0.76
2017	2	111	598	0.186	10.8	0.65	6.66	0.87	6.66	0.87
2018	0	129	513	0.251	0	NA	2.89	1.2	2.89	1.2
2019	0	73	323	0.226	0	NA	0.864	2	0.864	2
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0.203	3.7	0.203	3.7
2022	1	28	142	0.197	5.1	0.98	1.08	0.59	1.08	0.59
2023	0	37	219	0.169	0	NA	0.195	3.8	0.195	3.8

Table 7. BEAKED WHALES. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	1	178	4078	0.044	22.9	1	33.6	0.35	32.6	0.35
1991	0	470	4778	0.098	0	NA	32.2	0.24	31.3	0.24
1992	12	596	4379	0.136	88.2	0.31	53.7	0.15	52.4	0.16
1993	3	728	5442	0.134	22.4	0.59	44.9	0.16	43.7	0.16
1994	11	759	4248	0.179	61.6	0.29	38.3	0.13	37.4	0.13
1995	6	572	3673	0.156	38.5	0.39	27.4	0.17	26.8	0.17
1996	0	421	3392	0.124	0	NA	12.3	0.3	11.9	0.3
1997	0	692	3039	0.228	0	NA	5.84	0.25	5.66	0.25
1998	0	587	3353	0.175	0	NA	0.564	2	0.547	2
1999	0	526	2634	0.2	0	NA	0.913	1.9	0.885	1.9
2000	0	444	1936	0.229	0	NA	0.579	2.1	0.561	2.1
2001	0	339	1665	0.204	0	NA	0.134	4.3	0.13	4.3
2002	0	360	1630	0.221	0	NA	0.373	2.7	0.362	2.8
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0.205	3.9	0.199	3.9
2007	0	204	1241	0.164	0	NA	0.539	2.7	0.522	2.7
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0.383	4.2	0.372	4.2
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0.233	2.4	0.226	2.4
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0.621	1.3	0.602	1.3
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0.308	0.58	0.299	0.57

Table 8. COMMON DOLPHIN, LONG−BEAKED. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	4	178	4078	0.044	91.6	0.77	34.3	1.3	33.2	1.3
1991	5	470	4778	0.098	50.8	1	28.2	1	27.4	0.99
1992	5	596	4379	0.136	36.7	0.52	14.8	1.1	14.4	1.1
1993	2	728	5442	0.134	15	0.69	11.2	1.1	10.9	1.1
1994	1	759	4248	0.179	5.6	0.99	17.1	0.79	16.5	0.79
1995	4	572	3673	0.156	25.7	0.95	14.9	0.83	14.5	0.83
1996	0	421	3392	0.124	0	NA	13.8	1.4	13.3	1.4
1997	4	692	3039	0.228	17.6	0.79	19.9	0.55	19.3	0.55
1998	0	587	3353	0.175	0	NA	16	1	15.5	1
1999	3	526	2634	0.2	15	0.76	11.1	0.89	10.8	0.88
2000	0	444	1936	0.229	0	NA	7.59	1.2	7.32	1.2
2001	0	339	1665	0.204	0	NA	9.66	1.1	9.32	1.1
2002	4	360	1630	0.221	18.1	0.81	8.38	0.65	8.22	0.64
2003	0	298	1467	0.203	0	NA	5.66	1.8	5.46	1.8
2004	0	223	1084	0.206	0	NA	4.52	1.4	4.35	1.4
2005	3	225	1075	0.209	14.3	0.53	6.68	0.79	6.55	0.78
2006	0	266	1433	0.186	0	NA	4.68	1.3	4.51	1.3
2007	0	204	1241	0.164	0	NA	2.56	2.3	2.47	2.2
2008	1	149	1103	0.135	7.4	0.97	7.99	1.2	7.74	1.2
2009	0	101	761	0.133	0	NA	4.35	2.1	4.19	2.1
2010	1	59	492	0.12	8.3	0.96	1.75	2.2	1.73	2.2
2011	1	85	435	0.195	5.1	0.96	2.38	1.8	2.33	1.7
2012	0	83	445	0.187	0	NA	1.42	2.3	1.37	2.3
2013	0	175	470	0.372	0	NA	1.24	2.3	1.2	2.3
2014	0	97	409	0.237	0	NA	2.53	2.1	2.44	2.1
2015	1	74	361	0.205	4.9	0.97	1.82	1.4	1.79	1.4
2016	1	134	737	0.182	5.5	0.98	3.51	1.2	3.42	1.2
2017	0	111	598	0.186	0	NA	2.11	2.5	2.04	2.5
2018	0	129	513	0.251	0	NA	1.89	1.8	1.83	1.8
2019	0	73	323	0.226	0	NA	1.69	1.8	1.63	1.8
2020	2	51	230	0.222	9	0.96	3.25	0.94	3.2	0.92
2021	0	37	162	0.228	0	NA	0.134	6.5	0.129	6.5
2022	0	28	142	0.197	0	NA	0.461	3.5	0.444	3.5
2023	3	37	219	0.169	17.8	0.68	4.24	0.88	4.2	0.86

Table 9. RISSO'S DOLPHIN. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	21.8	1.3	21.8	1.3
1991	5	470	4778	0.098	50.8	0.53	27.6	0.23	27.6	0.23
1992	5	596	4379	0.136	36.7	0.53	28.1	0.24	28.1	0.24
1993	7	728	5442	0.134	52.3	0.52	30.8	0.18	30.8	0.18
1994	1	759	4248	0.179	5.6	1.07	20.8	0.27	20.8	0.27
1995	6	572	3673	0.156	38.5	0.65	19.7	0.52	19.7	0.52
1996	0	421	3392	0.124	0	NA	8.07	0.52	8.07	0.52
1997	3	692	3039	0.228	13.2	0.76	15	0.26	15	0.26
1998	0	587	3353	0.175	0	NA	5.51	0.57	5.51	0.57
1999	0	526	2634	0.2	0	NA	4.21	0.72	4.21	0.72
2000	2	444	1936	0.229	8.7	0.67	4.69	0.29	4.69	0.29
2001	0	339	1665	0.204	0	NA	3.08	0.48	3.08	0.48
2002	0	360	1630	0.221	0	NA	7.4	0.27	7.4	0.27
2003	4	298	1467	0.203	19.7	1	5.92	0.2	5.92	0.2
2004	0	223	1084	0.206	0	NA	1.45	0.62	1.45	0.62
2005	0	225	1075	0.209	0	NA	1.02	0.74	1.02	0.74
2006	0	266	1433	0.186	0	NA	1.54	0.5	1.54	0.5
2007	0	204	1241	0.164	0	NA	1.36	0.42	1.36	0.42
2008	1	149	1103	0.135	7.4	0.96	2.7	0.77	2.7	0.77
2009	0	101	761	0.133	0	NA	1.63	0.85	1.63	0.85
2010	0	59	492	0.12	0	NA	1.86	2.3	1.86	2.3
2011	1	85	435	0.195	5.1	1.01	1.68	0.19	1.68	0.19
2012	0	83	445	0.187	0	NA	1.37	0.98	1.37	0.98
2013	0	175	470	0.372	0	NA	2.07	1.4	2.07	1.4
2014	0	97	409	0.237	0	NA	1.51	1.1	1.51	1.1
2015	0	74	361	0.205	0	NA	2.56	0.58	2.56	0.58
2016	0	134	737	0.182	0	NA	1.51	0.73	1.51	0.73
2017	0	111	598	0.186	0	NA	0.822	0.74	0.822	0.74
2018	0	129	513	0.251	0	NA	1.18	1.5	1.18	1.5
2019	0	73	323	0.226	0	NA	0.132	1	0.132	1
2020	0	51	230	0.222	0	NA	0.131	0.73	0.131	0.73
2021	1	37	162	0.228	4.4	0.93	1.29	0.42	1.29	0.42
2022	0	28	142	0.197	0	NA	0.127	0.87	0.127	0.87
2023	0	37	219	0.169	0	NA	0.822	2.3	0.822	2.3

Table 10. PACIFIC WHITE−SIDED DOLPHIN. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	3	178	4078	0.044	68.7	0.55	35.3	1.1	35.3	1.1
1991	5	470	4778	0.098	50.8	0.64	26.6	0.76	26.6	0.76
1992	3	596	4379	0.136	22	0.75	31.5	0.76	31.5	0.76
1993	2	728	5442	0.134	15	0.71	15.6	0.77	15.6	0.77
1994	3	759	4248	0.179	16.8	0.74	25.3	0.56	25.3	0.56
1995	1	572	3673	0.156	6.4	1	13.4	0.94	13.4	0.94
1996	3	421	3392	0.124	24.2	0.73	12.2	1	12.2	1
1997	3	692	3039	0.228	13.2	0.59	9.44	0.77	9.44	0.77
1998	0	587	3353	0.175	0	NA	5.08	1.3	5.08	1.3
1999	0	526	2634	0.2	0	NA	8.73	0.88	8.73	0.88
2000	2	444	1936	0.229	8.7	0.71	5.71	0.87	5.71	0.87
2001	2	339	1665	0.204	9.8	0.71	9.13	0.93	9.13	0.93
2002	1	360	1630	0.221	4.5	0.98	4.43	1.1	4.43	1.1
2003	0	298	1467	0.203	0	NA	1.36	2.4	1.36	2.4
2004	0	223	1084	0.206	0	NA	3	1.4	3	1.4
2005	0	225	1075	0.209	0	NA	1.34	2	1.34	2
2006	0	266	1433	0.186	0	NA	1.53	2.4	1.53	2.4
2007	1	204	1241	0.164	6.1	0.97	2.42	1.2	2.42	1.2
2008	5	149	1103	0.135	37	0.68	9.32	0.85	9.32	0.85
2009	2	101	761	0.133	15.1	0.99	3.37	1.2	3.37	1.2
2010	0	59	492	0.12	0	NA	1.21	3.3	1.21	3.3
2011	0	85	435	0.195	0	NA	0.973	2.2	0.973	2.2
2012	0	83	445	0.187	0	NA	0.553	4.8	0.553	4.8
2013	0	175	470	0.372	0	NA	0.762	1.9	0.762	1.9
2014	0	97	409	0.237	0	NA	1.04	2.3	1.04	2.3
2015	0	74	361	0.205	0	NA	2.39	2.7	2.39	2.7
2016	0	134	737	0.182	0	NA	0.959	2.7	0.959	2.7
2017	0	111	598	0.186	0	NA	1.71	2.2	1.71	2.2
2018	0	129	513	0.251	0	NA	0.932	2.4	0.932	2.4
2019	0	73	323	0.226	0	NA	0.16	5	0.16	5
2020	0	51	230	0.222	0	NA	0.154	7.2	0.154	7.2
2021	0	37	162	0.228	0	NA	0.291	4.4	0.291	4.4
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0.182	6.9	0.182	6.9

Table 11. LEATHERBACK TURTLE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	1	178	4078	0.044	22.9	1.03	18	0.97	12.6	0.95
1991	1	470	4778	0.098	10.2	0.98	18.6	0.65	13	0.65
1992	4	596	4379	0.136	29.4	0.49	20.9	0.49	15.5	0.47
1993	3	728	5442	0.134	22.4	0.56	21.3	0.47	15.5	0.47
1994	1	759	4248	0.179	5.6	0.96	9.2	0.59	6.58	0.58
1995	5	572	3673	0.156	32.1	0.52	17.6	0.47	13.6	0.43
1996	2	421	3392	0.124	16.1	0.67	19.4	0.53	13.8	0.51
1997	4	692	3039	0.228	17.6	0.59	16.4	0.37	12.4	0.35
1998	0	587	3353	0.175	0	NA	8.05	0.72	5.48	0.73
1999	2	526	2634	0.2	10	0.74	7.55	0.58	5.77	0.53
2000	0	444	1936	0.229	0	NA	1.99	1.1	1.35	1.1
2001	0	339	1665	0.204	0	NA	1.35	1.5	0.919	1.5
2002	0	360	1630	0.221	0	NA	0.893	1.9	0.607	1.9
2003	0	298	1467	0.203	0	NA	0.222	3.4	0.151	3.4
2004	0	223	1084	0.206	0	NA	0.238	3.7	0.162	3.7
2005	0	225	1075	0.209	0	NA	1.01	1.6	0.687	1.6
2006	0	266	1433	0.186	0	NA	1.53	1.5	1.04	1.5
2007	0	204	1241	0.164	0	NA	0.941	2.1	0.64	2.1
2008	0	149	1103	0.135	0	NA	0.234	4.8	0.159	4.7
2009	1	101	761	0.133	7.5	0.97	1.98	1	1.67	0.84
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	1	83	445	0.187	5.4	1	1.35	0.72	1.24	0.55
2013	0	175	470	0.372	0	NA	0.883	1.3	0.6	1.3
2014	0	97	409	0.237	0	NA	0.136	3.8	0	0
2015	0	74	361	0.205	0	NA	0.6	2.5	0.408	2.5
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0.574	2.3	0.39	2.4
2018	0	129	513	0.251	0	NA	0.413	2.5	0.281	2.5
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0.131	4.9	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 12. DALL'S PORPOISE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	1	178	4078	0.044	22.9	0.96	13.4	0.92	13.4	0.92
1991	2	470	4778	0.098	20.3	0.68	17.4	0.58	17.4	0.58
1992	1	596	4379	0.136	7.3	1.05	24.7	0.36	24.7	0.36
1993	9	728	5442	0.134	67.3	0.46	45.9	0.33	45.9	0.33
1994	2	759	4248	0.179	11.2	0.7	18.5	0.38	18.5	0.38
1995	1	572	3673	0.156	6.4	1.03	10	0.56	10	0.56
1996	2	421	3392	0.124	16.1	0.68	7.73	0.66	7.73	0.66
1997	4	692	3039	0.228	17.6	0.8	11.2	0.52	11.2	0.52
1998	0	587	3353	0.175	0	NA	1.2	2	1.2	2
1999	0	526	2634	0.2	0	NA	2.86	1.5	2.86	1.5
2000	0	444	1936	0.229	0	NA	0.749	2.4	0.749	2.4
2001	0	339	1665	0.204	0	NA	0.255	3.7	0.255	3.7
2002	0	360	1630	0.221	0	NA	0.411	3.9	0.411	3.9
2003	0	298	1467	0.203	0	NA	0.42	3.2	0.42	3.2
2004	0	223	1084	0.206	0	NA	0.31	3.8	0.31	3.8
2005	0	225	1075	0.209	0	NA	0.396	3.6	0.396	3.6
2006	0	266	1433	0.186	0	NA	0.177	5.1	0.177	5.1
2007	0	204	1241	0.164	0	NA	0.27	4.8	0.27	4.8
2008	0	149	1103	0.135	0	NA	0.125	7.7	0.125	7.7
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0.255	3.3	0.255	3.3
2014	1	97	409	0.237	4.2	0.98	1.13	0.68	1.13	0.68
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0.462	3	0.462	3
2017	0	111	598	0.186	0	NA	0.797	2.5	0.797	2.5
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0.115	4.5	0.115	4.5
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0.286	2.7	0.286	2.7

Table 13. CUVIER'S BEAKED WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	20.4	0.39	19.5	0.39
1991	0	470	4778	0.098	0	NA	18.4	0.25	17.5	0.26
1992	6	596	4379	0.136	44.1	0.4	29.1	0.19	28	0.19
1993	3	728	5442	0.134	22.4	0.58	28.9	0.2	27.6	0.2
1994	6	759	4248	0.179	33.6	0.39	23.5	0.18	22.7	0.18
1995	6	572	3673	0.156	38.5	0.39	20.8	0.19	20.1	0.19
1996	0	421	3392	0.124	0	NA	9.33	0.4	8.89	0.4
1997	0	692	3039	0.228	0	NA	4.17	0.34	3.98	0.34
1998	0	587	3353	0.175	0	NA	0.295	2.3	0.281	2.3
1999	0	526	2634	0.2	0	NA	0.775	2	0.738	2
2000	0	444	1936	0.229	0	NA	0.52	2.1	0.495	2.1
2001	0	339	1665	0.204	0	NA	0	0	0	0
2002	0	360	1630	0.221	0	NA	0.344	2.6	0.328	2.6
2003	0	298	1467	0.203	0	NA	0.133	4	0.127	3.9
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0.295	3.2	0.281	3.1
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0.502	3.4	0.478	3.4
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0.126	3	0.12	3
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0.464	1.6	0.442	1.6
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0.22	0.56	0.209	0.55

Table 14. N. FULMAR. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	4.46	0.95	0.372	1.4
1991	0	470	4778	0.098	0	NA	0.494	1.6	0	0
1992	0	596	4379	0.136	0	NA	0.349	1.4	0	0
1993	0	728	5442	0.134	0	NA	0.48	1.2	0	0
1994	0	759	4248	0.179	0	NA	0.36	1.1	0	0
1995	0	572	3673	0.156	0	NA	3.71	0.66	0.309	1.1
1996	0	421	3392	0.124	0	NA	12.4	0.51	1.03	1
1997	0	692	3039	0.228	0	NA	1.92	1.4	0.16	1.7
1998	0	587	3353	0.175	0	NA	13.2	0.6	1.1	1.1
1999	0	526	2634	0.2	0	NA	17.7	0.53	1.48	1.1
2000	16	444	1936	0.229	69.8	0.34	31.2	0.3	17.3	0.081
2001	0	339	1665	0.204	0	NA	10.6	0.51	0.881	0.99
2002	1	360	1630	0.221	4.5	0.95	3.58	1.5	1.22	0.47
2003	14	298	1467	0.203	68.9	0.47	21.4	0.25	14.6	0.051
2004	0	223	1084	0.206	0	NA	7.44	0.83	0.62	1.2
2005	5	225	1075	0.209	23.9	0.95	11	0.37	5.5	0.11
2006	0	266	1433	0.186	0	NA	8.66	0.96	0.721	1.5
2007	0	204	1241	0.164	0	NA	6.05	0.93	0.504	1.4
2008	0	149	1103	0.135	0	NA	6.31	0.86	0.526	1.4
2009	0	101	761	0.133	0	NA	4.96	1	0.413	1.4
2010	0	59	492	0.12	0	NA	2.33	1.3	0.194	1.8
2011	0	85	435	0.195	0	NA	2.09	1.3	0.174	1.8
2012	0	83	445	0.187	0	NA	2.8	0.98	0.234	1.4
2013	0	175	470	0.372	0	NA	3.13	0.87	0.26	1.1
2014	0	97	409	0.237	0	NA	2.32	0.85	0.193	1.3
2015	0	74	361	0.205	0	NA	0.41	2.7	0	0
2016	0	134	737	0.182	0	NA	3.33	1.3	0.277	1.8
2017	0	111	598	0.186	0	NA	2.19	1	0.182	1.5
2018	0	129	513	0.251	0	NA	1.81	0.72	0.151	1.1
2019	0	73	323	0.226	0	NA	1.71	0.96	0.143	1.4
2020	0	51	230	0.222	0	NA	0.462	1.6	0	0
2021	0	37	162	0.228	0	NA	0.734	2	0	0
2022	0	28	142	0.197	0	NA	0.441	1.5	0	0
2023	0	37	219	0.169	0	NA	0.165	1.7	0	0

Table 15. LOGGERHEAD TURTLE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	20.4	1.2	4.81	1.4
1991	0	470	4778	0.098	0	NA	16.5	0.72	3.88	0.92
1992	2	596	4379	0.136	14.7	0.68	4.91	0.74	2.68	0.38
1993	5	728	5442	0.134	37.4	0.55	11.4	0.56	6.5	0.26
1994	0	759	4248	0.179	0	NA	4.62	1.2	1.09	1.4
1995	0	572	3673	0.156	0	NA	2.69	1.2	0.634	1.4
1996	0	421	3392	0.124	0	NA	1.36	1.6	0.319	2
1997	3	692	3039	0.228	13.2	0.57	9.84	0.7	4.61	0.42
1998	4	587	3353	0.175	22.8	0.8	6.39	0.44	4.56	0.17
1999	0	526	2634	0.2	0	NA	4.17	1.1	0.981	1.2
2000	0	444	1936	0.229	0	NA	2.91	0.95	0.684	1.2
2001	1	339	1665	0.204	4.9	0.97	5.71	0.86	2.11	0.65
2002	0	360	1630	0.221	0	NA	2.18	0.97	0.513	1.1
2003	0	298	1467	0.203	0	NA	2.49	1.1	0.587	1.3
2004	0	223	1084	0.206	0	NA	1.64	1.2	0.386	1.5
2005	0	225	1075	0.209	0	NA	1.55	1.4	0.365	1.5
2006	1	266	1433	0.186	5.4	1.01	2.68	0.85	1.4	0.4
2007	0	204	1241	0.164	0	NA	2.32	1.8	0.547	2.1
2008	0	149	1103	0.135	0	NA	0.221	2.7	0	0
2009	0	101	761	0.133	0	NA	0.628	2.5	0.148	3
2010	0	59	492	0.12	0	NA	0.128	11	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0.136	5	0	0
2015	0	74	361	0.205	0	NA	0.192	2	0	0
2016	0	134	737	0.182	0	NA	2.24	1.7	0.528	1.9
2017	0	111	598	0.186	0	NA	1.53	1.5	0.361	1.6
2018	0	129	513	0.251	0	NA	0.459	2.2	0.108	2.5
2019	0	73	323	0.226	0	NA	0.179	2.5	0	0
2020	0	51	230	0.222	0	NA	0.34	2.4	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	1	37	219	0.169	5.9	0.91	1.25	0.65	1.06	0.2

Table 16. PILOT WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	1	178	4078	0.044	22.9	1.03	5.69	2.1	5.69	2.1
1991	0	470	4778	0.098	0	NA	2.67	2.1	2.67	2.1
1992	1	596	4379	0.136	7.3	0.98	12.4	1.1	12.4	1.1
1993	8	728	5442	0.134	59.8	0.6	39.6	0.74	39.6	0.74
1994	0	759	4248	0.179	0	NA	6.34	1.2	6.34	1.2
1995	0	572	3673	0.156	0	NA	2.97	2	2.97	2
1996	0	421	3392	0.124	0	NA	4.11	2.5	4.11	2.5
1997	1	692	3039	0.228	4.4	1.01	3.02	1.7	3.02	1.7
1998	0	587	3353	0.175	0	NA	3.17	1.5	3.17	1.5
1999	0	526	2634	0.2	0	NA	1.99	1.6	1.99	1.6
2000	0	444	1936	0.229	0	NA	2.17	2	2.17	2
2001	0	339	1665	0.204	0	NA	2.3	2	2.3	2
2002	0	360	1630	0.221	0	NA	0.563	2.6	0.563	2.6
2003	1	298	1467	0.203	4.9	1.01	1.93	1	1.93	1
2004	0	223	1084	0.206	0	NA	0.155	4.9	0.155	4.9
2005	0	225	1075	0.209	0	NA	0.124	6.4	0.124	6.4
2006	0	266	1433	0.186	0	NA	0.107	6.3	0.107	6.3
2007	0	204	1241	0.164	0	NA	0.945	2.8	0.945	2.8
2008	0	149	1103	0.135	0	NA	0.131	7	0.131	7
2009	0	101	761	0.133	0	NA	0.583	3.9	0.583	3.9
2010	0	59	492	0.12	0	NA	0.868	5.3	0.868	5.3
2011	0	85	435	0.195	0	NA	0.254	5	0.254	5
2012	0	83	445	0.187	0	NA	0.135	7.9	0.135	7.9
2013	0	175	470	0.372	0	NA	0.33	2.9	0.33	2.9
2014	2	97	409	0.237	8.4	0.68	2.24	0.41	2.24	0.41
2015	0	74	361	0.205	0	NA	0.579	2.6	0.579	2.6
2016	0	134	737	0.182	0	NA	0.562	2.6	0.562	2.6
2017	0	111	598	0.186	0	NA	0.145	5.8	0.145	5.8
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0.184	5.3	0.184	5.3
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 17. MESOPLODON. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	1	178	4078	0.044	22.9	0.97	9.3	0.91	9.3	0.91
1991	0	470	4778	0.098	0	NA	8.9	0.62	8.9	0.62
1992	4	596	4379	0.136	29.4	0.49	17.6	0.32	17.6	0.32
1993	0	728	5442	0.134	0	NA	7.77	0.37	7.77	0.37
1994	3	759	4248	0.179	16.8	0.57	9.27	0.33	9.27	0.33
1995	0	572	3673	0.156	0	NA	3.51	0.55	3.51	0.55
1996	0	421	3392	0.124	0	NA	1.56	0.42	1.56	0.42
1997	0	692	3039	0.228	0	NA	0.866	0.61	0.866	0.61
1998	0	587	3353	0.175	0	NA	0.312	2.9	0.312	2.9
1999	0	526	2634	0.2	0	NA	0.637	2.1	0.637	2.1
2000	0	444	1936	0.229	0	NA	0.256	3.2	0.256	3.2
2001	0	339	1665	0.204	0	NA	0	0	0	0
2002	0	360	1630	0.221	0	NA	0.241	3.1	0.241	3.1
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0.257	3.2	0.257	3.2
2007	0	204	1241	0.164	0	NA	0.29	3.5	0.29	3.5
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0.194	2.5	0.194	2.5
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0.117	4.5	0.117	4.5
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 18. SPERM WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	6.09	2.8	3.05	2.9
1991	0	470	4778	0.098	0	NA	3.26	2.8	1.63	2.9
1992	3	596	4379	0.136	22	0.98	9.78	0.89	6.39	0.75
1993	3	728	5442	0.134	22.4	0.72	15.3	1.1	9.17	0.98
1994	0	759	4248	0.179	0	NA	1.49	2.1	0.746	2.2
1995	0	572	3673	0.156	0	NA	5.8	1.6	2.9	1.7
1996	1	421	3392	0.124	8.1	1.01	4.33	1.1	2.67	0.93
1997	0	692	3039	0.228	0	NA	4.24	1.2	2.12	1.3
1998	1	587	3353	0.175	5.7	0.98	6.31	1.4	3.66	1.3
1999	0	526	2634	0.2	0	NA	1.13	2.5	0.563	2.8
2000	0	444	1936	0.229	0	NA	0.745	1.5	0.373	1.6
2001	0	339	1665	0.204	0	NA	0.208	3.9	0.104	4.4
2002	0	360	1630	0.221	0	NA	0.274	2.9	0.137	2.9
2003	0	298	1467	0.203	0	NA	0.272	1.7	0.136	2
2004	0	223	1084	0.206	0	NA	0.23	2	0.115	2.2
2005	0	225	1075	0.209	0	NA	0.54	2.5	0.27	2.7
2006	0	266	1433	0.186	0	NA	0.545	2.6	0.273	2.7
2007	0	204	1241	0.164	0	NA	1.27	3	0.633	3.2
2008	0	149	1103	0.135	0	NA	0.309	2.5	0.155	2.6
2009	0	101	761	0.133	0	NA	0.337	2.6	0.169	3.5
2010	2	59	492	0.12	16.7	0.99	2.04	0.084	2.02	0.046
2011	0	85	435	0.195	0	NA	0.792	3.6	0.396	3.7
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0.124	2	0	0
2014	0	97	409	0.237	0	NA	0.293	3.8	0.147	4.3
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0.148	2.4	0	0
2017	0	111	598	0.186	0	NA	2.97	2.3	1.49	2.4
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 19. GRAY WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	0.87	4.1	0.696	4.5
1991	0	470	4778	0.098	0	NA	1.35	1.7	1.08	1.7
1992	0	596	4379	0.136	0	NA	0.394	3.1	0.315	3.3
1993	0	728	5442	0.134	0	NA	1.18	1.7	0.946	1.8
1994	0	759	4248	0.179	0	NA	1.88	1.5	1.51	1.6
1995	0	572	3673	0.156	0	NA	1.32	1.7	1.06	1.7
1996	0	421	3392	0.124	0	NA	0.516	3.2	0.412	3.3
1997	0	692	3039	0.228	0	NA	0.814	1.8	0.651	1.8
1998	1	587	3353	0.175	5.7	0.93	4.22	0.75	3.58	0.74
1999	1	526	2634	0.2	5	0.96	1.54	0.63	1.43	0.54
2000	0	444	1936	0.229	0	NA	0.369	2.2	0.295	2.2
2001	0	339	1665	0.204	0	NA	1.07	1.7	0.856	1.6
2002	0	360	1630	0.221	0	NA	0.687	1.8	0.549	1.8
2003	0	298	1467	0.203	0	NA	0.908	1.6	0.727	1.7
2004	0	223	1084	0.206	0	NA	0.719	1.9	0.576	1.9
2005	1	225	1075	0.209	4.8	0.99	1.27	0.59	1.22	0.52
2006	0	266	1433	0.186	0	NA	0.537	1.9	0.429	2
2007	0	204	1241	0.164	0	NA	0.438	2.5	0.35	2.5
2008	0	149	1103	0.135	0	NA	0.136	5.1	0.109	5.3
2009	0	101	761	0.133	0	NA	0.192	5	0.154	5.3
2010	0	59	492	0.12	0	NA	0.439	3.3	0.351	3.3
2011	0	85	435	0.195	0	NA	0.276	3	0.221	2.9
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	1	175	470	0.372	2.7	1.01	1.04	0.19	1.03	0.15
2014	0	97	409	0.237	0	NA	0.162	3.6	0.129	3.8
2015	0	74	361	0.205	0	NA	0.668	2	0.534	2
2016	0	134	737	0.182	0	NA	0.668	2.1	0.534	2.2
2017	0	111	598	0.186	0	NA	0.475	2.4	0.38	2.5
2018	1	129	513	0.251	4	1	1.17	0.51	1.14	0.41
2019	0	73	323	0.226	0	NA	0.202	2.9	0.162	3
2020	0	51	230	0.222	0	NA	0.474	1.8	0.379	1.8
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 20. HUMPBACK WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	1.01	3.6	0	0
1991	0	470	4778	0.098	0	NA	5.08	1.5	0	0
1992	0	596	4379	0.136	0	NA	0.544	2.8	0	0
1993	0	728	5442	0.134	0	NA	2.55	1.6	0	0
1994	1	759	4248	0.179	5.6	1.01	3.87	0.78	1	0
1995	0	572	3673	0.156	0	NA	1.09	1.9	0	0
1996	0	421	3392	0.124	0	NA	1.13	2.1	0	0
1997	0	692	3039	0.228	0	NA	1.35	1.6	0	0
1998	0	587	3353	0.175	0	NA	1.4	1.5	0	0
1999	1	526	2634	0.2	5	1.01	1.88	0.82	1	0
2000	0	444	1936	0.229	0	NA	1	1.7	0	0
2001	0	339	1665	0.204	0	NA	0.714	1.9	0	0
2002	0	360	1630	0.221	0	NA	1.09	1.5	0	0
2003	0	298	1467	0.203	0	NA	0.768	1.9	0	0
2004	1	223	1084	0.206	4.9	0.98	1.43	0.73	1	0
2005	0	225	1075	0.209	0	NA	0.271	3	0	0
2006	0	266	1433	0.186	0	NA	0.535	2.2	0	0
2007	0	204	1241	0.164	0	NA	0.629	2.1	0	0
2008	0	149	1103	0.135	0	NA	0.79	2.4	0	0
2009	0	101	761	0.133	0	NA	0.101	8	0	0
2010	0	59	492	0.12	0	NA	0.46	3.5	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0.146	4.2	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0.238	3.3	0	0
2016	0	134	737	0.182	0	NA	0.517	2.8	0	0
2017	0	111	598	0.186	0	NA	0.609	2.6	0	0
2018	0	129	513	0.251	0	NA	0.115	3.7	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	2	37	162	0.228	8.8	0.64	2.04	0.13	2	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 21. HUBB'S BEAKED WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	2.32	1.2	2.32	1.2
1991	0	470	4778	0.098	0	NA	5.96	0.78	5.96	0.78
1992	3	596	4379	0.136	22	0.58	11	0.42	11	0.42
1993	0	728	5442	0.134	0	NA	4.84	0.55	4.84	0.55
1994	2	759	4248	0.179	11.2	0.72	5.83	0.41	5.83	0.41
1995	0	572	3673	0.156	0	NA	2.15	0.76	2.15	0.76
1996	0	421	3392	0.124	0	NA	0.847	0.63	0.847	0.63
1997	0	692	3039	0.228	0	NA	0.519	0.85	0.519	0.85
1998	0	587	3353	0.175	0	NA	0.172	3.8	0.172	3.8
1999	0	526	2634	0.2	0	NA	0.676	1.9	0.676	1.9
2000	0	444	1936	0.229	0	NA	0.132	4.5	0.132	4.5
2001	0	339	1665	0.204	0	NA	0	0	0	0
2002	0	360	1630	0.221	0	NA	0.116	4.4	0.116	4.4
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0.367	3	0.367	3
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0.224	2.4	0.224	2.4
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0.151	4.5	0.151	4.5
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 22. MINKE WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	1.71	2.9	0.857	3.5
1991	0	470	4778	0.098	0	NA	2.66	1.9	1.33	2.2
1992	0	596	4379	0.136	0	NA	1.87	1.7	0.934	1.9
1993	0	728	5442	0.134	0	NA	2.78	1.4	1.39	1.6
1994	1	759	4248	0.179	5.6	1.02	3.06	0.89	2.03	0.74
1995	0	572	3673	0.156	0	NA	1.49	1.7	0.743	2.1
1996	1	421	3392	0.124	8.1	1	2.9	1.1	1.95	0.97
1997	0	692	3039	0.228	0	NA	1.03	1.8	0.515	2
1998	0	587	3353	0.175	0	NA	0.586	2.2	0.293	2.5
1999	1	526	2634	0.2	5	0.96	1.54	0.74	1.27	0.55
2000	0	444	1936	0.229	0	NA	0.325	2.6	0.162	2.6
2001	0	339	1665	0.204	0	NA	0.602	1.9	0.301	2.2
2002	0	360	1630	0.221	0	NA	0.286	2.8	0.143	3.3
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0.12	4.6	0	0
2005	0	225	1075	0.209	0	NA	0.141	4	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	2.09	1.4	1.05	1.6
2008	0	149	1103	0.135	0	NA	0.486	3.4	0.243	3.5
2009	0	101	761	0.133	0	NA	0.476	3.1	0.238	3.4
2010	0	59	492	0.12	0	NA	0.218	4.4	0.109	5.8
2011	1	85	435	0.195	5.1	0.96	1.16	0.51	1.08	0.29
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0.109	3.4	0	0
2014	0	97	409	0.237	0	NA	0.246	3.1	0.123	3.6
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0.269	3.5	0.135	4
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0.166	3.7	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 23. UNID. ZIPHIID. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	1.02	0.51	1.02	0.51
1991	0	470	4778	0.098	0	NA	6.98	0.82	6.98	0.82
1992	2	596	4379	0.136	14.7	0.71	5.38	0.5	5.38	0.5
1993	0	728	5442	0.134	0	NA	5.38	0.75	5.38	0.75
1994	1	759	4248	0.179	5.6	0.99	1.95	0.4	1.95	0.4
1995	0	572	3673	0.156	0	NA	0.758	0.48	0.758	0.48
1996	0	421	3392	0.124	0	NA	0.434	0.28	0.434	0.28
1997	0	692	3039	0.228	0	NA	0.216	0.32	0.216	0.32
1998	0	587	3353	0.175	0	NA	0	0	0	0
1999	0	526	2634	0.2	0	NA	0	0	0	0
2000	0	444	1936	0.229	0	NA	0	0	0	0
2001	0	339	1665	0.204	0	NA	0	0	0	0
2002	0	360	1630	0.221	0	NA	0	0	0	0
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0.333	3.2	0.333	3.2
2007	0	204	1241	0.164	0	NA	0.289	3.3	0.289	3.3
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0.799	2.6	0.799	2.6
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 24. BOTTLENOSE DOLPHIN. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	0	0	0	0
1991	0	470	4778	0.098	0	NA	0.24	7.1	0.24	7.1
1992	3	596	4379	0.136	22	0.95	11.1	1.9	11.1	1.9
1993	0	728	5442	0.134	0	NA	11.9	3	11.9	3
1994	0	759	4248	0.179	0	NA	0.532	4.8	0.532	4.8
1995	0	572	3673	0.156	0	NA	0.391	6.7	0.391	6.7
1996	0	421	3392	0.124	0	NA	0	0	0	0
1997	0	692	3039	0.228	0	NA	0.313	4.7	0.313	4.7
1998	0	587	3353	0.175	0	NA	0.98	4.9	0.98	4.9
1999	0	526	2634	0.2	0	NA	0.538	4.9	0.538	4.9
2000	0	444	1936	0.229	0	NA	0.685	5	0.685	5
2001	0	339	1665	0.204	0	NA	0.591	4.4	0.591	4.4
2002	0	360	1630	0.221	0	NA	0.168	5.5	0.168	5.5
2003	0	298	1467	0.203	0	NA	0.18	5.2	0.18	5.2
2004	0	223	1084	0.206	0	NA	0.319	4	0.319	4
2005	0	225	1075	0.209	0	NA	0.913	2.6	0.913	2.6
2006	0	266	1433	0.186	0	NA	0.293	5	0.293	5
2007	0	204	1241	0.164	0	NA	0	0	0	0
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	1	59	492	0.12	8.3	0.95	1.01	0.15	1.01	0.15
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0.751	5.9	0.751	5.9
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 25. STELLER'S SEA LION. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	0.399	5.4	0.399	5.4
1991	0	470	4778	0.098	0	NA	1.54	2	1.54	2
1992	1	596	4379	0.136	7.3	1	3.09	1.4	3.09	1.4
1993	0	728	5442	0.134	0	NA	1.12	2.2	1.12	2.2
1994	1	759	4248	0.179	5.6	1.01	1.35	0.81	1.35	0.81
1995	0	572	3673	0.156	0	NA	0.532	2.6	0.532	2.6
1996	0	421	3392	0.124	0	NA	1.62	2.3	1.62	2.3
1997	0	692	3039	0.228	0	NA	0.485	3.2	0.485	3.2
1998	0	587	3353	0.175	0	NA	0	0	0	0
1999	0	526	2634	0.2	0	NA	0.114	5.3	0.114	5.3
2000	0	444	1936	0.229	0	NA	0	0	0	0
2001	0	339	1665	0.204	0	NA	0.803	2	0.803	2
2002	0	360	1630	0.221	0	NA	0.692	2.3	0.692	2.3
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0.39	2.7	0.39	2.7
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0	0	0	0
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0.19	4.4	0.19	4.4
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 26. PYGMY SPERM WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	3.81	1.8	3.81	1.8
1991	0	470	4778	0.098	0	NA	1.23	0.83	1.23	0.83
1992	1	596	4379	0.136	7.3	1.01	2.02	0.34	2.02	0.34
1993	1	728	5442	0.134	7.5	0.96	2.18	0.57	2.18	0.57
1994	0	759	4248	0.179	0	NA	2.37	0.95	2.37	0.95
1995	0	572	3673	0.156	0	NA	2.3	0.97	2.3	0.97
1996	0	421	3392	0.124	0	NA	0.499	1.1	0.499	1.1
1997	0	692	3039	0.228	0	NA	0.477	1.6	0.477	1.6
1998	0	587	3353	0.175	0	NA	0.124	4.8	0.124	4.8
1999	0	526	2634	0.2	0	NA	0.143	4.4	0.143	4.4
2000	0	444	1936	0.229	0	NA	0	0	0	0
2001	0	339	1665	0.204	0	NA	0	0	0	0
2002	0	360	1630	0.221	0	NA	0	0	0	0
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0	0	0	0
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 27. GUADALUPE FUR SEAL. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	0	0	0	0
1991	0	470	4778	0.098	0	NA	0.68	3.3	0.68	3.3
1992	0	596	4379	0.136	0	NA	0	0	0	0
1993	0	728	5442	0.134	0	NA	0.852	2.4	0.852	2.4
1994	0	759	4248	0.179	0	NA	0.379	2.8	0.379	2.8
1995	0	572	3673	0.156	0	NA	0	0	0	0
1996	0	421	3392	0.124	0	NA	0.126	5.4	0.126	5.4
1997	0	692	3039	0.228	0	NA	0.71	3.1	0.71	3.1
1998	0	587	3353	0.175	0	NA	0.176	4.3	0.176	4.3
1999	0	526	2634	0.2	0	NA	0	0	0	0
2000	0	444	1936	0.229	0	NA	0	0	0	0
2001	0	339	1665	0.204	0	NA	0.48	2.4	0.48	2.4
2002	0	360	1630	0.221	0	NA	0	0	0	0
2003	0	298	1467	0.203	0	NA	0.656	2.2	0.656	2.2
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0.18	4.2	0.18	4.2
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0.174	6.1	0.174	6.1
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0.103	4.4	0.103	4.4
2016	0	134	737	0.182	0	NA	0.397	3.9	0.397	3.9
2017	0	111	598	0.186	0	NA	0.147	4.9	0.147	4.9
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	1	37	219	0.169	5.9	1	1	0	1	0

Table 28. STEJNEGER'S BEAKED WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	0.474	3.1	0.474	3.1
1991	0	470	4778	0.098	0	NA	3.31	1.2	3.31	1.2
1992	0	596	4379	0.136	0	NA	1.12	1.5	1.12	1.5
1993	0	728	5442	0.134	0	NA	1.11	1.5	1.11	1.5
1994	1	759	4248	0.179	5.6	1.05	1.77	0.76	1.77	0.76
1995	0	572	3673	0.156	0	NA	0.681	1.8	0.681	1.8
1996	0	421	3392	0.124	0	NA	0.116	0.66	0.116	0.66
1997	0	692	3039	0.228	0	NA	0	0	0	0
1998	0	587	3353	0.175	0	NA	0	0	0	0
1999	0	526	2634	0.2	0	NA	0	0	0	0
2000	0	444	1936	0.229	0	NA	0	0	0	0
2001	0	339	1665	0.204	0	NA	0	0	0	0
2002	0	360	1630	0.221	0	NA	0	0	0	0
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0	0	0	0
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 29. BAIRD'S BEAKED WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	0.383	2.7	0.383	2.7
1991	0	470	4778	0.098	0	NA	0.545	1.9	0.545	1.9
1992	0	596	4379	0.136	0	NA	1.79	1.2	1.79	1.2
1993	0	728	5442	0.134	0	NA	1.05	1.4	1.05	1.4
1994	1	759	4248	0.179	5.6	0.98	2.05	0.67	2.05	0.67
1995	0	572	3673	0.156	0	NA	1.05	1.5	1.05	1.5
1996	0	421	3392	0.124	0	NA	0.106	0.58	0.106	0.58
1997	0	692	3039	0.228	0	NA	0	0	0	0
1998	0	587	3353	0.175	0	NA	0	0	0	0
1999	0	526	2634	0.2	0	NA	0	0	0	0
2000	0	444	1936	0.229	0	NA	0.216	3	0.216	3
2001	0	339	1665	0.204	0	NA	0	0	0	0
2002	0	360	1630	0.221	0	NA	0	0	0	0
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0	0	0	0
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 30. STRIPED DOLPHIN. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	0	0	0	0
1991	0	470	4778	0.098	0	NA	0	0	0	0
1992	0	596	4379	0.136	0	NA	1.38	1.8	1.38	1.8
1993	0	728	5442	0.134	0	NA	0.73	2.5	0.73	2.5
1994	1	759	4248	0.179	5.6	0.97	2.12	0.97	2.12	0.97
1995	0	572	3673	0.156	0	NA	0.305	3.7	0.305	3.7
1996	0	421	3392	0.124	0	NA	0.134	6.6	0.134	6.6
1997	0	692	3039	0.228	0	NA	0	0	0	0
1998	0	587	3353	0.175	0	NA	0.219	4	0.219	4
1999	0	526	2634	0.2	0	NA	0	0	0	0
2000	0	444	1936	0.229	0	NA	0	0	0	0
2001	0	339	1665	0.204	0	NA	0	0	0	0
2002	0	360	1630	0.221	0	NA	0	0	0	0
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0	0	0	0
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 31. KILLER WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	0.341	9.4	0.341	9.4
1991	0	470	4778	0.098	0	NA	0.745	2.7	0.745	2.7
1992	0	596	4379	0.136	0	NA	0.111	5.5	0.111	5.5
1993	0	728	5442	0.134	0	NA	0.302	4.1	0.302	4.1
1994	0	759	4248	0.179	0	NA	0.165	4.5	0.165	4.5
1995	1	572	3673	0.156	6.4	1.01	2.34	1	2.34	1
1996	0	421	3392	0.124	0	NA	1.3	1.9	1.3	1.9
1997	0	692	3039	0.228	0	NA	0.143	3.8	0.143	3.8
1998	0	587	3353	0.175	0	NA	0.571	2.5	0.571	2.5
1999	0	526	2634	0.2	0	NA	0	0	0	0
2000	0	444	1936	0.229	0	NA	0	0	0	0
2001	0	339	1665	0.204	0	NA	0	0	0	0
2002	0	360	1630	0.221	0	NA	0	0	0	0
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0	0	0	0
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 32. GREEN TURTLE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	4.5	2.7	4.5	2.7
1991	0	470	4778	0.098	0	NA	0	0	0	0
1992	0	596	4379	0.136	0	NA	0.75	3.2	0.75	3.2
1993	0	728	5442	0.134	0	NA	0.119	4.4	0.119	4.4
1994	0	759	4248	0.179	0	NA	0	0	0	0
1995	0	572	3673	0.156	0	NA	0	0	0	0
1996	0	421	3392	0.124	0	NA	0	0	0	0
1997	0	692	3039	0.228	0	NA	0.243	2.8	0.243	2.8
1998	0	587	3353	0.175	0	NA	0	0	0	0
1999	1	526	2634	0.2	5	1.01	1.41	0.74	1.41	0.74
2000	0	444	1936	0.229	0	NA	0.298	2.8	0.298	2.8
2001	0	339	1665	0.204	0	NA	0	0	0	0
2002	0	360	1630	0.221	0	NA	0.145	3.9	0.145	3.9
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0.148	4.6	0.148	4.6
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0	0	0	0
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0.533	2.3	0.533	2.3
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0.207	3.7	0.207	3.7
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 33. OLIVE RIDELY TURTLE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023. Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV). Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	0	0	0	0
1991	0	470	4778	0.098	0	NA	0.307	3.4	0	0
1992	0	596	4379	0.136	0	NA	0	0	0	0
1993	0	728	5442	0.134	0	NA	0.167	4.9	0	0
1994	0	759	4248	0.179	0	NA	0.171	3.6	0	0
1995	0	572	3673	0.156	0	NA	0.178	4.7	0	0
1996	0	421	3392	0.124	0	NA	0.601	2.6	0	0
1997	0	692	3039	0.228	0	NA	0	0	0	0
1998	0	587	3353	0.175	0	NA	0.235	3.2	0	0
1999	1	526	2634	0.2	5	0.96	1.6	0.89	1	0
2000	0	444	1936	0.229	0	NA	0.419	2	0	0
2001	0	339	1665	0.204	0	NA	0.147	4	0	0
2002	0	360	1630	0.221	0	NA	0.197	3.7	0	0
2003	0	298	1467	0.203	0	NA	0	0	0	0
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0.297	4	0	0
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0	0	0	0
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0.318	2.9	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0

Table 34. FIN WHALE. Observed entanglements, observed sets, estimated sets, observer coverage, and estimated bycatch from 1990−2023.
Estimated annual bycatch from ratio estimates (RatioAnn) and regression trees (TreeEstAnn) are shown, along with coefficients of variation (CV).
Total mortality and serious injury (MSI) is based on prorating TreeEstAnn by the fraction of fishery observations resulting in death or serious injury (see text).

Year	ObsAnn	ObsEffortAnn	EstEffortAnn	ObsCovAnn	RatioAnn	CV.RatioAnn	TreeEstAnn	CV.TreeEstAnn	TreeEstAnn.MSI	CV.TreeEstAnn.MSI
1990	0	178	4078	0.044	0	NA	0	0	0	0
1991	0	470	4778	0.098	0	NA	0	0	0	0
1992	0	596	4379	0.136	0	NA	0.166	5.2	0.166	5.2
1993	0	728	5442	0.134	0	NA	0.596	3	0.596	3
1994	0	759	4248	0.179	0	NA	0.595	2.3	0.595	2.3
1995	0	572	3673	0.156	0	NA	0.115	3.8	0.115	3.8
1996	0	421	3392	0.124	0	NA	0.258	4.2	0.258	4.2
1997	0	692	3039	0.228	0	NA	0	0	0	0
1998	0	587	3353	0.175	0	NA	0.224	3.4	0.224	3.4
1999	1	526	2634	0.2	5	1.02	1.37	0.77	1.37	0.77
2000	0	444	1936	0.229	0	NA	0.353	2.3	0.353	2.3
2001	0	339	1665	0.204	0	NA	0.432	2.2	0.432	2.2
2002	0	360	1630	0.221	0	NA	0.235	3.4	0.235	3.4
2003	0	298	1467	0.203	0	NA	0.283	2.9	0.283	2.9
2004	0	223	1084	0.206	0	NA	0	0	0	0
2005	0	225	1075	0.209	0	NA	0	0	0	0
2006	0	266	1433	0.186	0	NA	0	0	0	0
2007	0	204	1241	0.164	0	NA	0.261	3.6	0.261	3.6
2008	0	149	1103	0.135	0	NA	0	0	0	0
2009	0	101	761	0.133	0	NA	0	0	0	0
2010	0	59	492	0.12	0	NA	0	0	0	0
2011	0	85	435	0.195	0	NA	0.106	4.8	0.106	4.8
2012	0	83	445	0.187	0	NA	0	0	0	0
2013	0	175	470	0.372	0	NA	0	0	0	0
2014	0	97	409	0.237	0	NA	0	0	0	0
2015	0	74	361	0.205	0	NA	0	0	0	0
2016	0	134	737	0.182	0	NA	0	0	0	0
2017	0	111	598	0.186	0	NA	0	0	0	0
2018	0	129	513	0.251	0	NA	0	0	0	0
2019	0	73	323	0.226	0	NA	0	0	0	0
2020	0	51	230	0.222	0	NA	0	0	0	0
2021	0	37	162	0.228	0	NA	0	0	0	0
2022	0	28	142	0.197	0	NA	0	0	0	0
2023	0	37	219	0.169	0	NA	0	0	0	0