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Marine mammal and sea turtle bycatch in the California/Oregon swordfish and thresher shark drift gillnet fishery in 2009.

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ABSTRACT

Marine mammal and sea turtle bycatch is reported for the California/Oregon large-mesh drift gillnet fishery, based on fishery observer data collected in 2009. Estimates of bycatch are generated using ratio estimation methods. One other fishery, the deep-set longline fishery, was observed at 100% observer coverage during 2009, but data confidentiality regulations prevent the reporting of observer information from this fishery because only one vessel was active.

In the California/Oregon large-mesh drift gillnet fishery for thresher sharks and swordfish, 101 sets during 17 fishing trips were observed out of an estimated 761 sets fished by all vessels (13% observer coverage). Observed bycatch included one short-beaked common dolphin (*Delphinus delphis*), two Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), and five California sea lions (*Zalophus californianus*). All marine mammals were dead upon retrieval. Estimated bycatch is 7 (CV=1.11) short-beaked common dolphins, 15 (CV=1.02) Pacific white-sided dolphins, and 37 (CV=0.83) California sea lions. In addition to the observed marine mammal bycatch, there was one leatherback turtle (*Dermochelys coriacea*) released alive in this fishery in 2009.

INTRODUCTION

Fishery Classification Criteria

The National Marine Fisheries Service (NMFS) is required under section 118 of the Marine Mammal Protection Act (MMPA) to place all U.S. commercial fisheries into one of three categories based on levels of incidental serious injury and mortality of marine mammals in each fishery (16 U.S.C. 1387 (c) (1)). Each year, NMFS publishes a 'List of Fisheries' in the Federal Register that determines whether fishery participants are subject to registration, observer coverage, and take reduction plan requirements. Fisheries are classified as Category I, II, or III, depending on the level of incidental takes relative to the Potential Biological Removal (PBR) for each marine mammal stock. The PBR level is defined in the MMPA as the maximum number of animals (not including natural mortality) that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. Fishery classifications are assigned via a two-tiered system. In Tier 1 analysis, if annual mortality and serious injury across *all* fisheries that interact with a stock is <= 10% of the PBR level for this stock, all fisheries interacting with that stock would be placed in Category III. If the annual mortality and serious injury across all fisheries interacting with that stock exceeds 10% of PBR, fisheries are then subject to Tier 2 analysis. In Tier 2 analysis, annual mortality and serious injury levels of a given stock in a given fishery result in the following fishery classifications:

Category I: annual mortality and serious injury is $\geq$50% of the PBR level
Category II: annual mortality and serious injury is between 1% and 50% of the PBR level
Category III: annual mortality and serious injury <= 1% of the PBR level

The Fishery

The ***California/Oregon large-mesh drift gillnet fishery for broadbill swordfish (Xiphias gladias) and thresher shark (Alopias vulpinus)*** is a Category I fishery with approximately 40 vessels participating. This fishery has been observed by NMFS annually since 1990. Observer coverage ranged between 4% and 18% (mean = 13%) of all sets from 1990 to 1996, averaged 20% between 1997 and 2005, and has dropped below 20% since 2006. A wide variety of cetacean, pinniped, sea turtle, and seabird species have been incidentally caught in this fishery (Julian and Beeson, 1998; Carretta *et al*., 2004). A Take Reduction Plan (TRP) was implemented in 1996 because bycatch levels exceeded PBR for some cetacean stocks. The TRP resulted in the mandatory use of acoustic pingers on all nets, net extenders to increase minimum fishing depth to 11 m (6 fm), and mandatory skipper education workshops. Although marine mammal bycatch was significantly reduced as a result of pinger use in this fishery (Barlow and Cameron 2003, Carretta *et al*. 2008), continued bycatch of leatherback turtles (Carretta *et al.* 2004) resulted in the establishment of a seasonal (15 August – 15 November) area closure in central California and southern Oregon waters in 2001 (Figure 1). An additional season/area closure in southern California is implemented during forecasted or existing El Niño periods to protect loggerhead turtles. Basic fishery descriptions can be found in marine mammal stock assessments published annually by NMFS (Carretta *et al*. 2009) and in the NMFS 2009 List of Fisheries (Federal Register, 73 FR 73032, December 1, 2008)

METHODS

Estimation of Fishing Effort and Observer Coverage

The number of sets fished in the California/Oregon drift gillnet fishery is estimated from vessel operators' reports to the NMFS observer contractor. In the drift gillnet fishery, one set is equal to one day of fishing effort, as nets are deployed near sunset and retrieved the next morning. Observer coverage is estimated as the number of observed sets, divided by the number of estimated sets fished.

Bycatch/Mortality Estimation

Bycatch and mortality is estimated with a ratio estimator (Julian and Beeson 1998, Carretta *et al*. 2004). No geographic or seasonal strata are used in estimating bycatch rates, because previous studies showed no improvement in bycatch point estimates or their precision with stratification (Carretta 2001). The bycatch rate for each species is calculated as:

$$\hat{r}_s = \frac{\sum b_s}{\sum d} \qquad (1)$$

where b_s is the observed bycatch (in individuals) of species *s* during a fishing trip and *d* is the number of days (= sets) observed during the trip. The variance of the bycatch rate ($\sigma^2_{\hat{r}_s}$), is estimated using a bootstrap procedure, where one trip represents the sampling unit. Trips are resampled with replacement until each bootstrap sample contains the same number of trips as the actual observed effort level. This method is preferable to resampling sets, because sets within a trip are more likely to be spatially and temporally correlated. A bycatch rate is then calculated from each bootstrap sample. This procedure is repeated 1,000 times, from which the bycatch rate sample variance $\sigma^2_{\hat{r}_s}$, is calculated.

Annual bycatch estimates ($\hat{m}_s$) for species *s* and the variance of the bycatch estimate (σ^2_m) are estimated for each species using the following formulae:

$$\hat{m}_s = \hat{D}\,\hat{r}_{s,} \qquad (2)$$

$$\sigma^2_m = \hat{D}^2\,\sigma^2_r \qquad (3)$$

where

$\hat{D}$ is the estimated number of days (= sets) fished, assumed to be known without error,
$\hat{r}_s$ is the kill rate per set for species *s,* and
σ^2_r is the bootstrap estimate of the kill rate variance.

RESULTS

Swordfish/thresher shark drift gillnet

In 2009, an estimated 761 sets were fished and 101 sets were observed from 17 vessel trips, resulting in an observer coverage rate of 13.3% (Table 1, Figure 1). Fishing effort in 2009 was determined exclusively through vessel activity reports submitted to the observer contractor, because complete logbook data were unavailable at the time this report was prepared. In 2009, 34 vessels made at least one set, though only 14 were observed. Eleven vessels were deemed ‘unobservable’, because they are typically smaller vessels that lack berthing space for an observer. The estimate of total fishing effort for these ‘unobservable’ vessels was 368 sets (or 48% of all estimated fishing effort in 2009). Nine additional vessels were not observed in 2009 for reasons ranging from a lack of observer funding during the period that these vessels fished to unavailability of observers at the time these vessels fished. The estimate of fishing effort for these nine vessels was 85 sets (or 11% of all estimated fishing effort in 2009). The long-term trend in fishing effort has been a decline from over 5,500 sets in 1993 to 761 sets in 2009 (Figure 2). In 2009, observed bycatch totals were one short-beaked common dolphin (*Delphinus delphis*), two Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), and five California sea lions (*Zalophus californianus*). All marine mammals were dead upon retrieval. Estimated bycatch is 7 (CV=1.11) short-beaked common dolphins, 15 (CV=1.02) Pacific white-sided dolphins, and 37 (CV=0.83) California sea lions. In addition to the observed marine mammal bycatch, there was one leatherback turtle (*Dermochelys coriacea*) released alive in this fishery in 2009. Observer notes regarding the released-alive turtle included "no injuries, turtle left area immediately upon being freed from net, no gear trailing". The observer also provided a visual estimation of the turtle's length as 150 cm.

DISCUSSION

Since acoustic pingers were introduced into the fishery in 1996, overall cetacean entanglement rates have declined by approximately 50% and no beaked whale bycatch has been observed (Barlow and Cameron 2003, Carretta *et al*. 2008). Short-beaked common dolphins continue to be the most commonly entangled species in the drift gillnet fishery. However, entanglement rates are much lower since the introduction of acoustic pingers (Figure 4), despite the fact that the fishery today operates almost exclusively south of Point Conception, where common dolphin abundance is highest (Barlow and Forney 2007). South of Point Conception, common dolphin entanglement rates in sets without pingers (122 entanglements/1,848 sets = 6.6 per 100 sets from 1990 to 1997) were approximately 50% higher than in sets with 20 or more pingers (138 entanglements/3,183 sets = 4.3 per 100 sets from 1997 to 2009). Common dolphin entanglement rates in 2009 were the lowest observed in any calendar year since observations began in this fishery in 1990. However, this observation also coincides with the lowest level of absolute observer effort (101 sets observed) for any year, and no sets were observed in January of 2009, which is the month when common dolphin entanglement rates are usually highest.

Barlow and Cameron (2003) reported a statistically significant decline in sea lion entanglement rates in sets outfitted with acoustic pingers during a 1996-1997 experiment, though this decline was somewhat unexpected, because some thought that pinnipeds might be attracted to pingered nets to feed on the captured fish, otherwise known as the "dinner bell" effect (Dawson 1994). Since 1998, sea lion entanglement rates (104 entangled in 3,722 sets = 2.8 per 100 sets) have nearly tripled, compared with entanglement rates observed prior to pinger use (35 entangled in 3,303 sets = 1.0 per 100 sets) (Figure 5). A number of factors may be responsible for the increase in sea lion entanglements, including habituation and attraction to pingers, an increasing sea lion population, shifts in the distribution of prey into areas where gillnet activity is greater, and a 2001 area closure that shifted fishing effort into southern California waters, where sea lions are more abundant. Although recent entanglement rates of California sea lions are higher than in years before pinger use, the **total** estimated annual bycatch has remained relatively constant (~ 50 animals per year) because of continued declines in drift gillnet fishing effort (Julian and Beeson 1995, Carretta et al. 2004).

The fraction of estimated sets fished in 2009 that involved 'unobservable' or 'unobserved' vessels was 59.5% (453 sets fished / 761 total estimated sets), which raises concerns about the randomness of the observer sample. An underlying assumption in the estimation of bycatch is that unobserved fishing effort is 'equivalent' to observed effort. This assumption requires that unobserved vessels are compliant with pinger, extender length, and other gear regulations, and that bycatch rates are no different for these vessels. If bycatch rates on unobserved vessels are significantly different, this would bias the resulting bycatch estimates. Vessels in this fishery are periodically boarded (inspected) for gear compliance issues and recorded violations have been rare. The area fished by vessels has contracted over the years and is dominated by effort west of San Diego, California. This is in part due to the fact that most remaining vessels are relatively small and fish nearer to the mainland than in previous years.

A video experiment was utilized in this fishery recently to see if video monitoring of bycatch would be feasible on unobservable vessels. Some shortcomings of that methodology were identified, such as the inability to identify bycatch to species, high cost, and battery power drain issues for the fishing vessels. The 2007 Pacific Offshore Take Reduction Team recommended that NMFS continue to pursue other technologies to address this gap in observer coverage, while continuing to refine the video technology for potential future use on unobservable vessels.

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Table 1. Fishery observer and fishing effort summaries for calendar year 2009 for the swordfish drift gillnet fishery.

Fishery	MMAP Category	Number of active vessels	Estimated Sets Fished	Observed Sets	Observer Coverage	Observed Species Interactions (number killed or injured)
CA/OR swordfish and thresher shark large-mesh drift gillnet	Category I	34 (14 observed)	761 sets[1]	101 sets	13.3% (sets)	Common dolphin, short-beaked (1) Pacific white-sided dolphin (2) CA sea lion (5)

Table 2. Summary of observed bycatch, rates, estimates and statistical precision for the California swordfish drift gillnet fishery in 2009.

Fishery and Species	Observed Bycatch	Bycatch per Set	Bycatch per Set Variance	Bycatch Estimate	Bycatch Estimate CV
CA/OR swordfish/thresher shark drift gillnet					
Short-beaked common dolphin	1	0.0099	9.7×10^{-5}	7	1.11
Pacific white-sided dolphin	2	0.0198	4.0×10^{-4}	15	1.01
California sea lion	5	0.0495	1.8×10^{-3}	37	0.83

1 Estimated fishing effort data provided by Scott Casey of Frank Orth & Associates.

Figure 1. Locations of 101 observed fishing sets, and marine mammal and sea turtle entanglements in the swordfish and thresher shark drift gillnet fishery in 2009. The numbers of entanglement locations shown are less than those reported in the text because the two Pacific white-sided dolphins were entangled in a single set. Key: ● = set locations; ▲=short-beaked common dolphin; □=Pacific white-sided dolphin; ○ = California sea lion, ■ = leatherback sea turtle. The dashed line indicates the southern boundary of a seasonal area closure where drift gillnet fishing is annually prohibited between 15 August and 15 November.

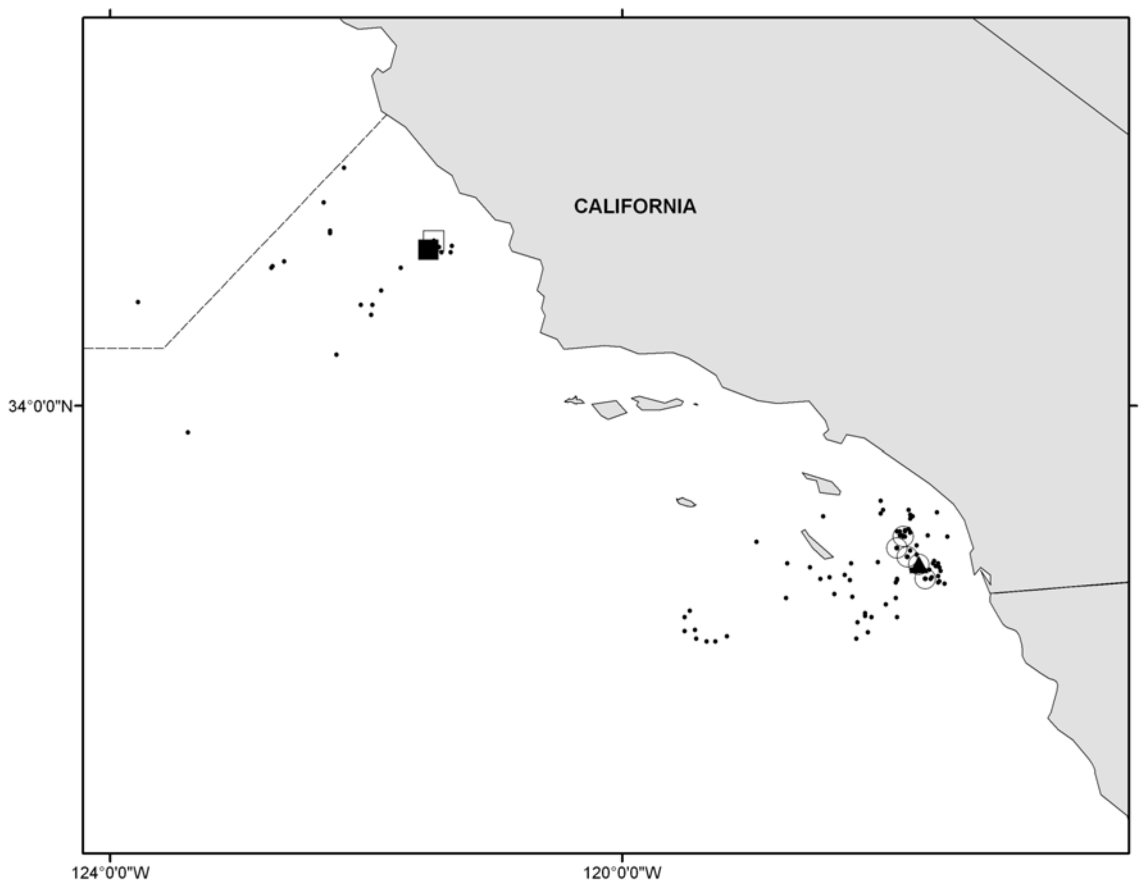

Figure 2. Estimated (gray) and observed (black) days of effort in the California swordfish and thresher shark drift gillnet fishery for 1990-2009. Percent values above bars represent the fraction of observer coverage in the fishery for a given year.

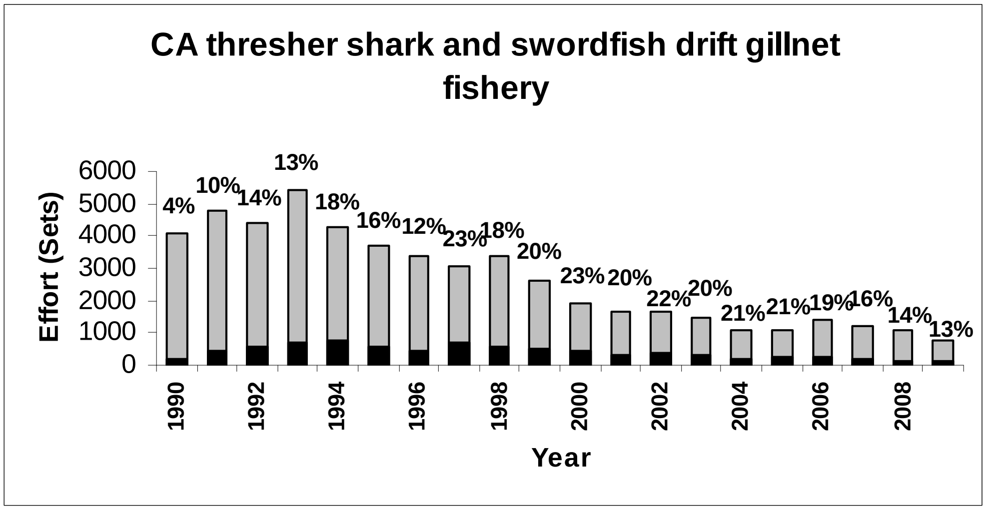

Figure 3. Bycatch rates (individuals per 100 sets) of cetaceans in the California swordfish and thresher shark drift gillnet fishery, 1990–2009.

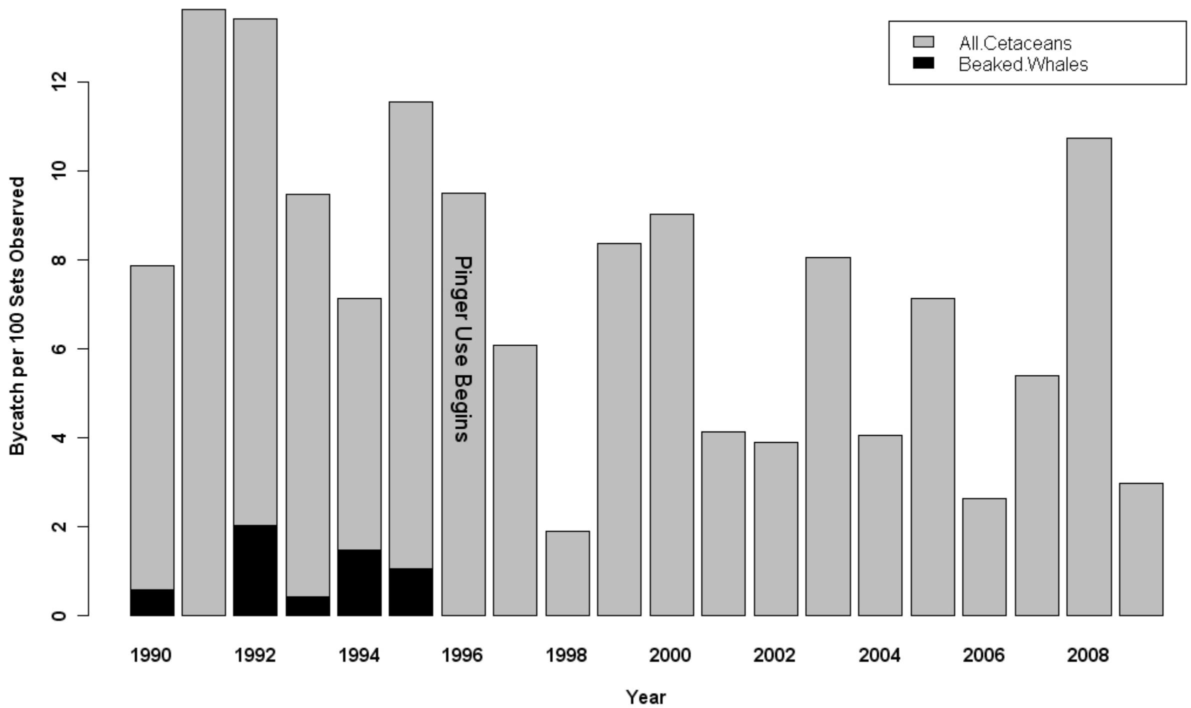

Figure 4. Entanglement rates of short-beaked common dolphin per 100 sets fished in the California swordfish drift gillnet fishery, 1990-2009. Pingers were not used from 1990-95 and were used experimentally in 1996 and 1997. In 1996, no short-beaked common dolphins were observed killed in 146 pingered sets. For the period 1998-2009, over 99% of all observed sets utilized pingers.

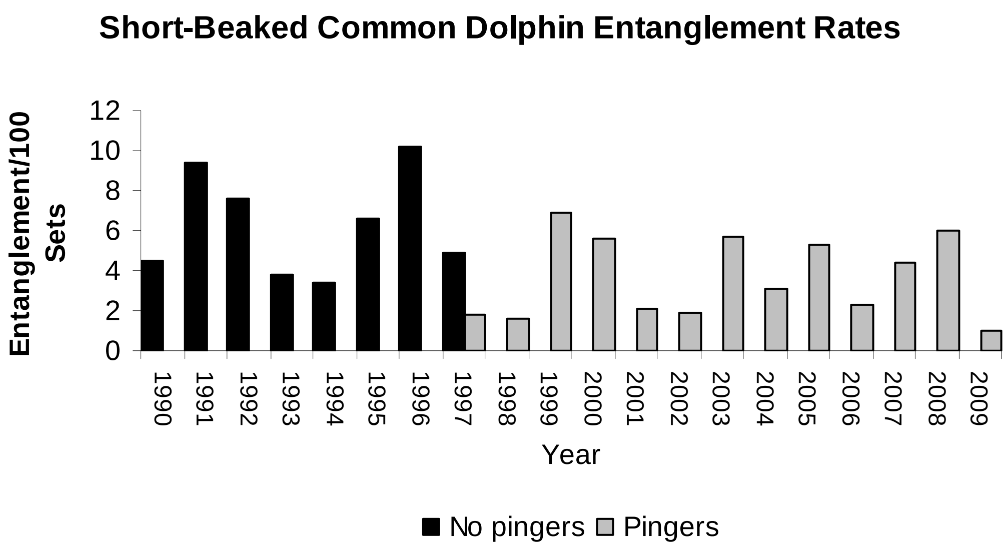

Figure 5. Entanglement rates of California sea lions per 100 sets fished in the California drift gillnet fishery for swordfish and thresher shark, 1990-2009. Pingers were not used from 1990-95 and were used experimentally in 1996 and 1997. For the period 1998-2009, over 99% of all observed sets utilized pingers.