Marine mammal and sea turtle bycatch in the California/Oregon thresher shark and swordfish drift gillnet fishery in 2006.

James V. Carretta[1] and Lyle Enriquez[2]

[1]Southwest Fisheries Science Center
NOAA, U.S. National Marine Fisheries Service
8604 La Jolla Shores Drive
La Jolla, CA 92037 USA
Jim.Carretta@noaa.gov

[2]Southwest Regional Office
NOAA, U.S. National Marine Fisheries Service
501 West Ocean Boulevard
Long Beach, CA 90802
Lyle.Enriquez@noaa.gov

ABSTRACT

Marine mammal and sea turtle bycatch in the California/Oregon large mesh drift gillnet fishery for thresher shark and swordfish is summarized for calendar year 2006. Observer coverage for 2006 was 18.5%, based on 266 observed fishing sets and an estimated 1,433 sets fished by all vessels. Observed bycatch totals were six short-beaked common dolphin (*Delphinus delphis*), one long-beaked common dolphin (*D. capensis*), twelve California sea lions (*Zalophus californianus*) and one loggerhead sea turtle (*Caretta caretta*). All marine mammals were dead upon retrieval, and the sea turtle was released alive. Estimated bycatch is 32 (CV = 0.52) short-beaked common dolphin; 5 (CV = 1.04) long-beaked common dolphin; 64 California sea lions (CV = 0.43); and 5 loggerhead sea turtles (CV = 1.11). Of the five estimated loggerhead turtle entanglements, only one mortality is predicted, based on the observed fraction of loggerhead turtles (81%) released alive in this fishery.

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 mortalities) that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. Category I

fisheries are defined as those for which the annual level of incidental take of one or more stocks is greater than or equal to 50% of a stock's PBR. Category II fisheries are defined as those for which the annual takes of one or more stocks are greater than 1% but less than 50% of PBR. Category III fisheries include those where the overall serious injury and incidental take of all marine mammal stocks, across all fisheries that interact with these stocks, is less than 10% of the stocks' PBR level. In cases where combined takes across all fisheries exceed 10% for one or more stocks, then only those fisheries with annual takes less than 1% of PBR are considered Category III.

The Fishery

The California/Oregon large mesh drift gillnet fishery for swordfish and thresher shark is a Category I fishery and has been observed by NMFS annually since 1990. Fishing effort has decreased from over 5,500 sets in 1993 to 1,433 sets in 2006 (Figure 1). Observer coverage ranged from 4% to 18% ($\bar{x}$ = 13%) of all sets from 1990-96 and has averaged approximately 20% since 1997. 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*., 2005). A Take Reduction Plan (TRP) was implemented in 1996 because bycatch levels exceeded PBR for some cetacean stocks. The TRP resulted in the use of acoustic pingers on all nets, net extenders to increase minimum fishing depth to 11 m (6 fm), and mandatory skipper education workshops. Barlow and Cameron (2003) reported on the overall decline in marine mammal bycatch resulting from the use of acoustic pingers in this fishery. A seasonal (15 August – 15 November) area closure was implemented in 2001 north of Point Conception to protect leatherback turtles in this region (Figure 2). An additional season/area closure in southern California is implemented during El Niño periods to protect loggerhead turtles.

METHODS

Estimation of Fishing Effort

The number of sets fished in the California/Oregon drift gillnet fishery is estimated from vessel operators' reports to the NMFS observer contractor[4] and logbook data summarized by the California Department of Fish and Game. Annual effort estimates from each source are usually similar, but the larger value is used for the purpose of bycatch estimation. In this fishery, one set is equal to one day of fishing effort, as nets are deployed near sunset and retrieved the next morning.

Bycatch/Mortality Estimation

Bycatch and mortality is estimated with a ratio estimator (Julian and Beeson 1998, Carretta *et al*. 2005). No geographic or seasonal strata are used in estimating bycatch rates, because previous studies showed no improvement in mortality estimates or its coefficients of variation with stratification (Carretta 2001). Yeung (1999) also found that point estimates of

[4] Personal communication, Carolyn Parker, Program Manager, Frank Orth and Associates, 4040 Lake Washington Blvd. NE, Suite 208, Kirkland, WA 98033. email: driftfoa@yahoo.com

marine mammal and sea turtle bycatch were insensitive to stratification, while pooling improved the precision of bycatch estimates. 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 number of species *s* entangled 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 (1 - 10 days in 2006) 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. A bycatch rate is then calculated from each bootstrap sample. This procedure is repeated 1,000 times, from which the bootstrap or 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 maximum number of days (= sets) fished,
$\hat{r}_s$ is the kill rate per set for species *s* and
σ^2_r is the bootstrap estimate of the kill rate variance.

RESULTS

Drift gillnet

An estimated 1,433 sets were fished in 2006 and 266 sets were observed from 48 vessel trips, resulting in an observer coverage rate of 18.5% (Figures 1 and 2). In 2006, 42 vessels made at least one set in this fishery, though only 36 were observed. Six vessels were deemed 'unobservable' and reported fishing 185 sets (about 13% of estimated total fishing effort). 'Unobservable' vessels are typically smaller vessels that lack berthing space for an observer.

Six short-beaked common dolphin, one long-beaked common dolphin, twelve California sea lions, and one loggerhead sea turtle were observed entangled (Table 1, Figure 3). Bycatch estimates (with coefficients of variation) are 32 (CV = 0.52) short-beaked common dolphin, 5 (CV = 1.04) long-beaked common dolphin, 64 (CV = 0.43) California sea lions, and 5 (CV = 1.11) loggerhead sea turtles. Only one loggerhead turtle mortality is predicted from the five estimated entanglements, based on the observed fraction of loggerhead turtles (13/16 = 81%) released alive in this fishery in this and all previous years.

Table 1. Summary of observed bycatch, bycatch rates, bycatch estimates and statistical precision for the California swordfish drift gillnet fishery in 2006.

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	6	0.023	1.4×10^{-4}	32	0.52
Long-beaked common dolphin	1	0.004	1.3×10^{-5}	5	1.04
California sea lion	12	0.045	3.7×10^{-4}	64	0.43
Loggerhead sea turtle	1	0.0037	1.5×10^{-5}	5*	1.11

*Only one turtle mortality is predicted out of the five estimated entangled, based on the observed fraction of loggerhead turtles (13/16 = 81%) released alive in this fishery.

DISCUSSION

Short-beaked common dolphins continue to be the most commonly entangled species in the drift gillnet fishery. However, entanglement rates are much lower (3.5 per 100 sets) since the introduction of acoustic pingers into this fishery, compared to sets without pingers (5.9 per 100 sets, Figure 4).

Entanglement rates of California sea lions have been higher in the years following the use of pingers (Figure 5). Barlow and Cameron (2003) showed that there was a statistically significant *decline* in sea lion entanglement rates in pingered verses non-pingered nets during a 1996-1997 experiment. Since 1998, the average entanglement per 100 sets (86 entangled in 3,268 sets = 2.6 per 100 sets) is more than double that observed prior to pinger use during 1990-95 (35 entangled in 3,303 sets = 1.0 per 100 sets). Barlow and Cameron (2003) reported an initial reduction of sea lion entanglement rates in pingered nets was unexpected because some predicted that pinnipeds might be attracted to pingered nets to feed on the captured fish (the "dinner bell" effect). A number of factors may be responsible for the recent 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.

Loggerhead turtle bycatch in this fishery usually occurs in the southern end of the fishing range, presumably during warm-water years. The one turtle caught in 2006 occurred in a set where the sea surface temperature was 19.0ºC during 'normal' sea surface temperature conditions (NOAA Coastwatch). Since the observer program for this fishery began in 1990, there have been 16 loggerheads observed entangled in over 7,600 observed sets. Sea surface temperature data are available for nine of the entanglements, with a mean temperature of 19.2ºC and a range between 16.5ºC and 21ºC.

ACKNOWLEDGMENTS

Thanks to Rand Rasmussen for maintaining the fishery observer database. Carolyn Parker at Frank Orth and Associates provided vital information on the large mesh drift gillnet

observer program. Dale Sweetnam of the CDFG provided information on fishing effort. Jay Barlow and Karin Forney improved the manuscript with their reviews. This work could not have been done without the diligent work of NMFS biological observers and the cooperation of the California commercial fishermen.

LITERATURE CITED

Barlow, J. and Cameron, G.A. 2003. Field experiments show that acoustic pingers reduce marine mammal bycatch in the California drift gillnet fishery. Marine Mammal Science 19(2):265-283.

Carretta, J.V. 2001. Preliminary estimates of cetacean mortality in California gillnet fisheries for 2000. Report SC/53/SM9 presented to the Scientific Committee of the International Whaling Commission, June 2001 (unpublished). 21p. [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA.]

Carretta, J.V., T. Price, D. Petersen, and R. Read. 2005. Estimates of Marine Mammal, Sea Turtle, and Seabird Mortality in the California Drift Gillnet Fishery for Swordfish and Thresher Shark, 1996-2002. Mar. Fish. Rev. 66 (2): 21-30.

Julian, F. and Beeson, M. 1998. Estimates of marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990-1995. U.S. Fish. Bull. 96:271-284.

NOAA Coastwatch El Nino Watch. http://coastwatch.pfel.noaa.gov/elnino.html

Yeung, C. 1999. Estimates of marine mammal and marine turtle bycatch by the U.S. Atlantic pelagic longline fleet in 1998. Department of Commerce NOAA Technical Memorandum NMFS-SEFSC-430. 26 p. Available from U.S. National Marine Fisheries Service, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, FL 33149.

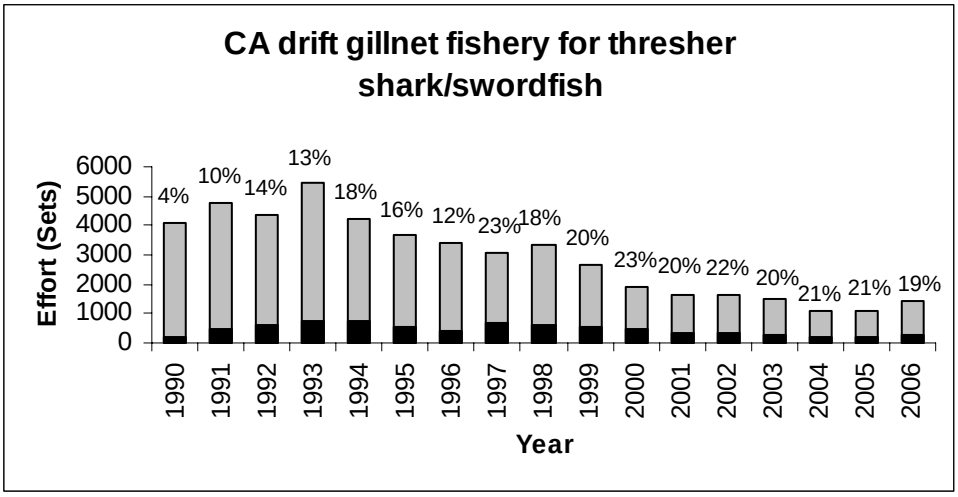

Figure 1. Estimated (gray) and observed (black) days of effort in the California swordfish and thresher shark drift gillnet fishery for 1990-2006. Percent values above bars represent the fraction of observer coverage in the fishery for a given year.

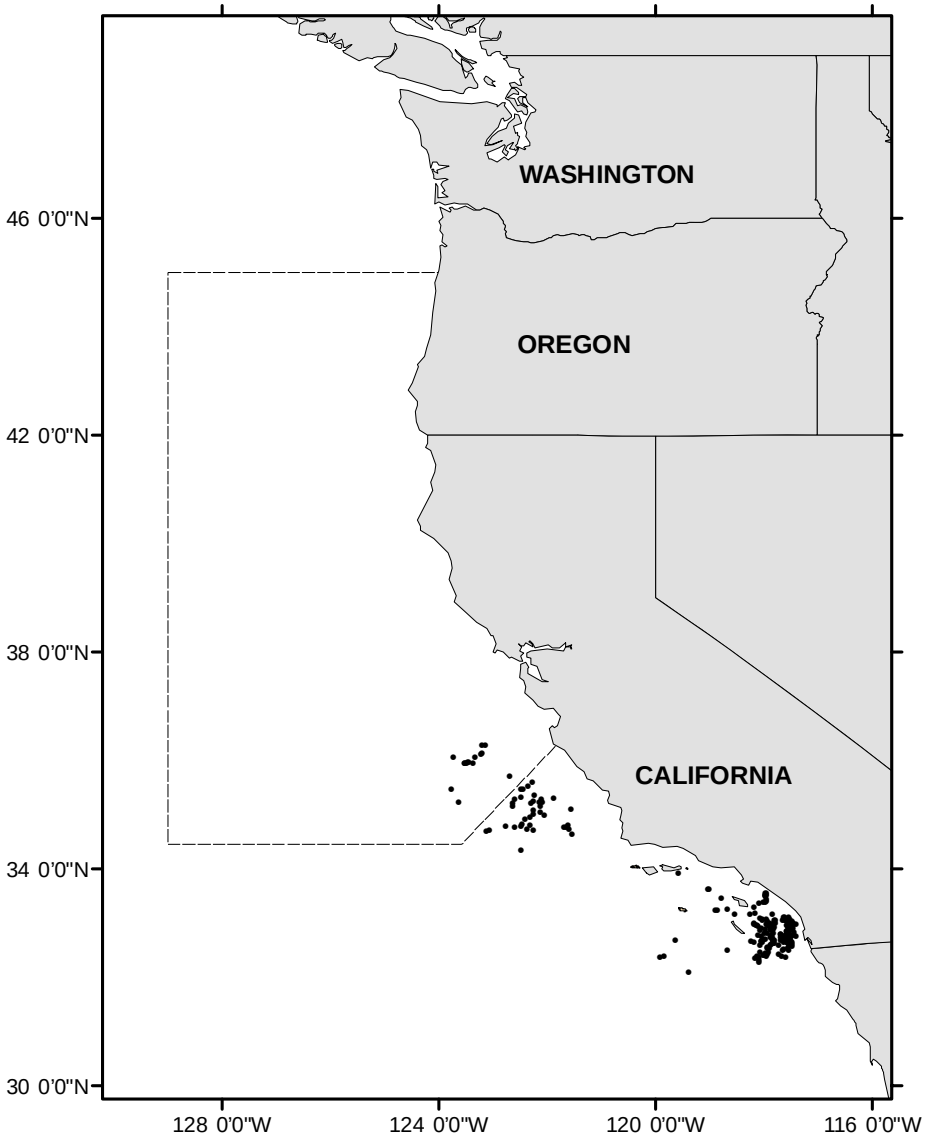

Figure 2. Locations of 266 observed sets in the large-mesh drift gillnet swordfish and thresher shark fishery in 2006. The region bounded by a dashed line represents a leatherback sea turtle conservation area closed to drift gillnet fishing each year between 15 August and 15 November.

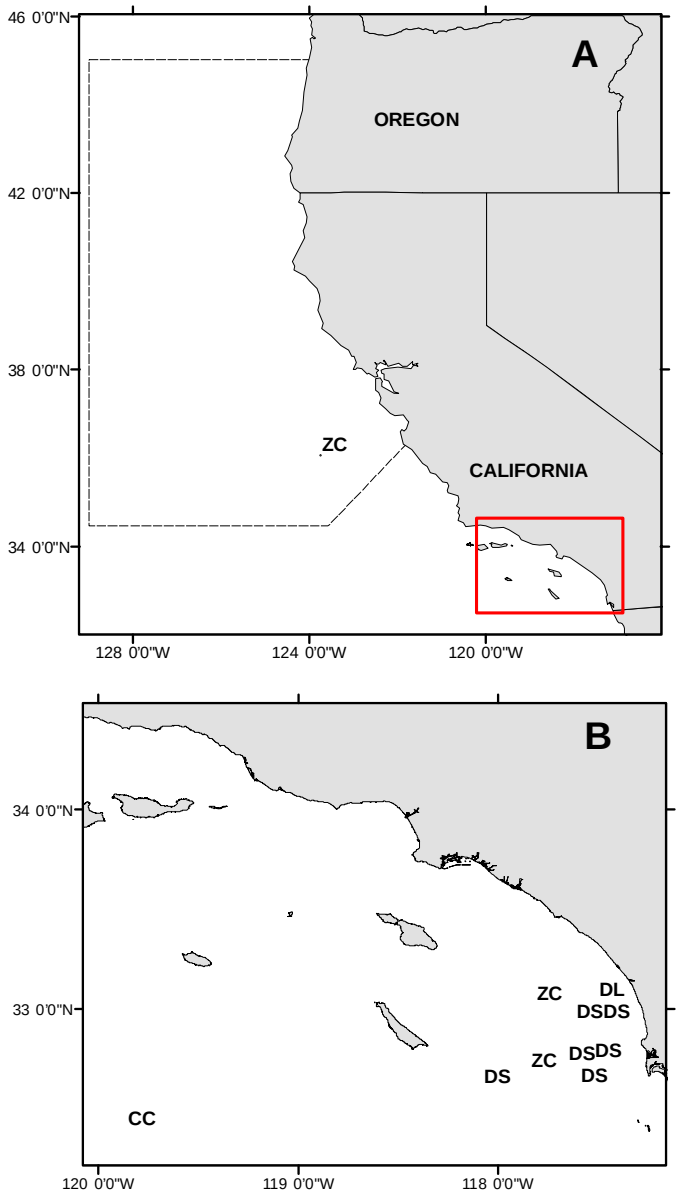

Figure 3. Locations of entangled marine mammals and sea turtles in the large mesh drift gillnet fishery in 2006. Inset area (B) shows entanglements in the Southern California Bight. The number of entanglement locations shown are less than those reported in the text due to multi-animal entanglements of sea lions and common dolphins in single sets. Key: ZC = California sea lion; DL = long-beaked common dolphin; DS = short-beaked common dolphin; CC = loggerhead sea turtle. All animals were killed except the loggerhead sea turtle, which was released alive. The dashed region in 3A indicates a seasonal area closure where drift gillnet fishing is prohibited between 15 August – 15 November annually.

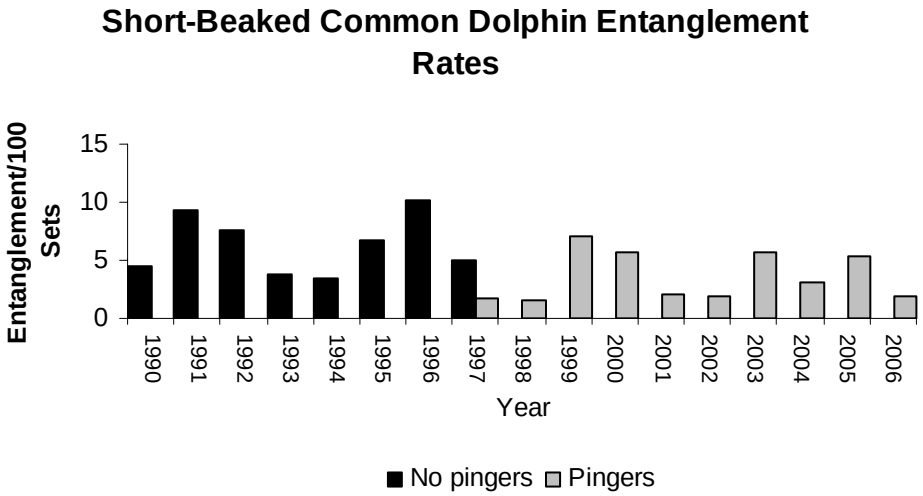

Figure 4. Entanglement rates of short-beaked common dolphin per set fished in the California swordfish drift gillnet fishery, 1990-2006. Pingers were not used from 1990-95 and were used experimentally in 1996 and 1997. In 1996, no short-beaked common dolphins were observed killed in 146 pingered sets. For the period 1998-2006, over 99% of all observed sets utilized pingers.

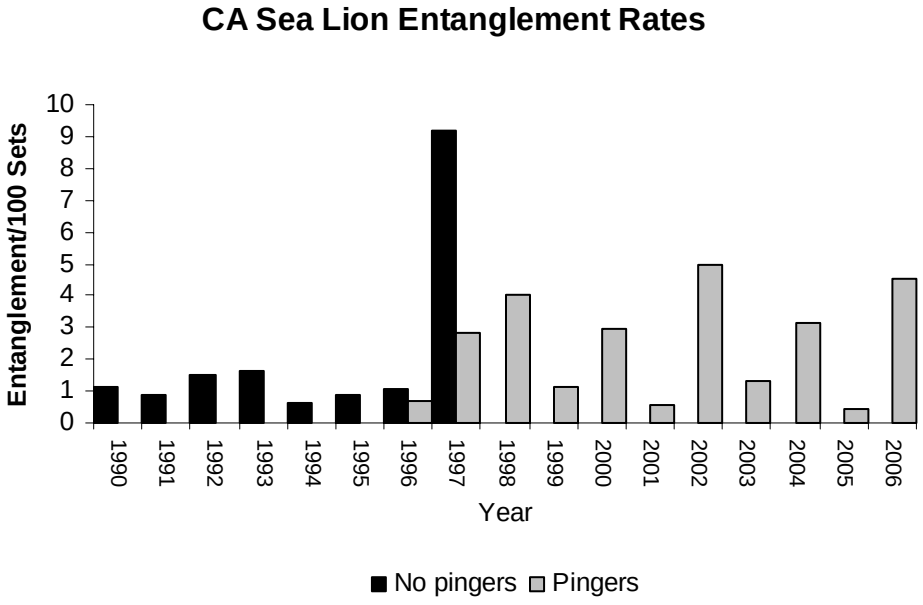

Figure 5. Entanglement rates of California sea lions per set fished in the California drift gillnet fishery for swordfish and thresher shark, 1990-2006. Pingers were not used from 1990-95 and were used experimentally in 1996 and 1997. For the period 1998-2006, over 99% of all observed sets utilized pingers.