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NOVEMBER 2005

PRELIMINARY ESTIMATES OF MARINE MAMMAL BYCATCH, MORTALITY, AND BIOLOGICAL SAMPLING OF CETACEANS IN CALIFORNIA GILLNET FISHERIES FOR 2004

by

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ADMINISTRATIVE REPORT LJ-05-10

Preliminary estimates of marine mammal bycatch, mortality, and biological sampling of cetaceans in California gillnet fisheries for 2004.

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ABSTRACT

Preliminary estimates of marine mammal bycatch in the California/Oregon large-mesh (≥ 14-inch) drift gillnet fishery for thresher shark and swordfish and the small-mesh (6.5-inch) drift gillnet fishery for white seabass, yellowtail, barracuda, and tuna are summarized for calendar year 2004. A third fishery, the set gillnet fishery for halibut and angel shark (8.5-inch mesh), has not been observed since 2000 in Monterey Bay and since 1994 in southern California. Although marine mammal mortality is known to have occurred in this fishery in the past, current mortality cannot be estimated because of this lack of recent observer data.

In the large-mesh drift gillnet fishery, seven short-beaked common dolphins (*Delphinus delphis*), one northern right whale dolphin (*Lissodelphis borealis*), and six California sea lions (*Zalophus californianus*) were observed killed in 2004. There was also one humpback whale (*Megaptera novaeangliae*) and one California sea lion entangled and released alive in this fishery in 2004. Estimated annual mortality by species (CVs in parentheses) is: 34 (0.49) short-beaked common dolphins, five (0.99) northern right whale dolphins, and 29 (0.44) California sea lions. Observer coverage in the thresher shark and swordfish drift gillnet fishery was 21% in 2004 (223 sets observed/1,084 sets estimated fished). Biological samples were collected from all cetaceans observed incidentally killed and life history data from these samples are summarized in the Appendix.

In the small-mesh drift gillnet fishery for white seabass, yellowtail, barracuda, and tuna, there was one long-beaked common dolphin (*Delphinus capensis*) and one California sea lion observed killed in 22 sets. In 2002, the most recent calendar year for which logbook data are available, approximately 200 small-mesh drift gillnet sets were fished in southern California. Based on this level of fishing effort and the observed 2004 kill rates, the annual estimate of mortality in this fishery for 2004 is 9 (0.94) long-beaked common dolphins and 9 (0.94) California sea lions.

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 where the annual level of incidental take is greater than or equal to 50% of a stock's PBR. Category II fisheries are defined as those where the annual takes are greater than 1% but less than 50% of PBR. Category III fisheries include those where the overall serious injury and incidental take across all fisheries that interact with the stock is less than 10% of the stock's PBR level.

California gillnet fisheries that interact with marine mammals

Table 1 lists the gillnet fisheries within California waters that are known to have (or had) marine mammal interactions.

Table 1. Characteristics of gillnet fisheries in California known to interact with marine mammals.

Fishery Name	MMPA Fishery Category	Mesh size
CA halibut and angel shark set gillnet	Category I	8.5 inch
CA/OR swordfish and thresher shark large-mesh drift gillnet	Category I	14-22 inch
CA white seabass, yellowtail, barracuda, and tuna small-mesh drift gillnet	Category II	6.0-6.5 inch

The California halibut and angel shark set gillnet fishery has been restricted to southern California waters south of Point Arguello since 2002. No observer program has existed for this fishery since 1994 in southern California and since 2000 in central California. The species most commonly observed killed in this fishery included harbor porpoise (*Phocoena phocoena*), California sea lions (*Zalophus californianus*), harbor seals (*Phoca vitulina*), and northern elephant seals (*Mirounga angustirostris*) (Julian and Beeson 1998, Forney et al. 2001). A portion of this fishery is composed of set gillnets with smaller mesh sizes (6.5 inch) that are set to catch white seabass and yellowtail. Fishing effort in this fishery totaled 2,788 sets in 2003. Owing to the absence of an observer program in recent years, there are no current estimates of fishery mortality for southern California waters for this fishery.

The California/Oregon swordfish and thresher shark large-mesh drift gillnet fishery has been observed by NMFS every year since 1990. Levels of fishing effort in this fishery have decreased from approximately 5,500 sets in 1993 to 1,084 sets in 2004 (Forney *et al.*, 2000; Read 2003a; 2003b; NMFS, unpublished data). Observer coverage in this fishery ranged from 4% to 18% (mean = 13%) from 1990-96 and has averaged 20% since 1997. Bycatch has included a wide variety of cetacean, pinniped, sea turtle, and seabird species (Julian and Beeson, 1998; Carretta *et al*., 2005). Initiation of a Take Reduction Plan (TRP) in 1996 followed concerns over incidental take levels that exceeded PBR for some cetacean stocks. The TRP resulted in the use of acoustic pingers all on nets (typically 20 each on the floatline and leadline), 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. In 2001, a seasonal (15 August – 15 November) area closure was implemented in the drift gillnet fishery north of Point Conception to protect leatherback turtles in this region. An additional season/area closure in southern California will be implemented during El Niño periods to protect loggerhead turtles in this region.

The California white seabass, yellowtail, barracuda, and tuna small-mesh drift gillnet fishery operates primarily within southern California around the Channel Islands. This fishery uses the same gear used by the portion of the set gillnet fishery that targets white seabass, but the gear is allowed to drift to target barracuda and tuna. NMFS initiated a three-year program in 2002 to observe a small portion of this fishery and there have been a total of 66 sets observed since 2002, with two long-beaked common dolphins and three California sea lions observed killed. Total fishing effort was 195 sets in 2002, the most recent year for which logbook data are available.

METHODS

Estimation of Fishing Effort

Fishing effort for the large-mesh drift gillnet fishery was estimated from the vessel operators' reports of the number of sets fished as received by the NMFS observer contractor[1]. In recent years, this contractor estimate of fishing effort has met or exceeded the number of sets determined from logbook and landing receipt data provided by the California Department of Fish and Game (CDFG). The CDFG stopped providing estimates of fishing effort in 2003.

Fishing effort in the small-mesh white seabass, yellowtail, barracuda, and tuna drift gillnet fishery is currently unknown for 2004. From 1999-2002, there were 140, 173, 111, and 195 small-mesh drift gillnet sets fished, respectively, as determined from logbook data (NMFS unpublished data). In the first half of 2003, there were at least 69 small-mesh drift gillnet sets and 30 sets where the fishing method was unspecified (Read 2003b). More recent logbook data for this fishery are currently unavailable. We estimated small-mesh drift gillnet effort for 2004 by assuming effort was equal to the most recent year (2002) for which complete logbook data are available.

Mortality Estimation

Mortality is estimated with ratio estimators, using trips as the sampling unit and the number of sets per trip as an auxiliary variable (Julian and Beeson 1998, Carretta *et al*. 2005). No geographic or seasonal strata are used in estimating kill rates as differences in previous mortality estimates and coefficients of variation using both seasonal stratification and pooling of all annual data have been negligible (Carretta, 2001; 2002). The kill rate for each species is calculated as

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

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

where k_s is the observed number of species *s* killed and *d* is the number of days (= sets) observed in the fishery.

Kill rate variances are estimated using a bootstrap procedure, where one trip (2 - 9 days in 2004) represents the sampling unit. Trips are resampled with replacement until each bootstrap sample contains the same number of trips as the actual observed level of effort. A kill rate is then calculated from each bootstrap sample. This procedure is repeated 1,000 times, from which the bootstrap sample variance (kill rate variance) is calculated.

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

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

$$\sigma_m^2 = D^2\,\sigma_r^2 \qquad (3)$$

where

D is the estimated minimum number of days (= sets) fished,
$\hat{r}_s$ is the kill rate per set for species *s* and
σ_r^2 is the bootstrap estimate of the kill rate variance.

The minimum number of sets fished (*D*) in the small-mesh white seabass, yellowtail, barracuda, and tuna drift gillnet fishery in 2004 is currently unknown, thus the most recent annual estimate of 195 sets fished in 2002 is used to calculate 2004 mortality in this fishery.

Biological Sampling

Biological samples or life history data were collected from all cetaceans observed incidentally killed in 2004. Details on sampling methods and results are given in the appendix.

RESULTS

CA/OR swordfish and thresher shark large-mesh drift gillnet

A total of 223 sets were observed out of a total estimated 1,084 sets fished in 2004 (21% observer coverage, Table 2). There were seven short-beaked common dolphins, six California sea lions, and one northern right whale dolphin observed killed in 2004. Additionally, there was one humpback whale and one sea lion observed entangled, both of which were released alive. The observer description of the humpback entanglement did not state if the whale was released with trailing gear, but the observer noted that a 50-fathom section of floatline was lost due to release of the whale. The humpback was caught in the upper third of the net, 20 ft. from a functioning acoustic pinger. Mortality and entanglement estimates for 2004 are summarized in Table 3. The locations of all observed large-mesh drift gillnet sets in 2004 are shown in Figure 1 and the locations of entangled marine mammals are shown in Figure 2.

Table 2. Summary of overall fishing effort, sets observed, percent observer coverage, and marine mammal interactions for two California drift gillnet fisheries in 2004.

Fishery	Sets Fished	Sets Observed	% Observer Coverage	Observed killed	Released alive
CA/OR swordfish/thresher shark drift gillnet, Category I	1084	223	21	14	2
CA yellowtail, barracuda, white seabass, and tuna drift gillnet, Category II	195[2]	23	11	2	0

CA white seabass, yellowtail, barracuda, and tuna small-mesh drift gillnet

A total of 22 sets were observed in 2004 and set locations are shown in Figure 3. Locations of all entangled marine mammals are shown in Figure 2. There were an estimated 195 sets fished in 2002, which results in an observer coverage level of 11%. There was one long-beaked common dolphin and one California sea lion observed killed. Mortality estimates for 2004 are summarized in Table 3.

Table 3. Summary of observed kill, kill per set, mortality estimates and statistical precision for two California drift gillnet fisheries in 2004. In addition to the observed kill summarized in this table, there was one humpback whale and one California sea lion entangled and released alive in the CA/OR swordfish/thresher shark drift gillnet fishery in 2004. Estimates of overall entanglement for species released alive are also summarized.

Fishery and Species	Observed kill	Kill per set	Kill rate variance	Mortality estimate	Boostrap CV
CA/OR swordfish/thresher shark drift gillnet					
Short-beaked common dolphin	7	0.031	2.3×10^{-4}	34	0.49
Northern right whale dolphin	1	0.004	1.8×10^{-5}	5	0.99
California sea lion	6	0.027	1.4×10^{-4}	29	0.44
CA yellowtail, barracuda, white seabass, and tuna drift gillnet					
Long-beaked common dolphin	1	0.045	1.9×10^{-3}	9	0.94
California sea lion	1	0.045	1.9×10^{-3}	9	0.94

2 - This estimate of fishing effort is based on sets fished in 2002, the most recent calendar year for which logbook data are available.

CA/OR swordfish/thresher shark drift gillnet	**Released Alive**	**Entangled per set**	**Entanglement rate variance**	**Entanglement Estimate**	**Bootstrap CV**
Humpback whale	1	0.004	1.7×10^{-5}	5	0.99
California sea lion	1	0.004	1.9×10^{-5}	5	0.93

DISCUSSION

The level of fishing effort in the CA/OR swordfish and thresher shark drift gillnet fishery in 2004 is the lowest (1,084 sets) since observations began in 1990 (Figure 4). Kill rates of short-beaked common dolphin were 3.1 per 100 sets in 2004, which is below the average of 3.5 per 100 sets observed in pingered sets since 1996 (Figure 5). By comparison, there was an average of 5.9 short-beaked common dolphins killed per 100 sets from 1990-96 in nets without pingers. This suggests that pingers are still effective at reducing entanglement of the most-commonly caught cetacean in this fishery.

A pattern of *increasing* kill rates of California sea lions is apparent in Figure 6. Barlow and Cameron (2003) showed that there was a statistically significant decline in sea lion kill rates in pingered vs non-pingered nets during a 1996-1997 experiment. Since 1998 however, the average kill per set (71 killed in 2760 sets = 0.026 per set) is more than double than that observed during 1990-95, before pinger use (35 killed in 3303 sets = 0.01 per set). Barlow and Cameron (2003) noted that the reduction in sea lion entanglement rates in pingered nets was surprising because of the prediction by some that pinnipeds might be attracted to pingered nets to feed on the captured fish (the “dinner bell” effect). The effects of pingers on captive sea lions was studied by Anderson (2000), who found that sea lions were startled by pingers, followed by avoidance behavior (leaving the water). A number of factors may be responsible for the observed increase in sea lion kill rates, including habituation and attraction to pingers (the “dinner bell” effect), an increasing sea lion population, and a 2001 area closure that shifted fishing effort into southern California waters, where sea lions are most abundant.

Future observer coverage of the small-mesh drift gillnet fishery is uncertain because of available funding and higher observer priorities in other fisheries. Based on the set locations observed over the past few years, this fishery is expected to interact primarily with California sea lions and long-beaked common dolphins.

Future monitoring of the previously observed California halibut and angel shark set gillnet fishery is uncertain, but based on the historical takes of marine mammals in this fishery, additional monitoring has been recommended by the MMPA Pacific Scientific Review Group.

ACKNOWLEDGMENTS

Thanks to Rand Rasmussen for maintaining the fishery observer database, Lyle Enriquez for providing effort and bycatch data, and Kelly Robertson for processing of biological samples. This work could not have been done without the diligent work of the NMFS biological observers and the cooperation of the California gillnet fishermen. Jay Barlow reviewed a draft of this manuscript.

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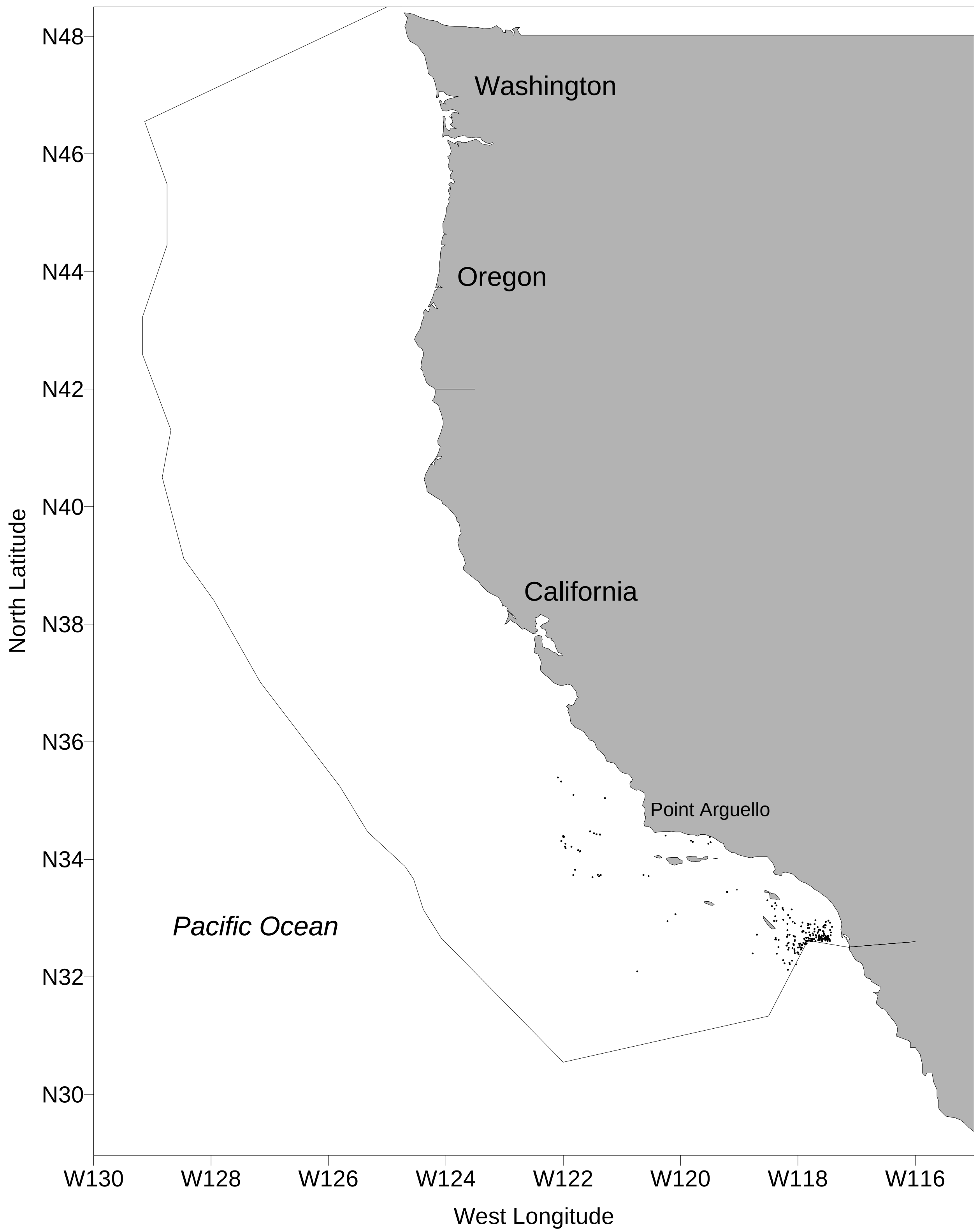

Figure 1. Locations of 222 observed sets in the California/Oregon swordfish/thresher shark large-mesh drift gillnet fishery in 2004. One observed set had no location reported.

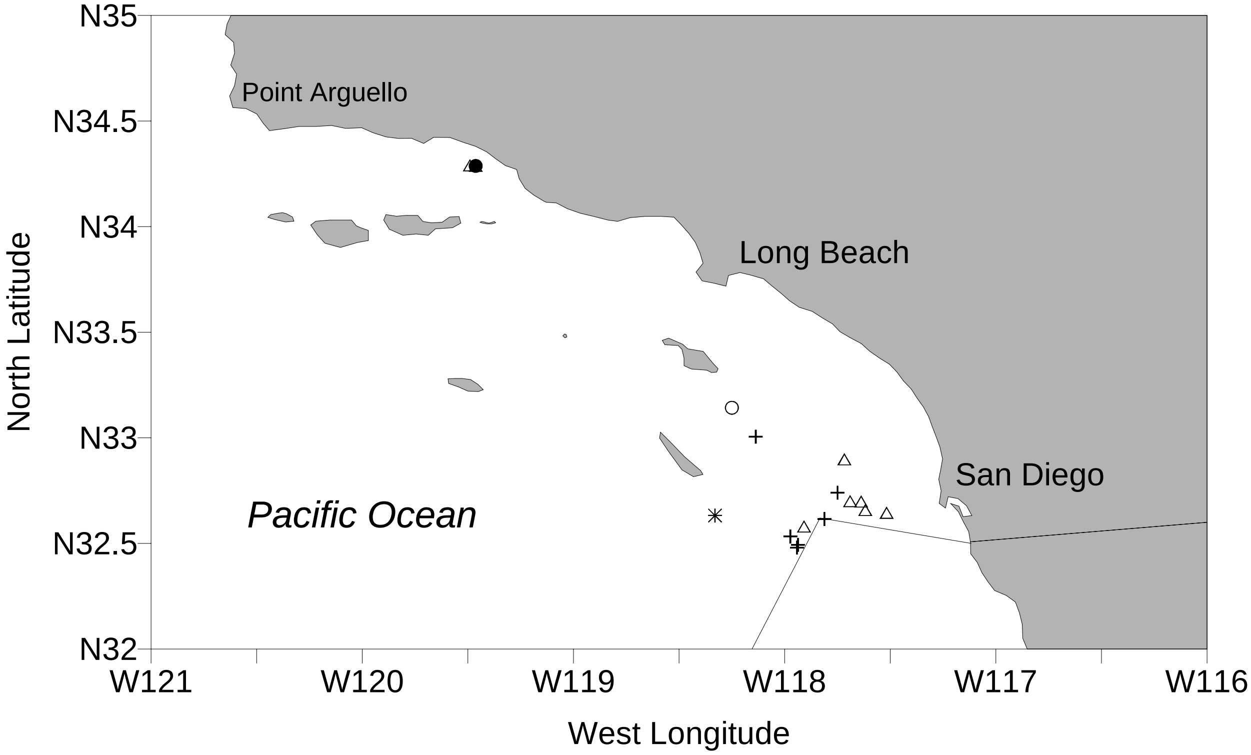

Figure 2. Locations of entangled marine mammals in the swordfish/thresher shark and yellowtail, barracuda, white seabass, and tuna drift gillnet fisheries in 2004. Key: △ = California sea lion; ✶ = humpback whale; ● = long-beaked common dolphin; ✚ = short-beaked common dolphin and ○ = northern right whale dolphin.

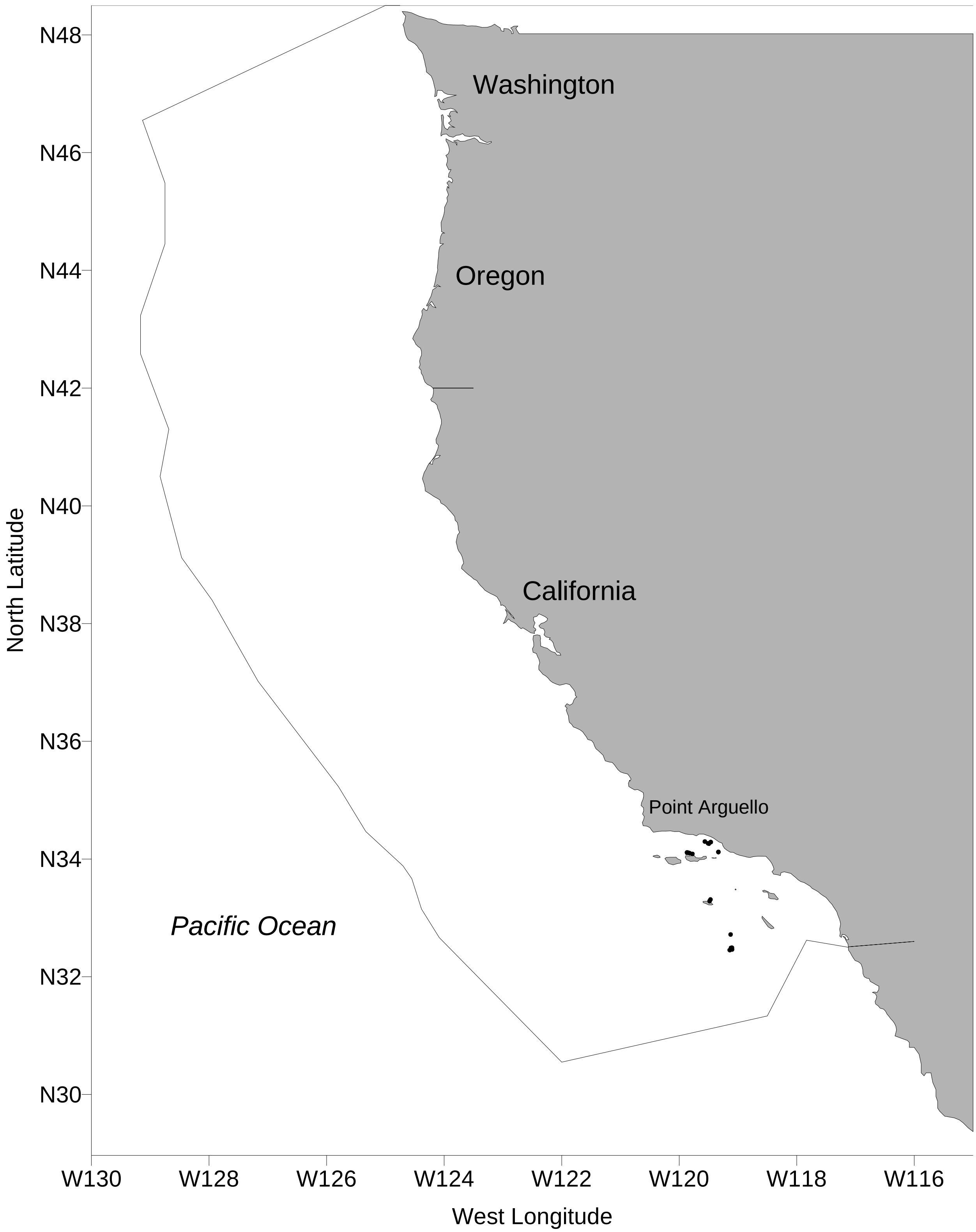

Figure 3. Locations of 22 observed sets in the California yellowtail, white seabass, barracuda, and tuna small-mesh drift gillnet fishery in 2004.

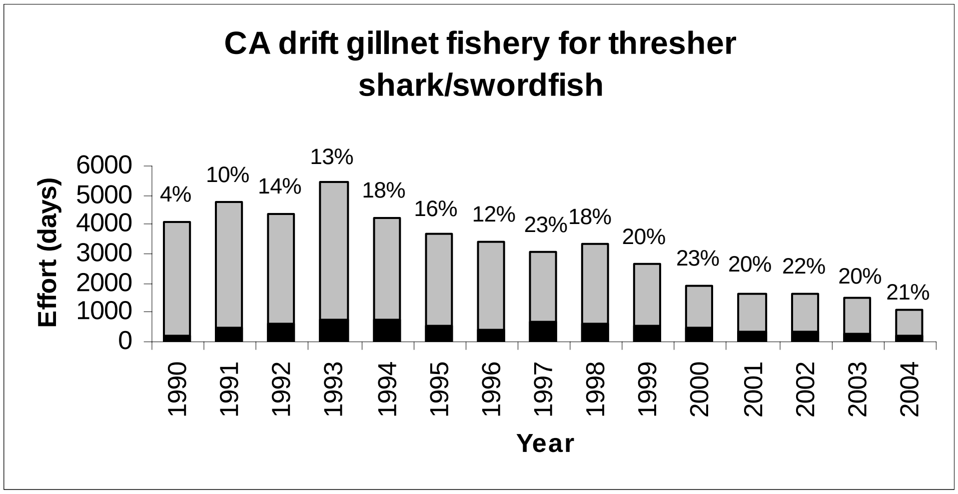

Figure 4. Estimated (gray) and observed (black) days of effort in the California swordfish and thresher shark drift gillnet fishery for 1990-2004. Percent values above bars represent the fraction of observer coverage in the fishery for a given year.

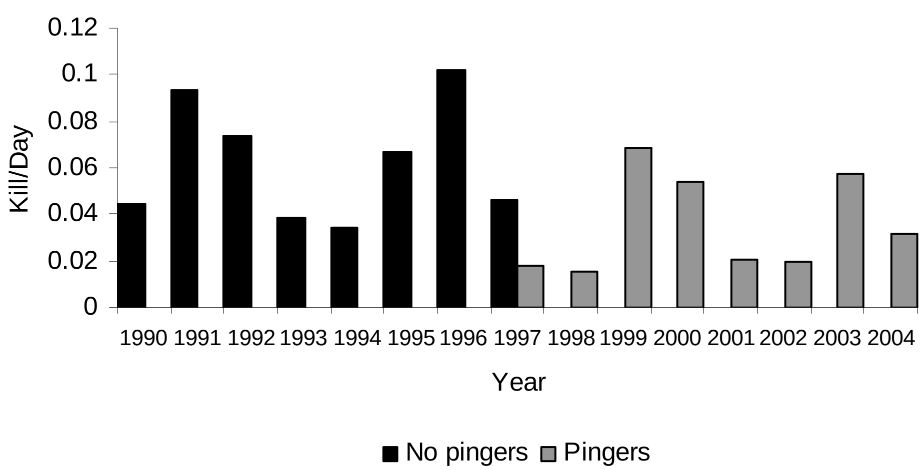

Figure 5. Kill rates of short-beaked common dolphin per set fished in the California drift gillnet fishery for swordfish and thresher shark, 1990-2004. Kill rates include observations from pingered and unpingered sets. Pingers were not used from 1990-95 and were used experimentally in 1996 and 1997. In 1996, no short-beaked common dolphins were observed killed in 146 pingered sets. For the period 1998-2004, over 99% of all observed sets utilized pingers.

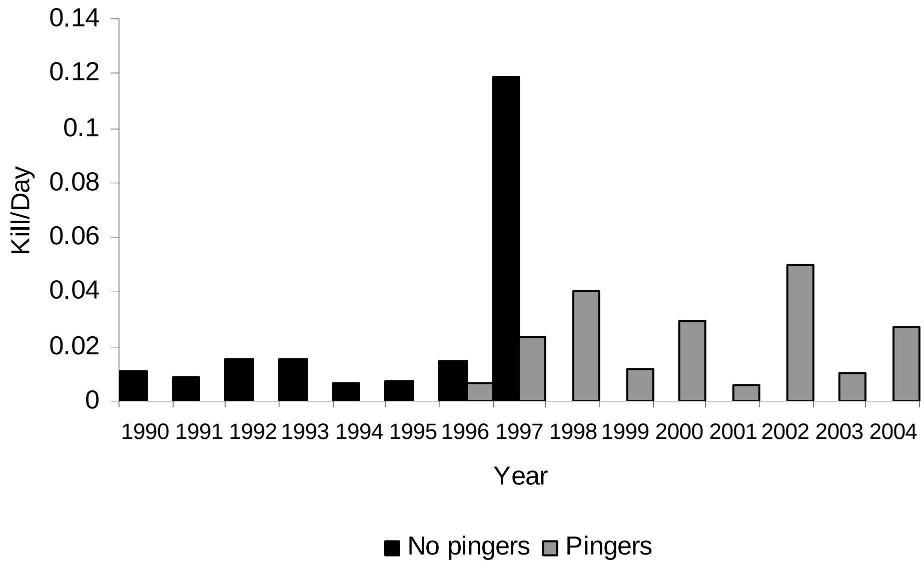

Figure 6. Kill rates of California sea lions per set fished in the California drift gillnet fishery for swordfish and thresher shark, 1990-2004. Kill rates include observations from pingered and unpingered sets. Pingers were not used from 1990-95 and were used experimentally in 1996 and 1997. For the period 1998-2004, over 99% of all observed sets utilized pingers.

APPENDIX

Biological sampling

Observers placed aboard California gillnet fishing vessels record the location and other pertinent data for each net set (*i.e.,* unit of fishing activity) including any incidental kill (Julian and Beeson 1995). For each incidental kill of a cetacean, observers record at least the species and gender of the animal. Additional biological data and samples (e.g. total body length, gonads, teeth, skin sample) are collected whenever possible. Procedures for the collection of biological data are described in Perrin *et al*. (1976) and Jefferson *et al*. (1994). The data form used by fishery observers in this program is 'Appendix 4' in Jefferson *et al*. (1994). Post-cruise processing of biological samples in the laboratory includes assessing the accuracy of species identifications made by observers in the field, examining the gonads to determine state of sexual maturity (Akin *et al*., 1993) and preparing collected teeth to estimate age (Perrin and Myrick, 1980; Myrick *et al*., 1983).

During 2004, nine cetaceans were recorded incidentally killed in the driftnet fishery: seven *D. delphis,* one *D. capensis* and one *Lissodelphis borealis*. Complete life history data, which includes total body length, gender, teeth, gonads, and a skin sample, were collected from all nine animals observed killed (Table 1). We summarized data collected by species, gender, and state of sexual maturity for all animals with data available at the time of this report (Table 2).

Whole carcasses were collected for one female and two male *D. delphis*. Heads were collected from all six of the other animals sampled. All data and specimen samples will be archived at the Southwest Fisheries Science Center (SWFSC). However, osteological specimens will be archived at the Natural History Museum of Los Angeles County, Los Angeles, California when processing at the SWFSC is completed.

Species Identification

Species identifications are confirmed using molecular genetic techniques for species that are difficult to identify in the field and when osteological specimens (e.g. a skull) are not available (Baker and Palumbi, 1994; Henshaw *et al*., 1997). In fact, several species have proven difficult for observers to identify in the field. These species include the two species of common dolphin (*Delphinus delphis* and *D. capensis*), the beaked whale species (family Ziphiidae), short-finned pilot whale (*Globicephala macrorhynchus*) and Risso=s dolphin *(Grampus griseus)* (Heyning and Perrin, 1994; Henshaw *et al.*, 1997; Chivers *et al*., 1997).

Of these difficult to identify species only *Delphinus* spp. were observed killed during 2004. When the carcass or head of an animal was not collected to morphologically determine species, molecular species identifications of *Delphinus* spp. specimens were based on a 410 base pair sequence of the 5' end of the mitochondrial DNA (mtDNA) gene, cytochrome-*B*, which is prepared using standard protocols (Palumbi *et al*., 1991; Saiki *et al*., 1988; Rosel *et al*., 1994). Species identifications are made by comparing sequences from the suspect, or unknown, specimen to all available cytochrome-*B* sequences from *Delphinus* spp. specimens with identifications confirmed by morphology (Rosel *et al.*, 1994; Southwest Fisheries Science Center, unpublished data). Molecular identifications of all other cetacean species were based on the comparison of a 400 base pair sequence of the 5' end of the mtDNA control region sequenced using standard protocols to a reference collection of sequences (Southwest Fisheries Science Center, unpublished data).

Species identifications were confirmed using molecular genetic techniques for one *Delphinus* spp. specimen collected. External morphology was used to confirm the identification of the other 6 *Delphinus* spp. sampled.

Gender determination

All specimens had gender determined in the field and confirmed by examination of sample material collected from each specimen.

SUMMARY

The collection of biological data from observed incidental kill in the driftnet fishery has regularly exceeded 95% (Chivers *et al*., 1997; Chivers and Robertson, 2000; 2001), and in 2001 through 2004 observers sampled 100% of the observed kill (Carretta and Chivers, 2003, 2004; Chivers *et al*., 2002, Carretta et al., this paper). On review of the data available, the species, gender and size composition of the observed kill in 2004 was comparable to that of prior years.

Table 1. The observed incidental kill and number of specimens collected by fishery observers during 2004 are listed by species. The seven *Delphinus delphis* and one *Lissodelphis borealis* were observed killed in the CA/OR swordfish and thresher shark large-mesh drift gillnet fishery. The one *Delphinus capensis* was observed killed in the CA yellowtail, white seabass, barracuda, and tuna small-mesh drift gillnet fishery. Specimens with minimum data collected are those for which species identity, and total body length and/or a skin sample were collected. Specimens with full life history data collected are those for which the species identification, gender, total body length, teeth, gonads, and skin samples were collected.

Species	Observed Incidental Kill	Specimens with minimum data collected	Specimens with full life history data collected
Delphinus delphis	**7**	**7**	**7**
Delphinus capensis	**1**	**1**	**1**
Lissodelphis borealis	**1**	**1**	**1**
TOTAL	**9**	**9**	**9**

Table 2. For each species, the gender and state of sexual maturity of each animal sampled by California drift gillnet fishery observers in 2004 is summarized. Females are considered sexually mature when 1 corpus or more are present in either ovary. Sexual maturity in males can only be definitively determined by examination of histological preparations of testes tissue. We do not presently have these data available, and therefore used testes weight, which increases markedly when a cetacean attains sexual maturity, as a proxy for estimating state of sexual maturity. We used the following published information to estimate the state of sexual maturity for males in our sample. All testes weight criteria are for the weight of one testis, and a testis weight greater than the minimum listed is considered sexually mature. (1) For *Delphinus*, males with weight of one testis > 200 g are considered sexually mature (Ferrero and Walker, 1994), and (2) for *Lissodelphis borealis*, > 300 g (Ferrero and Walker, 1993). If gonads for a specimen were not available, sexual maturity was "undetermined."

SPECIES	GENDER	SEXUAL MATURITY
Delphinus delphis	**Males**	**Immature (n=1)** **Mature (n=4)**
	Females	**Immature (n=2)**
Delphinus capensis	**Males**	**Immature (n=1)**
	Females	**(n=0)**
Lissodelphis borealis	**Males**	**(n=0)**
	Females	**Immature (n=1)**