Preliminary estimates of marine mammal mortality and biological sampling of cetaceans in California gillnet fisheries for 2003

2 authors:

James Carretta
National Oceanic and Atmospheric Administration
39 PUBLICATIONS **1,152** CITATIONS
SEE PROFILE

Susan J Chivers
National Oceanic and Atmospheric Administration
94 PUBLICATIONS **2,439** CITATIONS
SEE PROFILE

Preliminary estimates of marine mammal mortality and biological sampling of cetaceans in California gillnet fisheries for 2003.

James V. Carretta and Susan J. Chivers
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

ABSTRACT

Preliminary mortality estimates of marine mammals and other protected species incidentally caught in the California halibut and angel shark set gillnet fishery are summarized for the first six months of 2003 and for the thresher shark and swordfish drift gillnet fishery for the entire calendar year of 2003. Additional information on mortalities observed in the white seabass, yellowtail, barracuda, and tuna small-mesh drift gillnet fishery is also summarized. Biological life-history data collected from all cetaceans incidentally observed caught in the two drift gillnet fisheries is also reviewed. In the halibut and angel shark set gillnet fishery, estimated mortality for the first six months of 2003 (CV in parentheses) is 2 (0.71) unidentified common dolphins (*Delphinus* sp.), 686 (0.07) California sea lions (*Zalophus californianus*), 186 (0.09) harbor seals (*Phoca vitulina*), 16 (0.21) northern elephant seals (*Mirounga angustirostris*), 16 (0.35) unidentified pinnipeds, 1 (0.96) loggerhead sea turtle (*Caretta caretta*), 2 (0.71) green sea turtles (*Chelonia mydas*), 1 (0.96) leatherback sea turtle (*Dermochelys coriacea*), 1 (0.96) unidentified sea turtle, 1 (0.96) common murre (*Uria aalge*), and 60 (0.23) Brandt's cormorants (*Phalacrocorax penicillatus*). This fishery was last observed in 2000 and mortality estimates are based on past kill rates and current estimates of fishing effort. In the swordfish and thresher shark drift gillnet fishery, estimated 2003 annual mortality by species (CVs in parentheses) is: 84 (0.24) short-beaked common dolphins (*Delphinus delphis*), 20 (0.50) Risso's dolphins (*Grampus griseus*), 5 (1.00) northern right whale dolphins (*Lissodelphis borealis*), 5 (1.00) short-finned pilot whales (*Globicephala macrorhynchus*), 5 (1.00) northern elephant seals (*Mirounga angustirostris*), and 15 (0.58) California sea lions (*Zalophus californianus*). Observer coverage in the thresher shark and swordfish drift gillnet fishery was 20% in 2003 (298 sets observed/1,467 sets estimated fished). Biological samples were collected from all cetaceans observed incidentally killed in this fishery: 17 short-beaked common dolphins, 4 Risso's dolphins, 1 northern right whale dolphin, and 1 short-finned pilot whale.

Mortality was also observed in the 6.5-inch mesh white seabass, yellowtail, barracuda, and tuna drift gillnet fishery in 2003. One long-beaked common dolphin (*Delphinus capensis*) and two California sea lions were observed killed in this fishery. This fishery is part of the larger *set gillnet fishery* that targets white seabass and yellowtail. In recent years, fishermen have used the same nets with drift methods to also target barracuda and tuna. Between June 2002 and July 2003, there were 42 sets observed in this fishery. Data from this fishery are currently insufficient to reliably calculate kill rates or estimate annual mortality.

INTRODUCTION

The California halibut and angel shark set gillnet fishery is classified as a Category I fishery under the U.S. Marine Mammal Protection Act (MMPA), meaning that 'levels of incidental serious injury and mortality of a given marine mammal stock are greater than or equal to 50% of the Potential Biological Removal (PBR) level for that stock' (National Marine Fisheries Service (NMFS) List of Commercial Fisheries, 1996). PBR is defined 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' (Barlow *et al*., 1995). The California/Oregon thresher shark and swordfish drift gillnet fishery is classified as a Category II fishery under the MMPA, which reflects that serious injury and mortality levels are less than 50% of PBR. Category I and II fisheries are subject to monitoring by observer programs, which provide data on incidental marine mammal bycatch. NMFS observer programs for both the halibut and angel shark set gillnet and thresher shark and swordfish drift gillnet fisheries were initiated in 1990. Observers are placed on fishing vessels to record catch, bycatch and other gear, environmental variables and collect biological samples from incidentally caught marine mammals.

The halibut and angel shark set gillnet fishery was observed during 1990-1994 throughout its range (southern and central California), with levels of observer coverage ranging from 2-15% (mean = 9.6%) (Julian and Beeson, 1998). Historically, incidental takes of marine mammals in this fishery have been mostly California sea lions, harbor seals, and harbor porpoise (*Phocoena phocoena*) (Julian and Beeson 1998, Forney *et al*. 2001). In 1994, area closures restricted set gillnets to waters greater than 5.5 km (3 nmi) from the southern California mainland and greater than 1.85 km (1 nmi) from the Channel Islands. This closure resulted in a marked decrease in fishing effort in this fishery, from approximately 5,500-7,000 fishing days during 1990-93 to 2,000-4,000 days following the closure (Forney *et al.*, 2000; Cameron and Forney, 1999; 2000). In the central California portion of the fishery, depth restrictions in place since 1991 have not allowed fishing inshore of 55 m (30 fm). There was no observer coverage throughout this fishery during 1995-98. In 1999-2000, a NMFS observer program operated at 20% coverage levels in the Monterey Bay portion of this fishery, in response to concerns over the incidental take of harbor porpoise. A ban on gill and trammel nets inshore of 110 m (60 fm) from Point Reyes to Point Arguello became effective in September 2002. This ban was implemented by the California Department of Fish and Game (CDFG) because of concerns over the incidental mortality of common murre (*Uria aalge*) and California sea otters (*Enhydra lutris*). Fishermen appear to be complying with this area closure, as there was no set gillnet fishing effort reported in central California waters north of Point Arguello in the first six months of 2003. This closure is currently being legally challenged by fishermen in the California court system.

The thresher shark and swordfish 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 days in 1993 to 1,467 days in 2003 (Forney *et al*., 2000; Read 2003a; 2003b; NMFS, unpublished data). Observer coverage in this fishery ranged from 4% to 18% (mean = 13%) between 1990-96 and from 20% to 25% between 1997-2003. Bycatch in the thresher shark and swordfish drift gillnet fishery has included a wide variety of cetacean, pinniped, sea turtle, and seabird species (Julian and Beeson, 1998; Cameron and Forney, 1999; 2000). 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 regarding marine mammals and TRP goals. 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.

There is also a largely unobserved small-mesh (6.5-inch) set/drift gillnet fishery in California waters that targets white seabass, yellowtail, barracuda, and tuna. Historically, this fishery was known to entangle harbor porpoises (Norris and Prescott, 1961). Most of the effort in this fishery utilizes set gillnets, but in recent years, fishermen have used drift gillnets of the same mesh size to target barracuda and tuna. Observations of 42 small-mesh drift gillnet sets between June 2002 and July 2003 have documented incidental mortalities of 1 long-beaked common dolphin and 2 California sea lions. All three mortalities occurred in the second half of 2003, for which fishing effort information is not yet available. Data from this fishery are currently insufficient to reliably calculate kill rates or estimate annual mortality.

METHODS

Estimation of Total Fishing Effort

Estimates of fishing effort for all fisheries were provided by the California Department of Fish and Game (CDFG) through the first six months of 2003 (Read 2003a, 2003b) and augmented by examination of logbook data (NMFS, unpublished data). The CDFG will no longer provide fishing effort estimates beyond this period, and future effort estimates will be obtained through a NMFS review of logbook data and landing receipts. Fishing effort estimates for the second half of 2003 are currently unavailable, except for the thresher shark and swordfish drift gillnet fishery, where estimates for the whole calendar year were provided by the NMFS observer contractor[1] for this fishery, based on dock-round data that tracks when vessels are in port or out fishing. In past years, contractor and CDFG fishing effort estimates for the thresher shark and swordfish drift gillnet fishery have been similar, with contractor estimates being slightly higher (NMFS, unpublished data). Effort estimates for both fisheries are preliminary and may be revised upwards as additional fishing records are received. For this same reason, mortality estimates are also considered preliminary.

Mortality Estimation in the set gillnet fishery

Mortality in the halibut and angelshark set gillnet fishery is estimated with mean-per-unit (MPU) estimators, using effort days (= trips) as the sampling unit (Julian and Beeson, 1998; Cameron and Forney, 1999; 2000). As in previous analyses, kill rates are stratified by geographic area, and by calendar quarter for Southern California and Ventura. There were insufficient data to stratify by calendar quarter for other geographic strata. In 2003, the halibut

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

and angel shark set gillnet fishery was not observed and current mortality estimates are based on kill rates from 1991-94 observer program data (the last period for which year-round observations are available) and estimated fishing effort in 2003.

The kill rate for each stratum ($\hat{r}_s$) is calculated as

$$\hat{r}_s = \frac{\sum_i k_{i,s}}{d_s} \qquad (1)$$

where $k_{i,s}$ is the observed kill for the i^{th} observed day in stratum s and d_s are the number of days observed in stratum s. In lieu of analytical formulae previously used to estimate kill rate variances (Julian and Beeson, 1998; Cameron and Forney, 1999; 2000), we estimate kill rate variances using a bootstrap procedure, where one trip (= day) represented the sampling unit. Within a stratum, days are resampled with replacement until each bootstrap sample contains the same number of days 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. Estimated mortality, $\hat{m}$ and its associated variance are calculated for each stratum as

$$\hat{m}_s = D_s r_s \qquad (2)$$

$$\hat{\sigma}^2_{m,s} = D_s^2 \hat{\sigma}^2_{r,s} \qquad (3)$$

where

$\hat{m}_s$ is the estimated mortality within stratum s,

D_s is the estimated number of days fished in stratum s,

$\hat{r}_s$ is the kill rate in stratum s,

$\hat{\sigma}^2_{m,s}$ is the variance of the estimated mortality in stratum s, and

$\hat{\sigma}^2_{r,s}$ is the bootstrap sample variance of the kill rate in stratum s.

Quarterly estimates of mortality within a geographic stratum are added to yield annual mortality estimates for that stratum. Annual kill rates and standard errors within a stratum represent effort-weighted averages of the quarterly kill rates and standard errors (weighted by the number of days observed). Fishery-wide estimates of mortality and associated variances are obtained by adding mortality estimates and variances across all geographic strata. Annual

estimates of mortality are considered preliminary because fishing effort estimates will likely be revised upwards as more fishing records are received.

Mortality Estimation in the drift gillnet fishery

Mortality in the swordfish/shark drift gillnet fishery is estimated with mean-per-unit estimators, using days as the sampling unit, since trip-specific information was unavailable at the time of analysis. (*When trip-specific information becomes available, final mortality estimates will be made using ratio estimators, with trips as the sampling unit and the number of days per trip as an auxillary variable.*) No geographic or seasonal strata are used in estimating drift gillnet fishery kill rates. Differences in previous mortality estimates and coefficients of variation for this fishery using both seasonal stratification and pooling of all annual data have been negligible (Carretta, 2001; 2002). The kill rate for each species was calculated as

$$\hat{r}_s = \frac{\sum k_s}{\sum d} \qquad (4)$$

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

Precision of the mortality estimates is calculated using a sample-sized Poisson assumption, where the coefficient of variation (CV) of a mortality estimate is

$$CV = \sqrt{n_i} \Big/ n_i \qquad (5)$$

where n is the number of animals of species i observed killed. Carretta (2001; 2002) compared the precision of mortality estimates using both the Poisson assumption and bootstrap-based resampling methods and found similar results using both methods. In general, the bootstrap method yields higher variances.

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 (Lennert *et al.*, 1994). 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).

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*., 1997b). 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.*, 1997b; Chivers *et al*., 1997).

Gender determination

When gender was not determined in the field and the carcass was not collected for the determination to be made in the laboratory, gender is molecularly determined by amplifying the SRY gene. The gene is amplified with PCR using primers SRY-Y53-3C and SRY-Y53-3D (Fain and LeMay, 1995). We used the zinc finger gene (*i.e.*, ZFX/ZFY) as an internal control to confirm PCR conditions (Bérubé and Palsbøll, 1996a; 1996b).

Molecular gender determinations were made for two of the *G. griseus* specimens with only skin samples collected.

RESULTS

Set gillnet fishery for halibut and angel shark (8.5-inch mesh)

In the halibut and angel shark set gillnet fishery, the preliminary estimate of fishing effort for the first six months of 2003 was 1,965 days. All effort occurred south of Point Arguello, California (Figures 1-2), due to an area closure inshore of 110 m (60 fathoms) implemented in 2002 in central California. Effort in the set gillnet fishery by geographic stratum was: Channel Islands (77 days), Ventura (971 days), and Southern California (917 days). Effort by CDFG block is shown in Figure 2. Mortality estimates for the halibut and angel shark set gillnet fishery for the first six months of 2003 are presented in Table 1. There was no fishing effort in the Morro Bay and Monterey Bay strata in 2003 and it is assumed that there was no incidental mortality in these strata. For other geographic strata (Southern California, Ventura, and Channel Islands), the only cetacean species for which current estimates of mortality are available are unidentified common dolphin (*Delphinus sp.*) (Table 1). However, this estimate is based on 1991-94 kill rates (2 killed/2,289 days = 0.00087 killed/day) when the fishery outside of Monterey Bay was still observed, and it is unknown whether 1991-94 kill rates are still representative of current rates. Similarly, kill rates of pinnipeds for these strata are based on 1991-94 kill rates and thus are subject to a great degree of uncertainty.

Drift gillnet fishery for thresher shark and swordfish (14 to 22-inch mesh)

Drift gillnet fishing effort, observer coverage, observed mortalities, and annual mortality estimates for 2003 are summarized in Table 2. Observer coverage in this fishery was 20%, with 298 sets (=days) observed out of an estimated 1,467 sets fished during calendar year 2003. Effort in the first six months of 2003 was concentrated in southern California waters (Figure 3).

Effort for the remainder of the year is also expected to be concentrated in this region, as there is a large area closure north of Point Conception from August 15 to November 15 in this fishery. Observed mortalities in the fishery included 17 short-beaked common dolphins (*Delphinus delphis*), 4 Risso's dolphins (*Grampus griseus*), 1 northern right whale dolphin (*Lissodelphis borealis*), 1 short-finned pilot whale (*Globicephala macrorhynchus*), 3 California sea lions (*Zalophus californianus*), and 1 northern elephant seal (*Mirounga angustirostris*). A summary of biological sampling conducted on cetaceans observed killed in this fishery is presented in the Appendix. As in previous years, the short-beaked common dolphin was the most frequently entangled species, with 17 observed mortalities and a mortality estimate of 84 animals (CV = 0.24). The observed kill rate of short-beaked common dolphins in 2003 (0.057 killed/set) is higher than rates observed in 2001 and 2002, and is the second-highest kill rate observed in sets using pingers since their use began in 1996 (Figure 4).

Small-mesh drift gillnet fishery for white seabass, yellowtail, barracuda, and tuna (6.5-inch mesh)

NMFS initiated a three-year program in 2002 to observe a small portion of the small-mesh (6.5-inch) drift gillnet fishery targeting white seabass, yellowtail, barracuda, and tuna.[2] A total of 22 sets were observed in 2002, with one California sea lion observed entangled and released alive. Through July 31, 2003, there were 42 small-mesh drift gillnet sets observed with one long-beaked common dolphin and two California sea lion mortalities documented[3]. Logbook records indicate that from 1999-2002, there were 140, 173, 111, and 181 small-mesh drift gillnet sets fished, respectively. 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). Currently, sample sizes for this fishery are too small to reliably calculate kill rates or estimate annual mortality.

Biological sampling

During 2003, 23 cetaceans were recorded incidentally killed in the large-mesh driftnet fishery for swordfish and thresher shark: 17 *D. delphis*, 4 *Grampus griseus*, 1 *Globicephala macrorhynchus*, and 1 *Lissodelphis borealis*. One long-beaked common dolphin, *Delphinus capensis*, was killed in the small-mesh (6.0-6.5 inch) drift gillnet fishery that targets white seabass, yellowtail, barracuda, and tunas. Life history data, including at least the collection of a skin sample for molecular genetic analyses, were collected from all of these animals. Complete life history data, which includes total body length, gender, teeth, gonads, and a skin sample, were collected for 20 of the animals sampled (Table 3). The specimens with only a skin sample collected were 3 of the *G. griseus* observed killed and the *G. macrorhynchus*. We summarized data collected by species, gender, and state of sexual maturity for all animals with data available in time for this report (Table 4). Some of the whole carcasses have not yet been dissected, and age estimates were not available for this report.

Whole carcasses were collected for 2 female and 3 male *D. delphis*, and 1 female *L. borealis* specimens. Heads were collected from 15 of the other animals sampled. All materials

2 - Personal communication: Don Petersen, NMFS Southwest Regional Office, Long Beach, California, USA.
3 - Pacific Scientific Review Group Document PSRG-17c, presented at the Pacific Scientific Review Group Meeting, 17-20 November 2003, La Jolla, California, USA.

are archived at the Southwest Fisheries Science Center (SWFSC). However, the osteological specimens will be archived at the Natural History Museum of Los Angeles County, Los Angeles, California when processing at the SWFSC is completed.

Of the difficult to identify species, *Delphinus* spp., *G. griseus*, and *G. macrorhynchus* were observed killed during 2003. When the carcass or head of an animal was not collected, molecular identifications of *Delphinus* spp. specimens to species 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 or determined using molecular genetic techniques for the 4 *G. griseus* and 1 *G. macrorhynchus* sampled and external morphology for all 18 *Delphinus* spp. sampled.

DISCUSSION

Fishing effort in the halibut/angel shark set gillnet fishery has been between 3,200 and 4,200 sets for the period 1999-2002. In the first six months of 2003, there were 1,965 sets, which suggests that annual 2003 fishing effort will be similar to the past few years. A year-round ban on gillnets inshore of 110 m (60 fms) from Pt. Reyes to Point Arguello, California was implemented in 2002 and has resulted in the elimination of set gillnets in this region. It is expected that fishery-caused mortality of harbor porpoises in this region will remain near zero for as long as the closure is in effect. Considerable uncertainty remains in estimating cetacean and pinniped mortality for the southern California portion of the set gillnet fishery because this portion of the fishery has not been observed since 1994, and 2003 mortality estimates are based on kill rates observed from 1991-94 (Julian and Beeson 1998). Kill rates reported by Julian and Beeson (1998) may not reflect current conditions in the fishery, because of geographical changes in set gillnet effort since a 5.5 km (3 nmi) inshore ban was implemented in 1994.

Effort in the drift gillnet fishery has ranged between 1,400-1,900 days for the past four years and last exceeded 2,000 days in 1999 (Figure 5). The short-beaked common dolphin continues to be the most frequently entangled cetacean in the drift gillnet fishery, which probably reflects it being the most abundant cetacean in California waters (Barlow, 1995; Forney *et al*., 1995). A season/area closure to protect leatherback turtles has been in effect since 2001 and an additional closure in southern California during El NiZo years to protect loggerhead turtles was adopted in 2003.

The collection of biological data from observed incidental kill in the large-mesh driftnet fishery targeting swordfish and thresher shark has regularly exceeded 95% (Chivers *et al*., 1997; Chivers and Robertson, 2000; 2001), and in 2003 as in 2001 and 2002 (Carretta and Chivers, 2003; Chivers *et al*., 2002), observers sampled 100% of the observed kill. There were 23 cetaceans observed killed in the large-mesh drift gillnet fishery and all had at least total body length measured or a skin sample collected. Additionally, 15 animals had a complete suite of life

history data collected (i.e., species, gender, length, teeth, gonads, and skin), including one long-beaked common dolphin (*Delphinus capensis*) taken in the small-mesh drift gillnet fishery. The species, gender and size composition of the observed kill in 2003 was comparable to that of prior years.

ACKNOWLEDGMENTS

Thanks to Bob Read of the California Department of Fish and Game for providing estimates of fishing effort and Al Coan for providing logbook data. Thanks also to Rand Rasmussen for maintaining the observer database of incidental take and gear data, Lyle Enriquez for providing effort and bycatch data, and Kerri Danil 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 and Karin Forney reviewed the manuscript and provided valuable suggestions and improvements.

LITERATURE CITED

Akin, P. A., Peltier[Robertson], K. M. and Miller, R. B. 1993. Techniques for the preparation and examination of reproductive samples collected from dolphins in the eastern tropical Pacific. U.S. Department of Commerce, NOAA-Technical Memorandum-NMFS-SWFSC-192, 26pp.

Baker, C. S. and Palumbi, S. R. 1994. Which whales are hunted? A molecular approach to monitoring whaling. Science 265:1538-39.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. U.S. Fishery Bulletin 93:1-14.

Barlow, J., Swartz, S.L., Eagle, T.C., and Wade, P.R. 1995. U.S. Marine Mammal Stock Assessments: Guidelines for preparation, background, and a summary of the 1995 assessments. Department of Commerce NOAA Technical Memorandum, NMFS-OPR-95-6.

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.

Bérubé, M. and Palsbøll, P. 1996a. Identification of sex in cetaceans by multiplexing with three ZFX and ZFY specific primers. Molecular Ecology 5:283-7.

Bérubé, M. and Palsbøll, P. 1996b. Erratum of identification of sex in cetaceans by multiplexing with three ZFX and ZFY specific primers. Molecular Ecology 5:602.

Cameron, G.A. and Forney, K.A.. 1999. Preliminary estimates of cetacean mortality in the California gillnet fisheries for 1997 and 1998. Report SC/51/O4 presented to the Scientific Committee of the International Whaling Commission, May 1999

(unpublished). 14 p. [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA].

Cameron, G.A. and Forney, K.A. 2000. Preliminary estimates of cetacean mortality in California/Oregon gillnet fisheries for 1999. Report SC/52/O24 presented to the Scientific Committee of the International Whaling Commission, May 2000 (unpublished). 12 p. [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA].

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. 2002. Preliminary estimates of cetacean mortality in California gillnet fisheries for 2001. Report SC/54/SM12 presented to the Scientific Committee of the International Whaling Commission, April 2002 (unpublished). 22p. [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA.]

Carretta, J.V. and Chivers, S.J. 2003. Preliminary estimates of marine mammal mortality and biological sampling of cetaceans in California gillnet fisheries for 2002. Paper SC/55/SM3 presented to the IWC Scientific Committee, June 2003 (unpublished). [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA].

Chivers, S.J. and Robertson, K.M. 2000. Composition of the incidental kill of cetaceans in two California gillnet fisheries: 1990-1999. Paper SC/52/SM25 presented to the IWC Scientific Committee, June 2000 (unpublished). [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA].

Chivers, S.J. and Robertson, K.M. 2001. Life history characteristics of the incidental kill of cetaceans in the California drift and set gillnet fisheries during 2000. Paper SC/53/SM10 presented to the IWC Scientific Committee, June 2001 (unpublished). [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA].

Chivers, S. J., Robertson, K. M., and Danil, K. 2002. Life history characteristics of the incidental kill of cetaceans in the California drift and set gillnet fisheries during 2001. Paper SC/54/SM13 presented to the IWC Scientific Committee, June 2002 (unpublished). [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA].

Chivers, S. J., Robertson, K. M. and Henshaw, M. D. 1997. Composition of the incidental kill of cetaceans in two California gillnet fisheries: 1990-1995. Rep. int. Whal. Commn 47:909-15.

Fain, S.R. and J.P. LeMay. 1995. Gender identification of humans and mammalian wildlife species from PCR amplified sex linked genes. Proceedings of American Academy of Forensic Science.

Ferrero, R.C. and Walker, W.A. 1993. Growth and reproduction of the northern right whale dolphin, *Lissodelphis borealis*, in the offshore waters of the North Pacific Ocean. Can. J. Zool. 71(12):2335-44.

Ferrero, R.C. and Walker, W.A. 1994. Growth and reproduction of the common dolphin, *Delphinus delphis* Linneus, in the offshore waters of the North Pacific Ocean. Fishery Bulletin 93(3):483-94.

Forney, K.A., Barlow, J. and Carretta, J.V. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. U.S. Fishery Bulletin 93:15-26.

Forney, K.A., Barlow, J., Muto, M.M., Lowry, M., Baker, J., Cameron, G., Mobley, J., Stinchcomb, C., and Carretta, J.V. 2000. U.S. Pacific Marine Mammal Stock Assessments: 2000. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-300. 276p. [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038, USA].

Forney, K.A., S.R. Benson, and G.A. Cameron. 2001. Central California gillnet effort and bycatch of sensitive species, 1990-1998. pp. 141-160 *in* Proceedings – Seabird Bycatch: Trends, Roadblocks, and Solutions. University of Alaska Sea Grant, AK-SG-01-01.

Henshaw, M.D., LeDuc, R.G., Chivers, S.J. and Dizon, A.E. 1997*b*. Identifying beaked whales (family Ziphiidae) using mtDNA sequences. Marine Mammal Science 13(3):487-95.

Heyning, J.E. and Perrin, W.F. 1994. Two forms of common dolphins (genus *Delphinus*) from the eastern north Pacific: evidence for two species. Contr. Sci. Nat. Hist. Mus., Los Angeles County 442:1-35.

Jefferson, T.A., Myrick, Jr., A.C. and Chivers, S.J. 1994. Small cetacean dissection and sampling: A field guide. U. S. Department of Commerce, NOAA-Technical Memorandum-NMFS-SWFSC-198. 46pp.

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

Lennert, C., Kruse, S., Beeson, M. and Barlow, J. 1994. Estimates of incidental marine mammal bycatch in California gillnet fisheries for July through December, 1990. Rep. int. Whal. Commn (special issue 15):449-61.

Myrick, A. C., Jr., Hohn, A. A., Sloan, P. A., Kimura, M. and Stanley, D. 1983. Estimating age of spotted and spinner dolphins (*Stenella attenuata* and *Stenella longirostris*) from teeth. U. S. Department of Commerce, NOAA-Technical Memorandum-NMFS-SWFC-30, 17p.

National Marine Fisheries Service. 1996. Final List of Fisheries for 1996. Federal Register, Vol. 60, No. 249. December 28, 1995.

Norris, K.S. and J.H. Prescott. 1961. Observations on Pacific cetaceans of Californian and Mexican waters. Univ. Calif. Publ. Zool. 63(4):291-402.

Palumbi, S.R., Martin, A.P., Romero, S., McMillan, W.O., Stice, L. and Grawbowski, G. 1991. The simple fool♠s guide to PCR version 2.0. University of Hawaii, Honolulu. 44pp.

Perrin, W.F., Coe, J.M. and Zweifel, J.R. 1976. Growth and reproduction of the spotted porpoise, *Stenella attenuata*, in the offshore eastern tropical Pacific. Fishery Bulletin 74(2):229-69.

Perrin, W.F. and Myrick, A.C., Jr. 1980. Age determination of toothed whales and sirenians. Rep. int. Whal. Commn, Special Issue 3:48-9.

Perrin, W.F. and Reilly, S.B. 1984. Reproductive parameters of dolphins and small whales of the Family Delphinidae. Rep. int. Whal. Commn, Special Issue 6:97-133.

Read, R.B. 2003a. Effort estimates of California gillnet fisheries: halibut-angel shark set net, shark-swordfish drift net, white seabass-yellowtail set/drift net, for January 1 through March 31, 2003. Report submitted to NOAA Fisheries/National Marine Fisheries Service Southwest Region, 501 West Ocean Blvd., Suite 4200, Long Beach, CA 90802-4213, March 2003 in partial fulfillment of cooperative agreement NA97FX0307.

Read, R.B. 2003b. Effort estimates of California gillnet fisheries: halibut-angel shark set net, shark-swordfish drift net, white seabass-yellowtail set/drift net, for April 1 through June 30, 2003. Report submitted to NOAA Fisheries/National Marine Fisheries Service Southwest Region, 501 West Ocean Blvd., Suite 4200, Long Beach, CA 90802-4213, September 2003 in partial fulfillment of cooperative agreement NA97FX0307.

Rosel, P. E., Dizon, A. E. and Heyning, J. E. 1994. Genetic analysis of sympatric morphotypes of common dolphin (genus *Delphinus*). Marine Biology 119:159-67.

Saiki, R. K., Gelfand, D. H., Stoffle, S., Scharf, S. J., Higuchi, R., Horn, G. T., Mullis, K. B., and Erlich, H. A. 1988. Primer-directed amplification of DNA with a thermostable DNA polymerase. Science 239:487-91.

Table 1. Mortality estimates for the halibut/angel shark set gillnet fishery (8.5-inch mesh) for the period January – June 2003, based on 1991-94 kill rates. There was no observer coverage in this fishery in 2003. Estimated mortality is for the combined strata of 'Southern California', 'Ventura', and 'Channel Islands'. There was no fishing effort in the Monterey and Morro Bay strata in 2003, due to a ban on gillnets inshore of 110 meters. Mortality estimates are based on kill rates from the 1991-94 observer program and an estimated 1,965 days of fishing effort in 2003.

Species	1991-94 Kill per day	Variance of Kill Rate	Estimated Mortality	Mortality Variance	Mortality Standard Error	CV Mortality
Unidentified common dolphin (*Delphinus* sp.)	8.73×10^{-4}	3.89×10^{-7}	2	2	1	0.71
California sea lion (*Zalophus californianus*)	3.49×10^{-1}	6.24×10^{-4}	686	2,409	49	0.07
Harbor seal (*Phoca vitulina*)	9.44×10^{-2}	7.50×10^{-5}	186	290	17	0.09
Northern elephant seal (*Mirounga angustirostris*)	8.13×10^{-3}	3.00×10^{-6}	16	12	3	0.21
Unidentified pinniped	8.00×10^{-3}	8.00×10^{-6}	16	31	6	0.35
Loggerhead sea turtle (*Caretta caretta*)	4.36×10^{-4}	1.75×10^{-7}	1	1	1	0.96
Green/Black sea turtle (*Chelonia mydas*)	8.73×10^{-4}	3.89×10^{-7}	2	2	1	0.71
Leatherback sea turtle (*Dermochelys coriacea*)	4.36×10^{-4}	1.75×10^{-7}	1	1	1	0.96
Unidentified sea turtle	4.36×10^{-4}	1.75×10^{-7}	1	1	1	0.96
Common Murre (*Uria aalge*)	4.36×10^{-4}	1.75×10^{-7}	1	1	1	0.96
Brandt's Cormorant (*Phalacrocorax penicillatus*)	3.05×10^{-2}	4.77×10^{-5}	60	184	14	0.23

Table 2. Mortality estimates for the thresher shark/swordfish drift gillnet fishery (14 to 22-inch mesh) for calendar year 2003. Estimates are based on 20% observer coverage (298 sets observed/1,474 estimated sets fished). Observed mortalities, kill rates, estimated annual mortality for 2003, and associated coefficients of variation (CV) are given.

Species	Observed mortality	Observed kill per day	Estimated mortality	Poisson CV
Short-beaked common dolphin (*Delphinus delphis*)	17	5.70×10^{-2}	84	0.24
Risso's dolphin (*Grampus griseus*)	4	1.34×10^{-2}	20	0.50
Northern right whale dolphin (*Lissodelphis borealis*)	1	3.36×10^{-3}	5	1.00
Short-finned pilot whale (*Globicephala macrorhynchus*)	1	3.36×10^{-3}	5	1.00
California sea lion (*Zalophus californianus*)	3	1.00×10^{-2}	15	0.58
Northern elephant seal (*Mirounga angustirostris*)	1	3.36×10^{-3}	5	1.00

Table 3. The observed incidental kill and number of specimens collected by fishery observers during 2003 are listed by species. All of these species were observed killed in the large-mesh (>14 inch) thresher shark and swordfish driftnet fishery, with the exception of the long-beaked common dolphin (*Delphinus capensis*), which was killed in the small mesh (6.5-inch) drift gillnet fishery for white seabass and yellowtail. 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	**17**	**17**	**17**
Delphinus capensis	**1**	**1**	**1**
Grampus griseus	**4**	**3**	**1**
Globicephala macrorhynchus	**1**	**1**	**0**
Lissodelphis borealis	**1**	**1**	**1**
TOTAL	**24**	**24**	**20**

Table 4. For each species, we present the gender and state of sexual maturity of animals sampled by California drift gillnet fishery observers in 2003. 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), (2) for *Lissodelphis borealis*, > 300 g (Ferrero and Walker, 1993), and (3) for *Grampus griseus*, > 350 g (Perrin and Reilly, 1984). If gonads for a specimen were not available, sexual maturity was "undetermined."

SPECIES	GENDER	SEXUAL MATURITY
Delphinus delphis	**Males**	**Immature (n=1)** **Mature (n=2)** **Undetermined (n=5)**
	Females	**Immature (n=1)** **Mature (n=5)** **Undetermined (n=3)**
Delphinus capensis	**Males**	**Immature (n=1)** **Mature (n=0)**
	Females	**Undetermined (n=0)**
Globicephala macrorhynchus	**Males**	**Undetermined (n=0)**
	Females	**Undetermined (n=1)**
Grampus griseus	**Males**	**Immature (n=1)** **Undetermined (n=2)**
	Females	**Undetermined (n=1)**
Lissodelphis borealis	**Males**	**Undetermined (n=0)**
	Females	**Undetermined (n=1)**

Figure 1. Geographic strata used in the analysis of the halibut/angel shark set gillnet fishery.

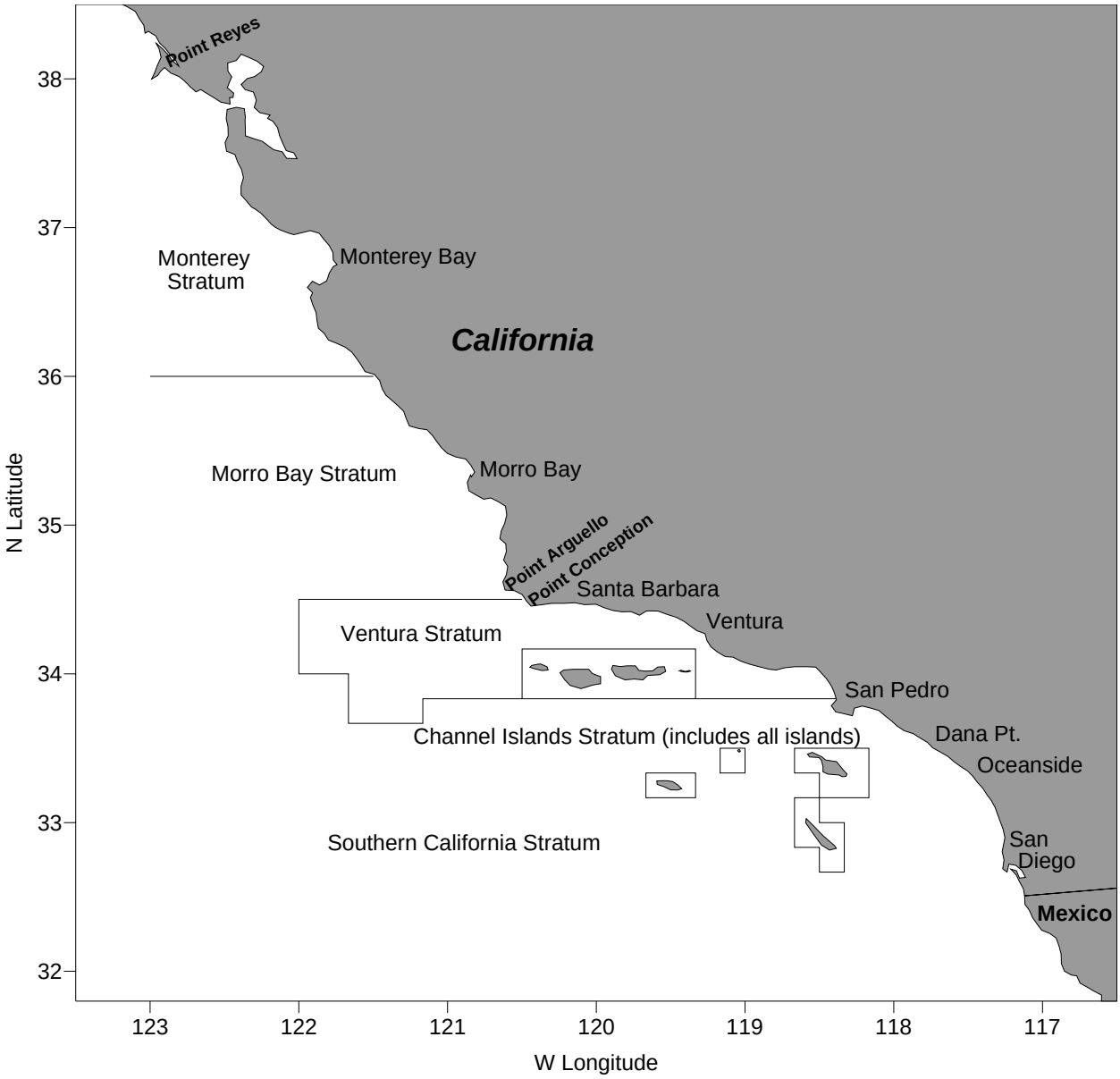


Figure 2. Estimated number of fishing effort days by CDFG block in the halibut/angel shark set gillnet fishery in southern California from January – June 2003. Effort estimates for the remainder of the calendar year were not available at the time of analysis.

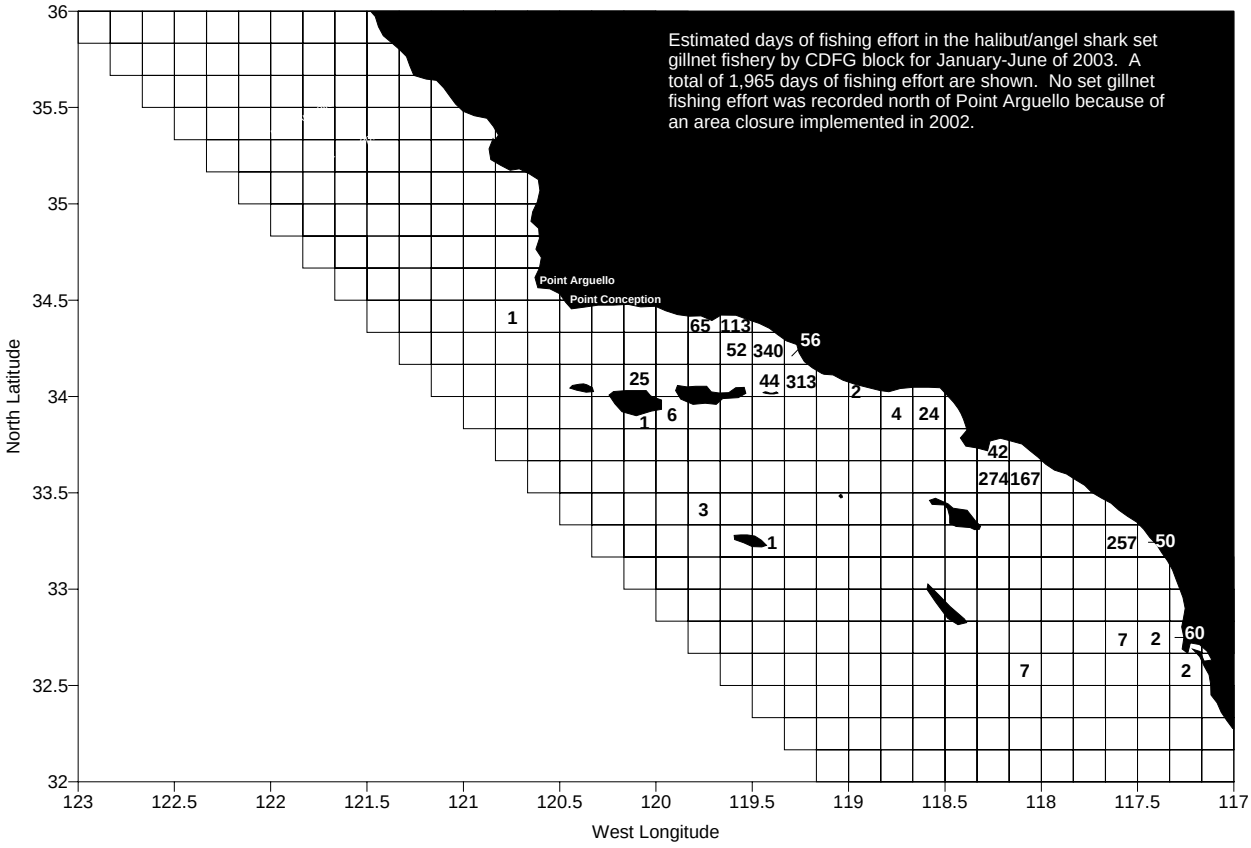
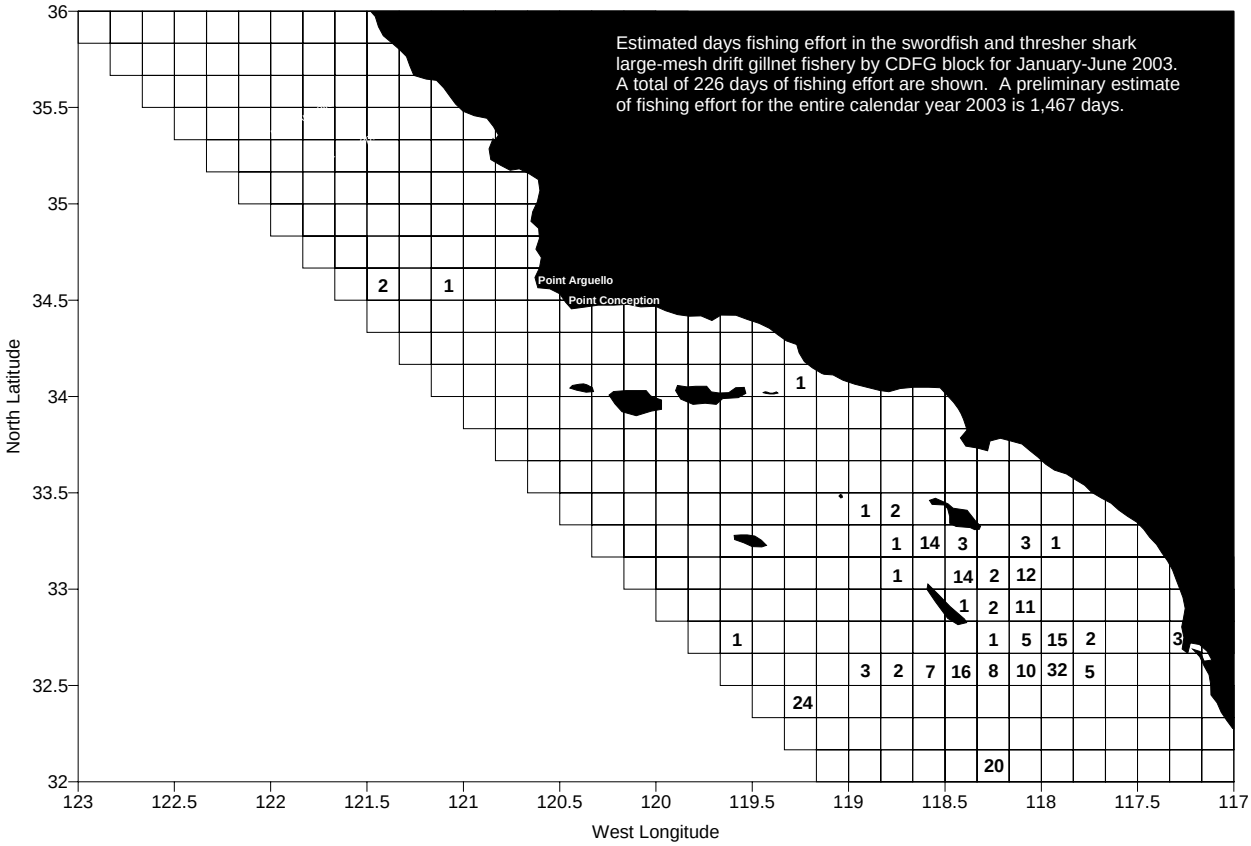


Figure 3. Estimated number of days of fishing effort by CDFG block in the thresher shark/swordfish drift gillnet fishery in southern California waters from January – June 2003. A preliminary total of 1,467 days of fishing effort occurred in this fishery in calendar year 2003. Set locations by CDFG block are shown for 226 sets during the first six months of 2003.



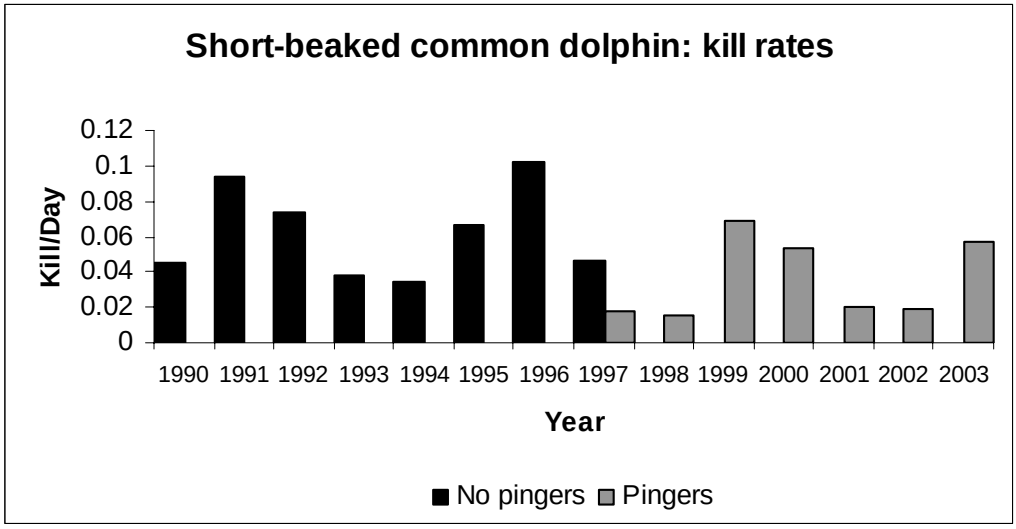


Figure 4. Kill rates of short-beaked common dolphin per day fished in the California drift gillnet fishery for swordfish and thresher shark, 1990-2003. Kill rates include observations from pingered and unpingered sets. Pingers were not used from 1990-95 and were used experimentally in 1996 and 1997. In 1996, no short-beaked common dolphins were observed killed in 146 pingered sets. For the period 1998-2003, over 99% of all observed sets utilized pingers.

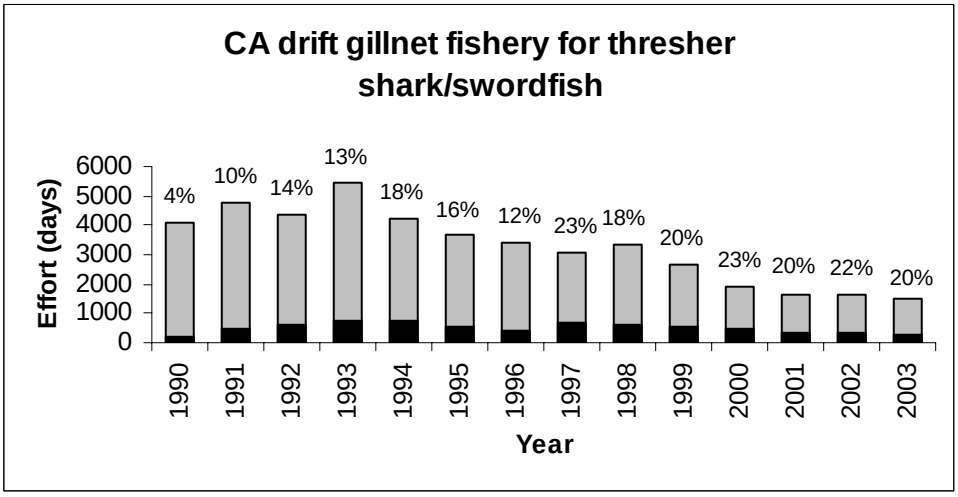


Figure 5. Estimated (gray) and observed (black) days of effort in the California thresher shark and swordfish drift gillnet fishery for 1990-2003. Percent values above bars represent the fraction of observer coverage in the fishery for a given year.