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by

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Marine mammal and seabird bycatch in observed California commercial fisheries in 2007.

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ABSTRACT

Marine mammal and seabird bycatch is reported for two California commercial gillnet fisheries, based on fishery observer data collected in 2007. Estimates of bycatch in the gillnet fisheries are generated using ratio estimation methods. Observations from two California purse seine fisheries are also reported, but no protected species bycatch was observed. A deep-set longline fishery was also observed in 2007 (at 100% observer coverage), 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, 204 sets were observed out of an estimated 1,241 sets fished by all vessels (16.4% observer coverage). Observed bycatch totals were nine short-beaked common dolphins (*Delphinus delphis*), one Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), one northern right whale dolphin (*Lissodelphis borealis*), eight California sea lions (*Zalophus californianus*), and one northern elephant seal (*Mirounga angustirostris*). All marine mammals were dead upon retrieval. Estimated bycatch is 54 (CV = 0.41) short-beaked common dolphins; 6 (CV = 1.00) Pacific white-sided dolphins; 6 (CV = 1.01) northern right whale dolphins; 48 (CV = 0.65) California sea lions; and 6 (CV = 0.94) northern elephant seals.

In the halibut and white seabass set gillnet fishery, 248 sets were observed out of an estimated 1,387 sets fished by all vessels (17.8% observer coverage). Observed bycatch totals were 34 California sea lions, two harbor seals (*Phoca vitulina*), one unidentified pinniped, four Brandt's Cormorants (*Phalacrocorax penicillatus*), and one unidentified cormorant. All animals were dead upon retrieval. Estimated bycatch is 190 (CV = 0.68) California sea lions, 11 (CV = 0.73) harbor seals, 5 (CV = 1.20) unidentified pinnipeds, 22 (CV = 0.56) Brandt's cormorants, and 1 (CV = 1.16) unidentified cormorant.

In the California squid purse seine fishery, 83 sets were observed during 32 fishing trips, with approximately 1.3% observer coverage. In the California anchovy, mackerel, sardine purse seine fishery, 142 sets were observed during 76 fishing trips, with approximately 5% observer coverage. No marine mammal or seabird mortality was observed in either fishery. Photographic evidence from the squid purse seine fishery indicates that vessels in this fishery interact with Ashy Storm Petrels (*Oceanodroma homochroa*), which land on deck after getting disorientated by lights used to attract squid. These storm petrels are occasionally preyed upon by Western Gulls (*Larus occidentalis*) after becoming disoriented. There is currently a petition before the US Fish and Wildlife Service to list the Ashy Storm Petrel as endangered under the Endangered Species Act (ESA).

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. 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 Fisheries

Basic fishery descriptions can be found in marine mammal stock assessments published annually by NMFS (Carretta *et al.* 2007) and in the NMFS 2008 List of Fisheries (Federal Register, 72 FR 66048, November 27, 2007).

The *California/Oregon large mesh drift gillnet fishery for swordfish and thresher shark* 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 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.*, 2004). 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. 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 resulted in the establishment of a seasonal (15 August – 15 November) area closure in central California and southern Oregon waters in 2001 (Figure 1A). An additional season/area closure in southern California is implemented during El Niño periods to protect loggerhead turtles.

The *California set gillnet fishery for halibut and white seabass* is a Category I fishery and has been observed intermittently since 1994. Approximately 30-40 vessels participate in this fishery. This fishery was previously referred to as the 'CA halibut and angel shark set gillnet fishery', but the angel shark has not been a target species in this fishery since 1994, when regulatory changes resulted in nets being fished more than 3 nmi from the mainland in southern California. The fishery once extended to central California, but a 2002 area closure inshore of 60 fathoms (110 m) effectively eliminated the fishery north of Point Arguello. A variety of marine mammal, seabird, and sea turtle

species were documented as bycatch in this fishery in the early 1990s (Julian and Beeson 1998, Forney *et al.* 2001).

The *California anchovy, mackerel, and sardine purse seine fishery* is a Category II fishery, with approximately 60 vessels. A pilot observer program began in 2004 and has continued through 2007, with observer coverage levels less than 5%. Marine mammal interactions with this fishery are largely limited to California sea lions entering and exiting purse seines to feed on aggregated catches. One sea otter was observed released alive in this fishery in 2005.

The *California squid purse seine fishery* is a Category II fishery, with approximately 85 vessels. A pilot observer program began in 2004 and has continued through 2007, with observer coverage levels less than 2%. Historically, the fishery interacted with pilot whales in the 1980s, and recent strandings of Risso's dolphin in 2002 and 2003 were attributed to this fishery (NMFS Southwest Regional Stranding Program, as reported in the stock assessment for this species; Carretta *et al.* 2007). Recent observed mortality or injuries in the squid fishery have included one California sea lion (2004), one unidentified common dolphin (2005), one unidentified dolphin (2006), and several unidentified birds (multiple years), which observer records indicate were probably Western Gulls (*Larus occidentalis*). Most interactions in this fishery involve sea lions jumping into and out of purse seines to feed on aggregated catches.

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 and California Department of Fish and Game logbook data. Annual effort estimates from each source are usually similar, but the larger value is used for the purpose of bycatch estimation. 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. For the halibut and white seabass set gillnet fishery, multiple sets (up to 3) may be made in one day and total fishing effort is estimated directly from the number of sets reported in logbook data. Observer coverage is also estimated as the number of observed sets, divided by the number of estimated sets fished. At the time this report was prepared, logbook data for 2007 were unavailable and fishing effort is estimated to be equal to the number of sets obtained from logbooks in 2006 (1,387 sets).

Purse seine fisheries in California are characterized by multiple sets per day (usually 2-3) over small spatial scales. One fishing trip is equivalent to one day of effort, although some sets may occur prior to midnight and others after. Landing receipts are available for all the purse seine fisheries, and one receipt represents a minimum of one day of effort. Logbook data exist only for the squid purse seine fishery and not for purse seine fisheries targeting sardine, anchovy, mackerel, and tuna. Fishing effort in California purse seine fisheries is reported as the number of days (=trips) fished, based on landing receipt data provided by the CDFG. Observer coverage is estimated as the number of observed trips, divided by the number of logbook trips reported. At the time this report was prepared, logbook and landing data for 2006 and 2007 were unavailable and purse seine fishing effort is estimated from 2005 data.

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 mortality estimates or its coefficients of variation with stratification (Carretta 2001). Yeung (1999) also found that point estimates of 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

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

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 ($\sigma_{\hat{r}_s}^2$), 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. 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 $\sigma_{\hat{r}_s}^2$, is calculated.

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

$$\hat{m}_s = \hat{D} \hat{r}_s, \quad (2)$$

$$\sigma_m^2 = \hat{D}^2 \sigma_r^2 \quad (3)$$

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_r^2 is the bootstrap estimate of the kill rate variance.

RESULTS

Drift gillnet

In 2007, an estimated 1,241 sets were fished and 204 sets were observed from 34 vessel trips, resulting in an observer coverage rate of 16.4% (Table 1, Figures 1A and 1B). In 2007, 40 vessels made at least one set, though only 22 were observed. Eighteen vessels were deemed ‘unobservable’ and reported fishing 326 sets (about 26% of total estimated fishing effort). ‘Unobservable’ vessels are typically smaller vessels that lack berthing space for an observer. Fishing effort has declined from over 5,500 sets in 1993 to 1,241 sets in 2007 (Figure 2). Observed bycatch totals were nine short-beaked common dolphins (*Delphinus delphis*), one Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), one northern right whale dolphin (*Lissodelphis borealis*), eight California sea lions (*Zalophus californianus*), and one northern elephant seal (*Mirounga angustirostris*). All marine mammals were dead upon retrieval. Estimated bycatch is 54 (CV = 0.41)

short-beaked common dolphins; 6 (CV = 1.00) Pacific white-sided dolphins; 6 (CV = 1.01) northern right whale dolphins; 48 (CV = 0.65) California sea lions; and 6 (CV = 0.94) northern elephant seals (Table 2).

Set gillnet

Two hundred forty-eight sets were observed (Figure 3) in calendar year 2007 out of an estimated 1,387 sets fished, resulting in an observer coverage level of 17.8%. Observed bycatch totals were 34 California sea lions, two harbor seals (*Phoca vitulina*), one unidentified pinniped, four Brandt's Cormorants (*Phalacrocorax penicillatus*), and one unidentified cormorant (*Phalacrocorax sp.*) (Figure 4). All animals were dead upon retrieval. Estimated bycatch is 190 (CV = 0.68) California sea lions, 11 (CV = 0.73) harbor seals, 5 (CV = 1.20) unidentified pinnipeds, 22 (CV = 0.56) Brandt's Cormorants, and 1 (CV = 1.16) unidentified cormorant (Table 3). Fishing effort peaked at over 7,000 sets in 1991 (Julian and Beeson 1998) and has declined to fewer than 2,000 sets by approximately 30 vessels in recent years (Figure 5).

Purse seine

In the squid purse seine fishery, 83 sets were observed during 32 fishing trips in 2007. Based on 2005 logbook data, estimated fishing effort in 2007 was 2,448 trips, and therefore observer coverage is estimated at 1.3%. No marine mammals, sea turtles, or seabirds were observed as bycatch in this fishery, though there were interactions with 49 California sea lions and 40 unidentified birds.

In the anchovy, sardine, and mackerel purse seine fishery, 142 sets were observed during 76 fishing trips in 2007. Based on 2006 logbook data, estimated fishing effort in 2007 was 1,510 trips, and therefore, observer coverage is estimated at 5%. No marine mammals, sea turtles, or seabirds were observed as bycatch in this fishery, though there were interactions with 91 California sea lions, three Brown Pelicans (*Pelecanus occidentalis*), and one unidentified bird.

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 6). Entanglement rates of California sea lions have been higher in the years following the use of pingers (Figure 7). Barlow and Cameron (2003) reported a statistically significant *decline* in sea lion entanglement rates in nets with 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 (the "dinner bell" effect). Since 1998, sea lion entanglement rates (94 entangled in 3,455 sets = 2.7 per 100 sets) have more than doubled, compared with entanglement rates observed prior to pinger use during 1990-95 (35 entangled in 3,303 sets = 1.0 per 100 sets). 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. In contrast, since pingers were introduced, cetacean entanglement rates have declined by approximately 50% and observations of beaked whale bycatch have been nonexistent (Carretta *et al.* 2008).

California sea lions and harbor seals were killed at low levels relative to their respective PBR levels (~8,500 for sea lions and ~1,900 for harbor seals) in the halibut and white seabass set gillnet fishery in 2007. This was the first year since 1994 that the fishery was observed at adequate levels,

so additional data will be required to determine what impacts the fishery may continue to have on these species.

Marine mammal and seabird interactions that result in the death or injury of the animal appear to be rare events in coastal purse seine fisheries in California.

ACKNOWLEDGMENTS

Thanks to Rand Rasmussen for maintaining the fishery observer database. Amy Betcher, Al Coan, and John Childers provided logbook data used to estimate set gillnet fishing effort. Scott Casey at Frank Orth and Associates provided vital information on fishing effort in the large mesh drift gillnet fishery. We thank Jay Barlow, Karin Forney, and Bill Perrin for their comments on the manuscript. This work could not have been done without the diligent work of NMFS biological observers and the cooperation of the California commercial fishermen.

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Table 1. Fishery observer and fishing effort summaries for calendar year 2007 for fisheries summarized in this report.

Fishery	MMPA Fishery Category	Approximate number of active vessels	Estimated Number sets/trips fished	Observed sets/trips fished	Observer Coverage Rate	Observed Species Interactions (number killed or injured)
CA/OR swordfish and thresher shark large-mesh drift gillnet	Category I	40 (22 observed)	1,241 sets ^a	204 sets	16.4% (sets)	Common dolphin, short-beaked (9) Northern right whale dolphin (1) Pacific white-sided dolphin (1) CA sea lion (8) Northern elephant seal (1)
CA halibut and white seabass set gillnet	Category I	58	1,387 sets ^b	248 sets	17.8% (sets)	CA sea lion (34) Harbor seal (2) Unidentified pinniped (1) Brandt's Cormorant (4) Unidentified cormorant (1)
CA market squid purse seine fishery	Category II	84	2,448 trips ^c	32 trips, 83 sets,	1.3% (trips)	none
CA anchovy, mackerel, and sardine purse seine fishery	Category II	61	1,510 trips ^c	76 trips, 142 sets	5% (trips)	none

Table 2. Summary of observed bycatch, rates, estimates and statistical precision for the California swordfish drift gillnet fishery in 2007.

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	9	0.044	3.1×10^{-4}	54	0.41
Pacific white-sided dolphin	1	0.005	2.4×10^{-5}	6	1.00
Northern right whale dolphin	1	0.005	2.4×10^{-5}	6	1.01
California sea lion	8	0.039	6.4×10^{-4}	48	0.65
Northern elephant seal	1	0.005	2.0×10^{-5}	6	0.94

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

b Fishing effort estimated from calendar year 2006 logbook data.

c Effort is based on 2005 logbook and/or landing receipt data. 2006 and 2007 data were not available at the time this report was prepared.

Table 3. Summary of observed bycatch, rates, estimates, and statistical precision for the CA halibut and white seabass set gillnet fishery in 2007. Bycatch rates and estimates are based on 2007 observer data and 2006 logbook effort.

Fishery and Species	Observed Bycatch	Bycatch per Set	Bycatch per Set Variance	Bycatch Estimate	Bycatch Estimate CV
CA angel shark halibut and white seabass set gillnet					
California sea lion	34	0.14	8.7×10^{-3}	190	0.68
Harbor seal	2	0.008	3.4×10^{-5}	11	0.73
Unidentified pinniped	1	0.004	1.87×10^{-5}	5	1.20
Brandt's Cormorant	4	0.016	7.9×10^{-5}	22	0.56
Unidentified cormorant	1	0.004	1.75×10^{-5}	5	1.16

Figure 1. Locations of observed fishing sets and entangled marine mammals in the large mesh swordfish drift gillnet fishery in 2007. The number of entanglement locations shown are less than those reported in the text due to multi-animal entanglements of common dolphin and sea lions in single sets. Key: ZC = California sea lion; MA = northern elephant seal; DD = unidentified common dolphin; DS = short-beaked common dolphin; LO = Pacific white-sided dolphin, LB = northern right whale dolphin. All animals died except the loggerhead sea turtle, which was released alive. The dashed region in 1A indicates a seasonal area closure where drift gillnet fishing is prohibited between 15 August – 15 November annually.

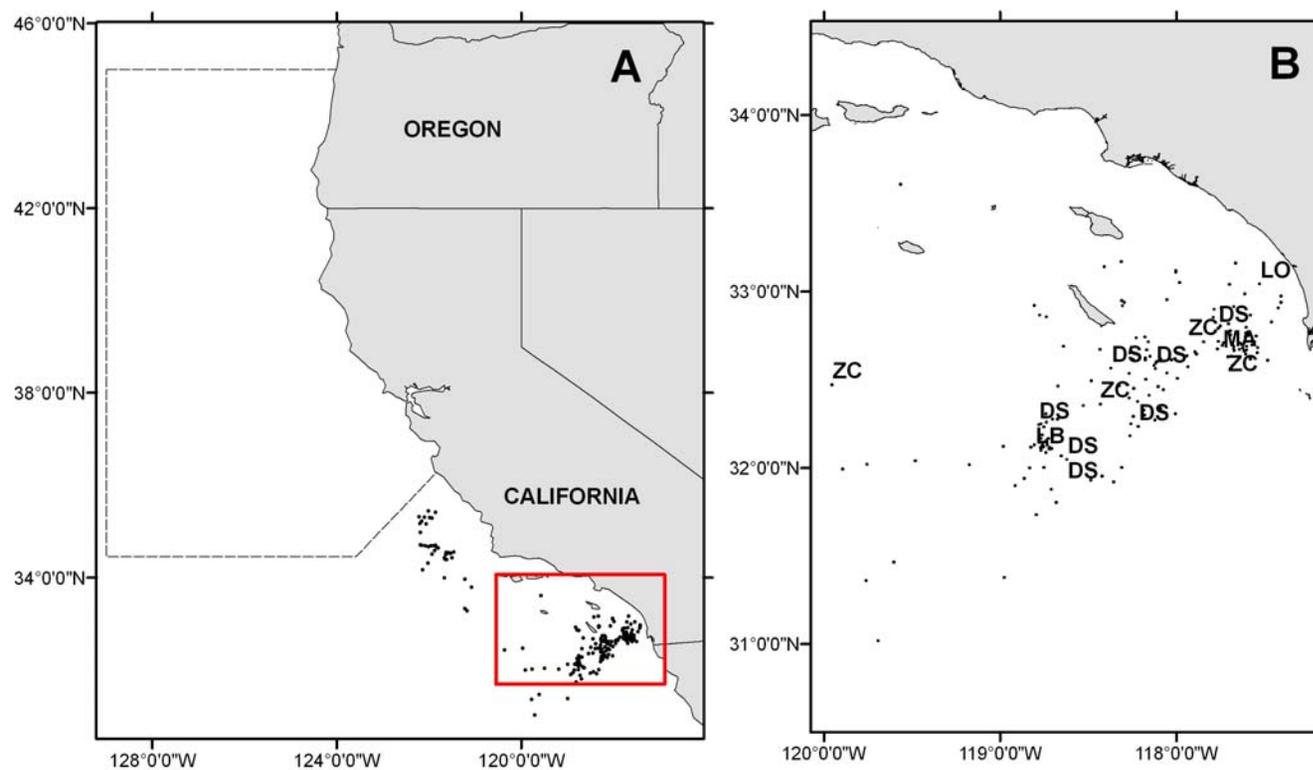


Figure 2. Estimated (gray) and observed (black) days of effort in the California swordfish and thresher shark drift gillnet fishery for 1990-2007. Percent values above bars represent the fraction of observer coverage in the fishery for a given year.

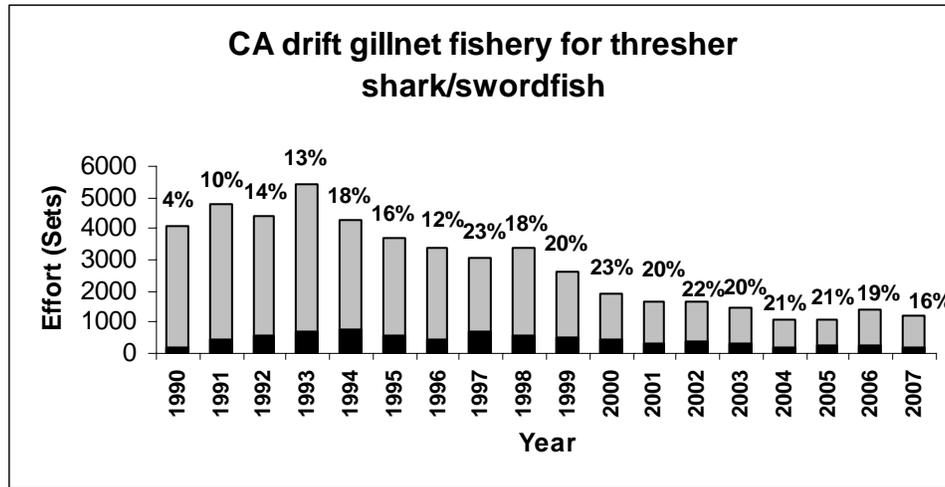


Figure 3. Locations of observed fishing sets (n=248) in 2007 in the halibut and white seabass set gillnet fishery.

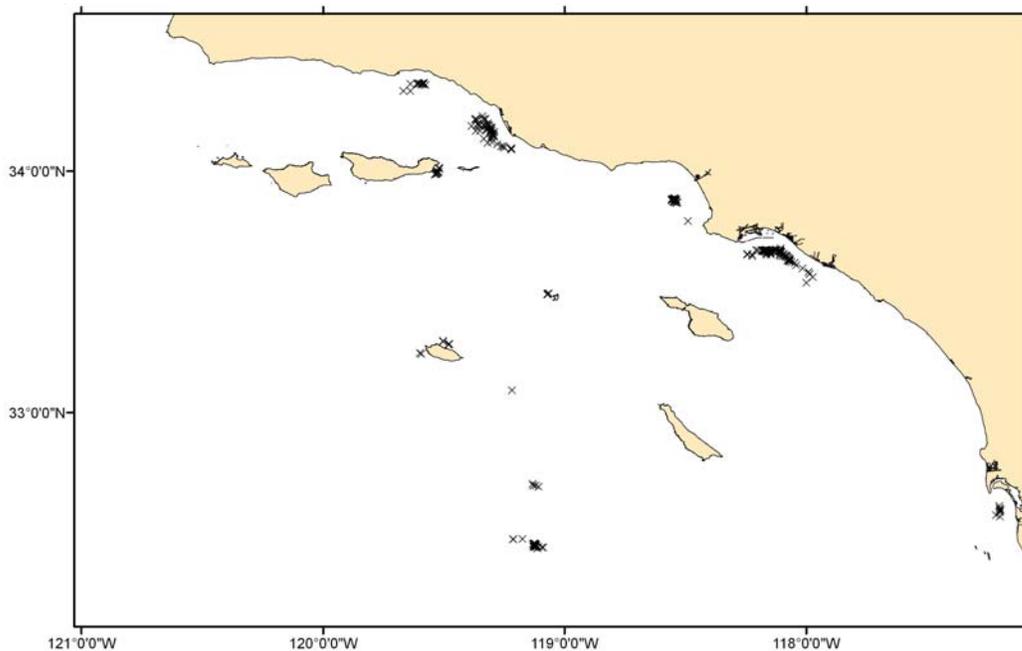


Figure 4. Locations of marine mammal and seabird bycatch in the halibut and white seabass set gillnet fishery, 2007. Species key: ZC = California sea lion, PV = harbor seal, PU = unidentified pinniped, pPN = Brandt's Cormorant, pSP = unidentified cormorant. The number of entanglement locations shown are less than those reported in the text due to multi-animal entanglements in single sets.

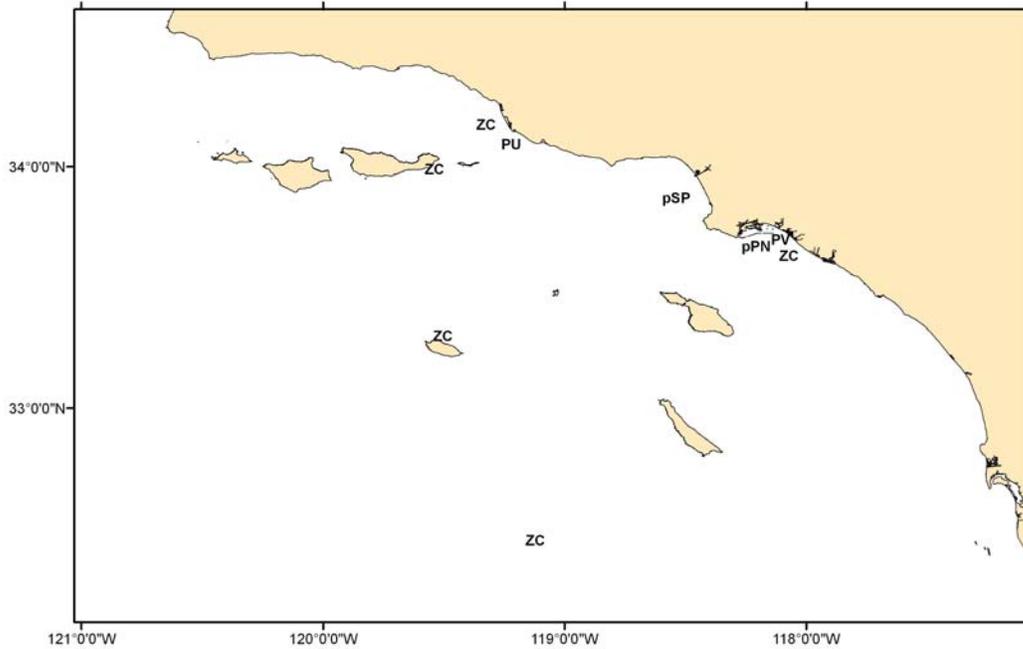
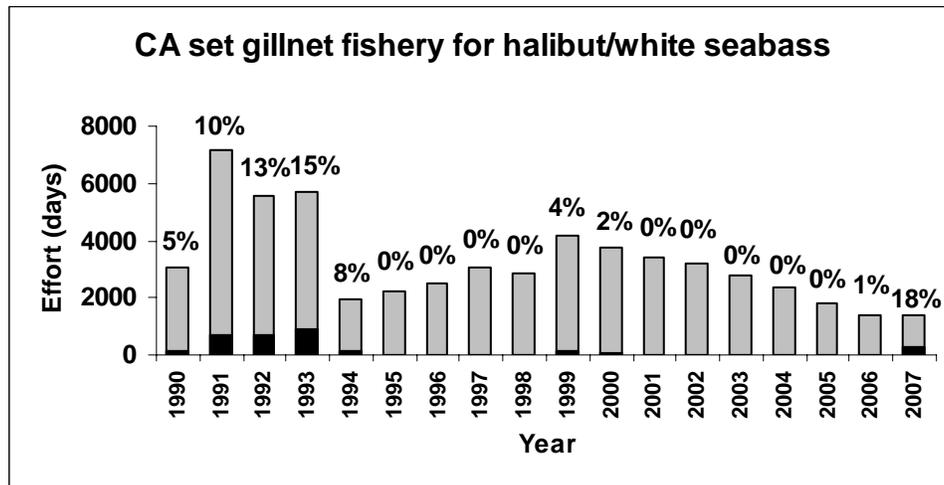


Figure 5. Estimated (gray) and observed (black) days of effort in the California halibut/white seabass set gillnet fishery for 1990-2007. Estimated fishing effort in 2007 is based on 2006 logbook data. Percent values above bars represent the fraction of observer coverage in the fishery for a given year.



Short-Beaked Common Dolphin Entanglement Rates

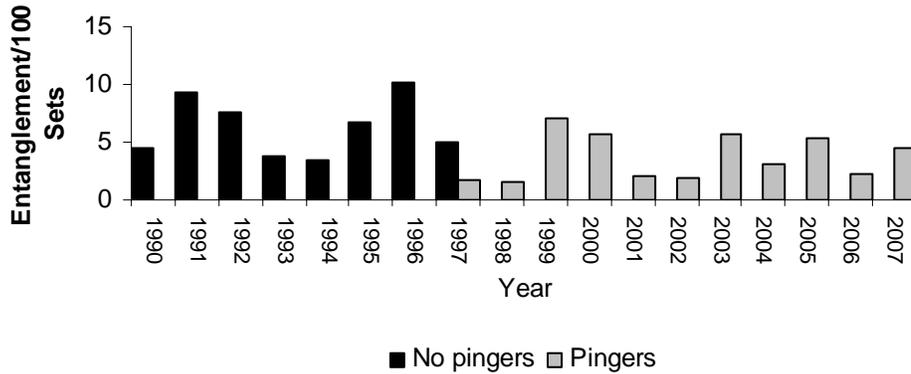


Figure 6. Entanglement rates of short-beaked common dolphin per set fished in the California swordfish drift gillnet fishery, 1990-2007. Pingers were not used from 1990-95 and were used experimentally in 1996 and 1997. In 1996, no short-beaked common dolphins were observed killed in 146 pingered sets. For the period 1998-2007, over 99% of all observed sets utilized pingers.

CA Sea Lion Entanglement Rates

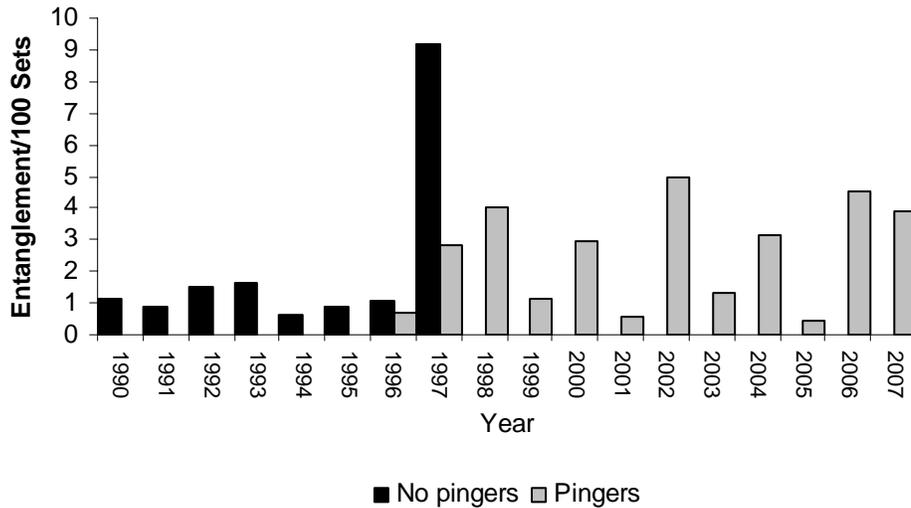


Figure 7. Entanglement rates of California sea lions per set fished in the California drift gillnet fishery for swordfish and thresher shark, 1990-2007. Pingers were not used from 1990-95 and were used experimentally in 1996 and 1997. For the period 1998-2007, over 99% of all observed sets utilized pingers.