Preliminary Estimates of Cetacean Mortality in the California Gillnet Fisheries for 1997 and 1998.

(International Whaling Commission Working Paper)

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ABSTRACT

Non-fish bycatch is estimated for two California gillnet fisheries, the swordfish/shark drift-net fishery and the halibut/angel shark set-net fishery, for the calendar years 1997 and 1998. These estimates are based on observations made by biological technicians placed aboard commercial fishing vessels as part of a National Marine Fisheries Service (NMFS) Observer Program and estimates of days of fishing effort provided by the California Department of Fish and Game (CDFG). In the drift-net fishery the sampling unit is a multi-day "trip", hence a ratio estimator is used with days per trip as the auxiliary variable to obtain an analytical variance estimator. Estimation procedures for 1997 differ from those used in previous years due to the completion of an experiment to test the effectiveness of acoustic warning devices (pingers). Estimated mortality and observed mortality (in parentheses) in the drift gillnet fishery included 209 (41) cetaceans, 246 (44) pinnipeds and 13 (3) turtles in 1997 and 54 (11) cetaceans, 144 (29) pinnipeds and 5 (1) turtles in 1998. Drift gillnet mortality in pingered nets in 1997 and 1998 was considerably lower than mortality in unpingered nets in previous years. The set-net fishery has not been observed since July 1994. Therefore, mean per unit estimators with fishing day as the sampling unit were used to estimate 1997 and 1998 mortality based on data from the July 1990 - July 1994 observer program. Estimates were made separately within each of six geographical strata, including an additional stratification for central California, and combined to provide total mortality estimates. Set gillnet mortality was estimated to be higher in 1997-98 than in 1994-96, due primarily to increased fishing effort.

INTRODUCTION

Mortality estimates for the California swordfish/shark drift-net fishery and the halibut/angel shark set-net fishery are used to monitor the magnitude of marine mammal/fishery interaction and to assist in fishery management. Barlow et al. (1994), Lennert et al. (1994), and Julian and Beeson (1998) described these two gillnet fisheries and showed that they caused enough marine mammal mortality to be classified as Category I fisheries under the U. S. Marine Mammal Protection Act (MMPA). A National Marine Fisheries Service (NMFS) observer program was implemented in July of 1990 whereby observers were placed on board fishing vessels to record catch, bycatch and other gear and environment variables. Observation of the set-net fishery was discontinued in July of 1994, because total fishing effort had declined and bycatch of marine mammal species was below the maximum level allowed under the MMPA, while the drift-net fishery continues to be observed. In this paper we present cetacean, pinniped, turtle and seabird mortality estimates for both fisheries for the years 1997 and 1998, as well as information on catch of target and non-target fish species.

Efforts to reduce cetacean mortality in the drift-net fishery included an experiment to test the effectiveness of acoustic deterrent devices for reducing cetacean entanglement. The experiment started in August of 1996 and was continued until October 28, 1997, the day pingers became mandatory in that fishery. Preliminary analyses of the experimental data show a dramatic reduction in mortality for the most commonly entangled species, short-beaked common dolphin (*Delphinus delphis*), northern elephant seal (*Mirounga angustirostris*) and California sea lion (*Zalophus californianus*) (Barlow and Cameron 1999 SC/51/SM2). Experiments using pingers conducted in fisheries where there was frequent harbor porpoise *(Phocoena phocoena)* entanglement (Gearin et al. 1996; Kraus et al. 1995, 1997; Larsen 1997) achieved similar results.

The completion of the pinger experiment on October 28 poses a problem for 1997 mortality estimation in the drift-net fishery. Prior to October 1997, virtually all sets with pingers were observed as either part of the pinger experiment or because observers brought pingers with them. During the month of October, it is likely that there was an increase in the number of unobserved sets with pingers as fishers prepared for the new regulation requiring mandatory pinger use effective October 28. For the drift-net fishery, the analysis estimates mortality separately (using ratio estimation) for each period (Jan 1 - Oct 27 and Oct 28 - Dec 31) based on estimates of fishing effort which will be described below.

In the California halibut/angel shark set-net fishery estimates of mortality are highly uncertain because the fishery has not been observed since July of 1994. In addition, shifts in the location of fishing effort within central California have led to concerns about a possible increase in harbor porpoise mortality which may not be captured by previous methods of estimation (Forney et al., in review). These concerns have resulted in the reinstatement of the observer program effective April 1999. Mortality estimation methods used in this paper for 1997 and 1998 differ from those used in previous years by including a new stratification of the central California region into 2 strata: Morro Bay and Monterey Bay. Stratification by quarter for the southern California and Ventura strata was discontinued in the 1998 analyses due to a lack of fishing effort data by quarter.

METHODS

Fishing Effort Estimation

As in previous years, NMFS has received effort estimates from the California Department of Fish and Game (CDFG) stratified by fishing block (Beeson 1996a,b; 1997a,b). Effort is measured in effort-days, defined as one day of fishing for one vessel. One set comprises an effort-day in the drift-net fishery (1997-1998 average net length: 1728 m, SD=180 m; 945 fm, SD=98 fm) and, historically, three sets constitute an effort-day in the set-net fishery (1990-1994 average net length: 477 m, SD=173.4 m; 261 fm, SD=94.8 fm). CDFG combines fishing vessel logs, NMFS observer data, and sales receipts of landed fish to assign effort to a particular fishery, CDFG fishing block (typically 10' squares) and (in previous years) calendar quarter (Julian and

Beeson 1998). Effort targeting halibut and angel shark with mesh size of at least 21.6 cm (8.5") was reported for the set-net fishery, whereas effort targeting swordfish and shark with stretched mesh size of approximately 51 cm (20") was reported for the drift-net fishery. Sources of variation in calculating estimates of total effort were previously examined (Julian 1994). Because these variations are nominal and calculating direction and magnitude of their biases is intractable using current data collection procedures, estimates of effort were assumed to be accurate.

In contrast to previous years, quarterly data were not available for 1998 and were available only for the second half of 1997. To estimate 1997 effort by block for quarters 3 and 4 in the set-net fishery, the difference of the calendar year total (3,092) and the sum of quarters 1 and 2 (1,128 + 968) was apportioned to quarters 3 and 4 using the proportion of effort in quarters 3 and 4 of 1996. Effort for 1996 was thought to be a better predictor of 1997 effort than an average of past years, due to trends in relative effort among the strata observed from 1990-1996. Effort for 1998 was not prorated to calendar quarter.

In the drift-net fishery, 1997 effort estimates for calendar quarters 1 and 2 (379 effort days) were assigned to the experimental period (Jan 1 - Oct 27). Total effort for the remainder of the year was calculated as the difference between total 1997 effort and the sum of quarter 1 and 2 effort (3,039 - 379 = 2,660 effort days) and was apportioned to either the experimental period or mandatory period (Oct 28 - Dec 31) based on the proportion of observed sets between July 1 and December 31 that fell within each period. This method results in a total of 1,798 estimated sets (1,626 without pingers and 172 with pingers) during the experimental period and 1,241 sets during the mandatory period. Because of inconsistencies in protocol, 27 experimental sets that were not pingered during the mandatory period were considered as part of the experimental unpingered effort. Conversely, 16 experimental sets that used pingers after October 27, 1997 were included as part of the experimental pingered effort. This yielded the following three strata:

1. Experimental period, 172 + 16 = 188 pingered effort days. All effort was observed, thus the total mortality for this stratum equals the observed mortality.
2. Experimental period, 1,626 + 27 = 1,653 unpingered effort days.
3. Mandatory period, 1,241 - 16 - 27 = 1,198 pingered effort days.

Effort for 1998 was available only for the entire year, and no further stratification was applied.

Analytical Methods

1997 Drift-net Mortality Estimates

Mortality estimates for the drift-net fishery in 1997 were calculated for all cetacean species for which kill was observed during 1997. Estimates were calculated using a ratio estimator as done for previous years (Julian 1994; Julian and Beeson 1998). However, in order to calculate mortality estimates for 1997, separate estimates were produced for the periods January 1 - October 27 and October 28 - December 31 and then combined using the combined ratio estimate (Cochran 1977 p. 165). Mortality estimates for the first period were calculated as the sum of mortality observed when pingers were used and estimated mortality for the sets not using pingers (as in Julian 1997). Experimental sets without pingers that took place during the mandatory period were also included in the mortality rate estimate for the experimental period. Hence, this estimate was based on 263 sets of an estimated 1,653 sets (17.0%). The analysis assumes that unobserved fishing effort during this period did not use pingers. During October there were 83 sets that were not part of the pinger experiment. Of these 83 sets, 16 (19.3%) used pingers. The fraction of sets for which pingers were used by the fishing fleet is likely to be less than 19% because pingers were often supplied by the observers on board. Presumably, as the date of mandatory compliance approached, however, a greater fraction of skippers had purchased and were beginning to use pingers. Since there is little reliable information regarding unobserved sets, we assume that no pingers were used on unobserved vessels until the date of mandatory compliance. If this assumption is greatly violated, the estimates will overestimate mortality for most species because experimental results suggest that pingers reduce cetacean bycatch (Kraus 1997, Barlow and Cameron 1999 SC/51/SM2). For the period October 28 - December 31, we assumed that the 241 observed sets for this period (20.0% of an estimated 1,198 sets) were a representative sample of the fishery. Based on the observer data, pinger compliance (using at least 1 pinger) in November and December was 77% and 90% respectively whereas full pinger compliance (using at least 41 pingers) was only 9% and 13%. On average, only 27 pingers were employed on each net during the mandatory period, with a significant increasing trend from November (25 pingers) to December (30 pingers). It is likely that pinger compliance for unobserved sets is less than for observed sets; hence, the estimated rate of mortality for the mandatory period will likely underestimate the true mortality.

1998 Drift-net Mortality Estimates

For the calendar year 1998, pinger use was mandatory. The calculation of mortality estimates in this analysis does not account for different levels of pinger use during each trip, rather it is assumed that the random sample of observed trips is a representative sample of all vessel trips. Ratio estimators were calculated as in previous years (Julian 1994; Julian 1997; Julian and Beeson 1998)

1997 and 1998 Set-net Mortality Estimates

The geographical strata used in previous analyses have been modified for the 1997 and 1998 mortality estimates by breaking up the central California stratum into 2 regions; Monterey Bay (CDFG blocks 101-499,500-538) and Morro Bay (CDFG blocks 539-650). Justification for the stratification is based on the significant difference between entanglement rates (entanglements per net pull) for harbor porpoise in Morro Bay and Monterey Bay found using an analysis of variance model (ANOVA) of the form $\log(n+1) = \mu + \beta_i x_i + \varepsilon$, where n, is the number of observed entanglements, μ is the model mean, β_i are the coefficients for stratum x_i, and ε is a random error term. (See Forney et al. 1999, Lennert et al. 1994). The additional stratification may not be necessary for some other species, such as pinnipeds. In such cases, the resulting mortality estimates are expected to be less precise, but not biased as a result of the stratification.

Mortality estimates were calculated as for previous years (Julian 1994; Julian 1997; Julian and Beeson 1998) based on observations during the period 1 July 1990 through 31 July 1994. For 1997, mortality rates are stratified by area and for southern California and Ventura by calendar quarter, and combined to arrive at total mortality estimates. For 1998, rates and mortality were not stratified by quarter because quarterly effort estimates were not available. Estimates were calculated for harbor porpoise, California sea lion, harbor seal (*Phoca vitulina*), northern elephant seal, Common Murre (*Uria aalge*), Brandt’s Cormorant *(Phalacrocorax penicillatus)*, and unidentified cormorant *(Phalacrocorax sp.)*.

RESULTS

Drift-net Fishery, 1997 and 1998

In 1997, 692 sets (118 trips) out of an estimated 3,039 sets (1 set = 1 effort-day) were observed for a coverage rate of 23%. In 1998, 587 sets (116 trips) out of an estimated 2,907 sets were observed for a coverage rate of 20%. More than one-half of the observed sets in the drift-net fishery for both years occurred south of San Pedro with the bulk of the remaining sets occurring off of Monterey Bay and the San Francisco area in 1997, and between Monterey Bay and Morro Bay in 1998 (Figures 1 and 2). The geographic distribution of observed entanglements appears to match the distribution of observed sets (Figures 3 and 4). In 1997, 36 nets with cetacean entanglement contained 42 cetaceans, and in 1998, there were 11 nets with cetacean entanglement (one animal in each). Methods of species identification are reported in Henshaw et al. (1998, SC/50/SM5) and Chivers et al. (1999, SC/51/SM6). Table 1 summarizes observed entanglements for these species, stratified by month for both years. Observed catch/bycatch of other selected species is also included.

Estimated mortality of marine mammals (Tables 2 and 3) for the calendar year 1997 (with coefficient of variation and number observed entanglements in parentheses) is: 25 (0.74, 4) long-beaked common dolphins (*Delphinus capensis*), 101 (0.31, 20) short-beaked common dolphins, 5 (0.96, 1) unidentified common dolphins, 29 (0.42, 5) northern right whale dolphins (*Lissodelphis borealis*), 12 (0.69, 3) Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), 11 (0.96, 3) Risso’s dolphins (*Grampus griseus*), 20 (0.95, 4) Dall's porpoise (*Phocoenoides dalli*), 6 (0.96, 1) short-finned pilot whales (*Globicephala macrorhynchus*), 45 (0.33, 8) northern elephant seals, 201 (0.34, 36) California sea lions, 7 (0.95, 2) leatherback turtles (*Dermochelys coriacea*) and 6 (0.95, 1) loggerhead turtles (*Caretta caretta*). For the calendar year 1998 estimated cetacean mortality is: 45 (0.32, 9) short-beaked common dolphins, 5 (0.90, 1) gray whales (*Eschrichtius robustus*), and 5 (0.89, 1) sperm whales (*Physeter macrocephalus*). Estimated mortality of pinnipeds and turtles is: 20 (0.44, 4) northern elephant seals, 114 (0.23, 23) California sea lions, and 5 (0.89, 1) loggerhead turtles.

In addition to these mortalities, a number of animals were entangled and released alive in the driftnet fishery in 1997: 1 short-beaked common dolphin (injured), 1 northern elephant seal (injured), 3 California sea lions (1 injured, 2 alive), 2 leatherback turtles (alive) and 2 loggerhead turtles (alive). Three loggerhead turtles were entangled and released alive in 1998.

Set-net Fishery, 1997 and 1998

This fishery was not observed in either 1997 or 1998. CDFG estimates a total of 3,092 and 2,818 days of fishing effort in 1997 and 1998 respectively. The distribution of overall set-net effort for the first two quarters of 1997 and total effort for the calendar year 1997 were obtained from CDFG. Effort distribution for quarters 1 and 2 provided by CDFG and apportioned effort for quarters 3 and 4 are plotted in Figure 5, while effort distribution for 1998 is plotted in Figure 6. Since January 1 1995, California law requires gillnet fishing to be outside of 3 miles from shore for latitudes south of Pt. Arguello (approximately 34^{B}36’N). Consequently, effort (and any marine mammal mortality) for this fishery took place further offshore in areas where this legal restriction was imposed. Major areas of activity include: Monterey Bay, Ventura, San Pedro, Oceanside, and San Diego.

For this fishery, four years of past observations, from July 1990 - July 1994, indicate that the only cetacean species consistently entangled in this fishery was the harbor porpoise.

Although two unidentified common dolphin and one unidentified cetacean were entangled in 1992, mortality estimates are not provided for these species because they are not consistently entangled. Mortality estimates were determined for harbor porpoise, pinnipeds, and seabirds.

During 1997, estimated mortalities (with coefficients of variation in parentheses) are: 53 (0.27) harbor porpoise, 1,206 (0.06) California sea lions, 60 (0.24) northern elephant seals, 349 (0.08) harbor seals, 2,563 (0.16) Common Murre, 79 (0.11) Brandt's Cormorants, and 52 (0.36) unidentified cormorants. Estimated mortalities for 1998 are: 38 (0.27) harbor porpoise, 1,228 (0.07) California sea lions, 70 (0.26) northern elephant seals, 392 (0.10) harbor seals, 1,882 (0.16) Common Murre, 78 (0.25) Brandt's Cormorants, and 70 (0.51) unidentified cormorants (Tables 4 and 5).

DISCUSSION

Drift-Net Fishery

The termination of the pinger experiment on October 28, 1997 resulted in two separate patterns of fishing practice for unobserved sets for the two periods split by this date. Hence, the 1997 data were post-stratified and two separate estimates of mortality were calculated for each period and combined to produce a total mortality estimate using standard procedures. The mortality estimate for the experimental period may overestimate the true mortality due to the use of pingers on unobserved sets in October 1997, prior to the mandatory date. However, the mortality estimate for the mandatory period will underestimate the true mortality for this period if pinger use for unobserved sets is less than for observed sets. We believe that pinger use will be less for unobserved sets because the data shows that the number of pingers used for experimental sets (when pingers were used) is significantly greater than the number used for non-experimental sets during the mandatory period. Mortality estimates for 1997 presented here are generally higher than those presented to the International Whaling Commission in the spring of 1998 (Cameron 1998) due to a submission of additional records documenting approximately 400 effort days. Bias may be introduced into the 1998 mortality estimates if pinger use on unobserved sets differs from the observed sets. For example, fishers may attach fewer pingers during rough weather when not observed.

Overall cetacean mortality appears to have decreased in the drift gillnet fishery compared to previous years. There were 418 estimated cetacean mortalities during 1996, 209 during1997 and only 54 during 1998. However, preliminary data for early 1999 indicate a greater number of entanglements (11 in January alone) than in 1997-98, and future studies will investigate causes of this increase.

Set-Net Fishery

Previous estimates of mortality in this fishery used current year observer data. However, since 1995, mortality estimates have been based on observer data from July 1990 through July 1994 due to the discontinuation of the observer program. Mortality estimates for 1997 (Table 3), therefore, reflect the product of mean-per-unit estimates based on observed mortality from 1990 - 1994 and fishing effort for 1997 and 1998 supplied by CDFG (with quarterly effort available only for the first half of 1997). Considering the incomplete effort estimates and the lack of observer data for the past two years, mortality estimates for this fishery should be treated with caution. Changes in effort, both seasonal and geographical, within a stratum or changes in species density can bias estimates of mortality. Since 1994 effort has shifted from the Morro Bay area to the Monterey Bay area. Within Monterey Bay, effort has shifted south along the bay into areas that showed very high entanglement rates of harbor porpoise in the late 1980's. For this reason, the harbor porpoise mortality estimate presented here may underestimate true mortality.

A more complete discussion of these potential sources of bias can be found in Forney et al. (1999).

The 1997 mortality estimates presented here are generally higher than those presented to the International Whaling Commission (IWC) in the spring of 1998 (Cameron 1998). Since neither total calendar year effort (that included logbook, landing and observer data) by CDFG block nor effort by block for quarters 3 and 4 was available at that time, effort data from 1994 - 1996 was averaged to apportion corrected total effort for quarters 3 and 4 to blocks. In contrast, estimates presented here used the recently available CDFG estimate of total 1997 calendar year effort, and apportioned the difference of the calendar year effort and the sum of 1997 quarters 1 and 2 effort to individual blocks based on 1996 quarters 3 and 4 effort. This change in allocation of estimated effort results in higher estimated mortality for most species even though total estimated effort (3,092) is less than the effort used in the spring IWC report (3,215). For species that are most abundant in central California, such as harbor porpoise and Common Murre, this is primarily due to an underestimation of effort in the Monterey Bay area using the earlier methods.

The 1998 estimates of mortality were not stratified by quarter as for previous years. Comparison of mortality estimates for the most commonly entangled species shows nominal changes in the mortality estimates across years and methods of analysis (Table 6). In general, however, it is expected that mortality estimates separating Monterey Bay and Morro Bay will be more accurate than unstratified estimates (Forney et al. 1999), because the geographical distribution of effort in this fishery varies between years and differences in entanglement rates appear to exist between these two central California regions for at least some species.

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Table 1. Observed cetacean, pinniped, turtle and bird entanglements (mortalities and injuries) stratified by species and month for the drift gillnet fishery for calendar years 1997 and 1998. Observed catch of selected target and non-target fish is included.

	1997							1998						
Month	Jan	Aug	Sep	Oct	Nov	Dec	Total	Jan	Aug	Sep	Oct	Nov	Dec	Total
Observed days	81	47	91	212	143	118	692	137	31	68	137	115	99	587
Observed Trips	14	12	17	35	17	23	118	25	8	14	25	22	22	116
Total Cetaceans	3	2	8	19	8	2	42	1	0	1	2	0	5	11
Total Pinnipeds	5	1	9	18	6	9	48	4	2	2	2	9	10	29
Total Turtles	0	2	0	5	0	0	7	1	3	0	0	0	0	4
Total Birds	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Common Dolphin (long-beaked)	0	0	0	4	0	0	4	0	0	0	0	0	0	0
Common Dolphin (short-beaked)	3	2	3	10	2	1	21	1	0	1	2	0	5	9
Common Dolphin (unidentified)	0	0	0	0	1	0	1	0	0	0	0	0	0	0
N. Right Whale Dolphin	0	0	0	3	2	0	5	0	0	0	0	0	0	0
P. White-sided Dolphin	0	0	2	0	0	1	3	0	0	0	0	0	0	0
Risso’s Dolphin	0	0	1	0	2	0	3	0	0	0	0	0	0	0
Dall's Porpoise	0	0	1	2	1	0	4	0	0	0	0	0	0	0
Gray Whale	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Short Finned Pilot Whale	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Sperm Whale	0	0		0	0	0	0	0	0	0	0	1	0	1
N. Elephant Seal	2	0	1	4	2	0	9	1	0	0	1	1	1	4
CA Sea Lion	3	1	8	14	4	9	39	3	1	2	1	8	8	23
Unidentified Pinniped	0	0	0	0	0	0	0	0	1	0	0	0	1	2
Leatherback Turtle	0	0	0	4	0	0	4	0	0	0	0	0	0	0
Loggerhead Turtle	0	2	0	1	0	0	3	1	3	0	0	0	0	4
Unidentified Bird	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Swordfish	78	32	69	526	498	338	1541	346	2	123	460	280	171	1382
Thresher Shark (common)	160	94	107	162	232	19	774	14	187	2	80	56	60	399
Tresher Shark (bigeye)	0	7	15	43	10	1	76	0	7	0	5	3	0	15
Mako Shark	103	68	273	225	124	169	962	81	9	35	107	78	66	376
Blue Shark	147	62	224	1087	516	187	2223	243	13	481	1262	367	94	2460
Bluefin Tuna	3	39	19	308	244	47	660	19	0	86	130	72	16	323
Albacore	31	83	200	582	279	114	1289	35	1	284	883	643	85	1931
Skipjack Tuna	0	116	270	601	301	102	1390	17	2	539	1187	40	32	1817
Pacific Mackerel	90	201	95	33	9	72	500	34	36	3	4	1	8	86
Opah	336	71	25	47	65	132	676	155	4	70	85	52	74	440
Ocean Sunfish	526	22	78	419	524	880	2449	189	13	257	912	1005	1706	4082

Table 2. Observed and estimated cetacean, pinniped, and turtle mortality and mortality rates in the California swordfish/shark drift gillnet fishery during 1997.

SPECIES	ESTIMATED TOTAL MORTALITY (1997)	OBSERVED TOTAL MORTALITY (1997)	OBSERVED MORTALITY EXP PERIOD NO PINGERS	OBSERVED MORTALITY EXP PERIOD PINGERS	OBSERVED MORTALITY MANDATORY PERIOD	STD. ERROR OF MORTALITY ESTIMATE	C.V. OF MORTALITY ESTIMATE	OBSERVED KILLED 7/90-1/98
All Cetaceans	209	41	22	6	13	42.6	0.21	423
Common Dolphin (long-beaked)	25	4	4	0	0	18.7	0.74	12
Common Dolphin (short-beaked)	101	20	10	3	7	30.0	0.31	215
Common Dolphin (unidentified)	5	1	0	0	1	4.8	0.96	22
N. Right Whale Dolphin	29	5	3	0	2	12.1	0.42	42
P. White-sided Dolphin	12	3	1	1	1	7.7	0.69	23
Risso's Dolphin	11	3	0	1	2	9.6	0.96	27
Dall's Porpoise	20	4	3	1	0	17.9	0.95	22
Short Finned Pilot Whale	6	1	1	0	0	6.1	0.96	11
All Pinnipeds	246	44	30	3	11	66.3	0.27	179
N. Elephant Seal	45	8	7	1	0	14.5	0.33	97
California Sea Lion	201	36	23	2	11	67.2	0.34	78
Leatherback Turtle	7	2	1	1	0	6.0	0.95	14
Loggerhead Turtle	6	1	1	0	0	6.0	0.95	3

Table 3. Observed and estimated cetacean, pinniped, and turtle mortality and mortality rates in the California swordfish/shark drift gillnet fishery during 1998.

SPECIES	ESTIMATED TOTAL MORTALITY (1998)	OBSERVED TOTAL MORTALITY (1998)	STD.ERROR OF MORTALITY ESTIMATE	C.V. OF MORTALITY ESTIMATE	OBSERVED KILLED 7/90-1/99
All Cetaceans	54	11	15.43	0.28	432
Common Dolphin (short-beaked)	45	9	14.35	0.32	233
Gray Whale	5	1	4.44	0.90	2
Sperm Whale	5	1	4.40	0.89	8
All Pinnipeds	144	29	27.26	0.19	204
N. Elephant Seal	20	4	8.67	0.44	100
California Sea Lion	114	23	26.07	0.23	98
Unidentified Pinniped	10	2	6.27	0.63	2
Loggerhead Turtle	5	1	4.42	0.89	3

Table 4. Estimated cetacean, pinniped, and seabird mortality and mortality rates in the California halibut/angel shark set gillnet fishery during 1997. There was an estimated total effort of 3,092 days in this

fishery. Estimates of total mortality are reported to the nearest individual. Because this fishery was not observed during 1997, only mortality estimates are reported.

SPECIES	ESTIMATED TOTAL MORTALITY (1997)	STD. ERROR OF MORTALITY ESTIMATE	C.V. OF MORTALITY ESTIMATE	RATE, MORTALITY PER EFFORT-DAY	STD. ERROR OF RATE	OBSERVED MORTALITY 7/90-7/94
Harbor Porpoise	53	14.59	0.27	0.017	0.0047	18
California Sea Lion	1,206	67.53	0.06	0.390	0.0218	897
Northern Elephant Seal	60	14.18	0.24	0.020	0.0046	36
Harbor Seal	349	29.48	0.08	0.113	0.0095	259
Common Murre	2,563	414.66	0.16	0.829	0.1341	880
Brandt's Cormorant	79	19.49	0.11	0.026	0.0063	70
Unidentified Cormorant	52	18.57	0.36	0.017	0.0060	38

Table 5. Estimated cetacean, pinniped, and seabird mortality and mortality rates in the California halibut/angel shark set gillnet fishery during 1998. There was an estimated total effort of 2,818 days in this fishery. Estimates of total mortality are reported to the nearest individual. Because this fishery was not observed during 1998, only mortality estimates are reported.

SPECIES	ESTIMATED TOTAL MORTALITY (1998)	STD. ERROR OF MORTALITY ESTIMATE	C.V. OF MORTALITY ESTIMATE	RATE, MORTALITY PER EFFORT-DAY	STD.ERROR OF RATE
Harbor Porpoise	38	10.19	0.27	0.013	0.0036
California Sea Lion	1,228	90.37	0.07	0.436	0.0321
Northern Elephant Seal	70	18.27	0.26	0.025	0.0065
Harbor Seal	392	40.79	0.10	0.139	0.0145
Common Murre	1,882	292.69	0.16	0.668	0.1039
Brandt's Cormorant	78	19.18	0.25	0.028	0.0068
Unidentified Cormorant	70	35.72	0.51	0.025	0.0127

Table 6. Estimated mortality and coefficient of variation, for several species entangled in the set gillnet fishery during 1997 and 1998 under differing geographic stratifications (4 regions vs. 5 regions) and with or without stratification by quarter.

	1997		1998	
Species	4 regions, with quarters	5 regions, with quarters	4 regions, without quarter	5 regions, without quarter
Harbor Porpoise	49(0.27)	53(0.27)	41(0.27)	38(0.27)
California Sea Lion	1,220(0.06)	1,206(0.06)	1,214(0.07)	1,228(0.07)
Northern Elephant Seal	69(0.25)	60(0.24)	62(0.24)	70(0.26)
Harbor Seal	368(0.09)	349(0.08)	374(0.10)	392(0.10)
Common Murre	2,415(0.16)	2,563(0.16)	2,026(0.16)	1,882(0.16)

Figure 1. Approximate location of observed sets from the drift-net fishery during calendar year 1997 (n=692

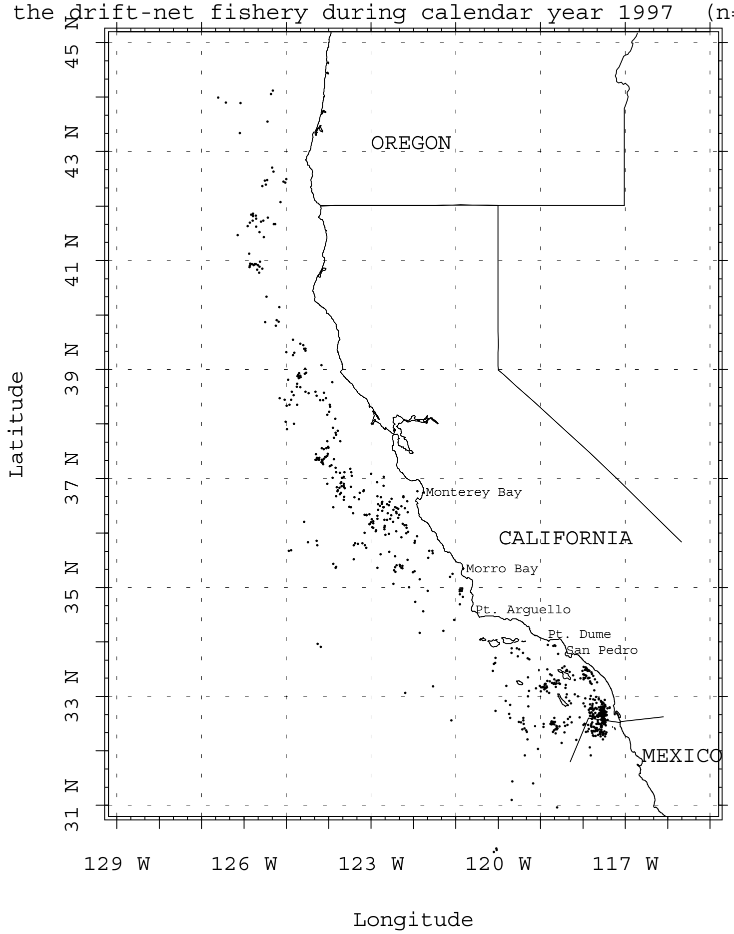
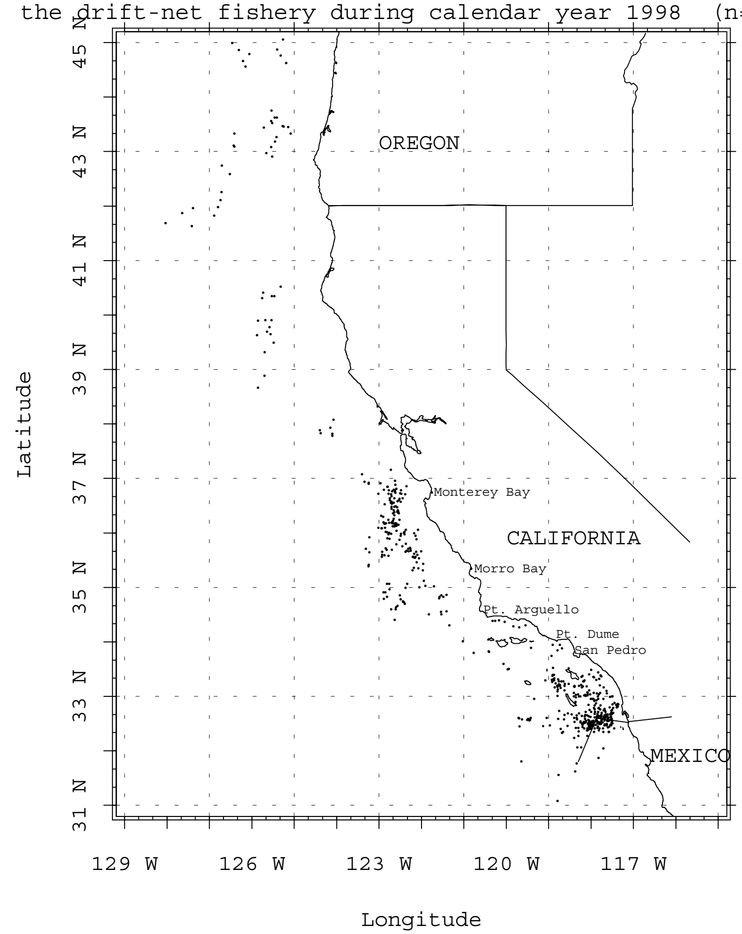
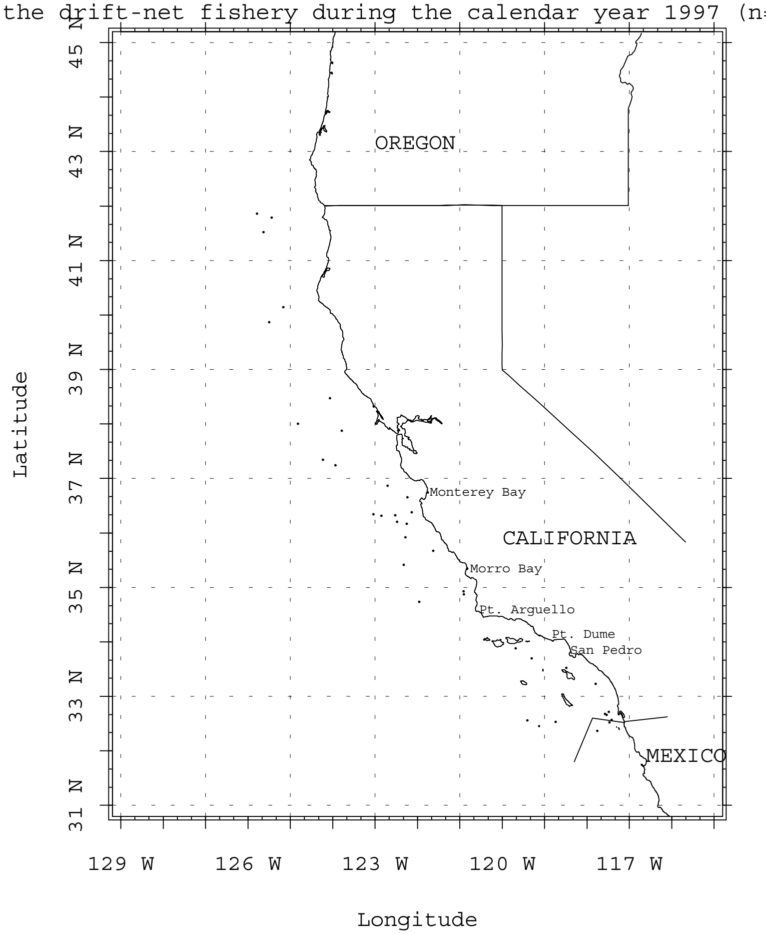


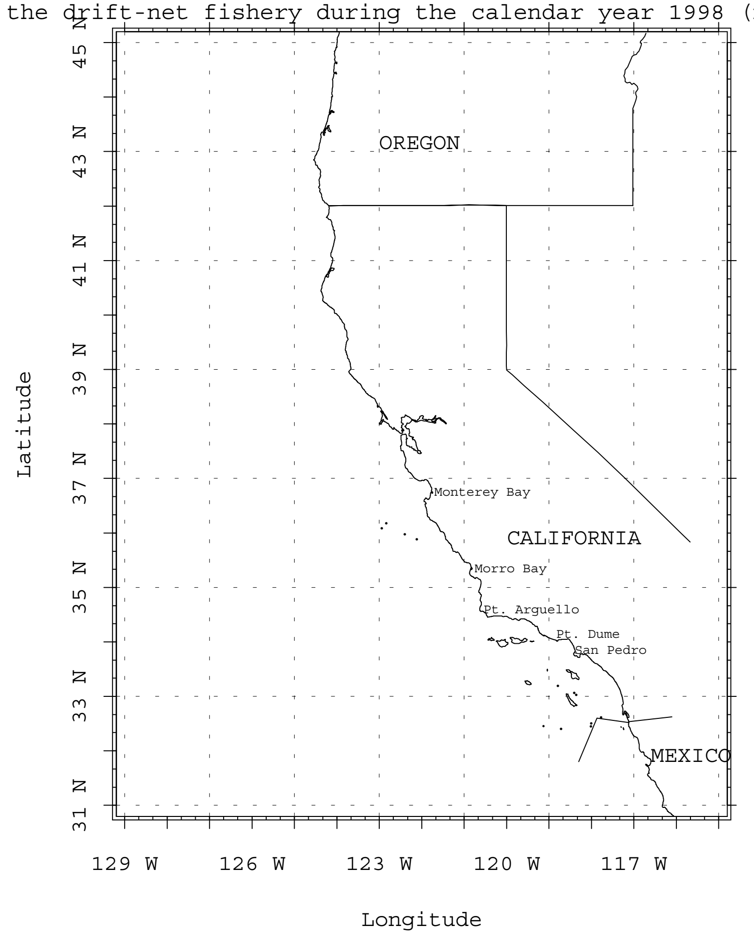
Figure 2. Approximate location of observed sets from the drift-net fishery during calendar year 1998 (n=587



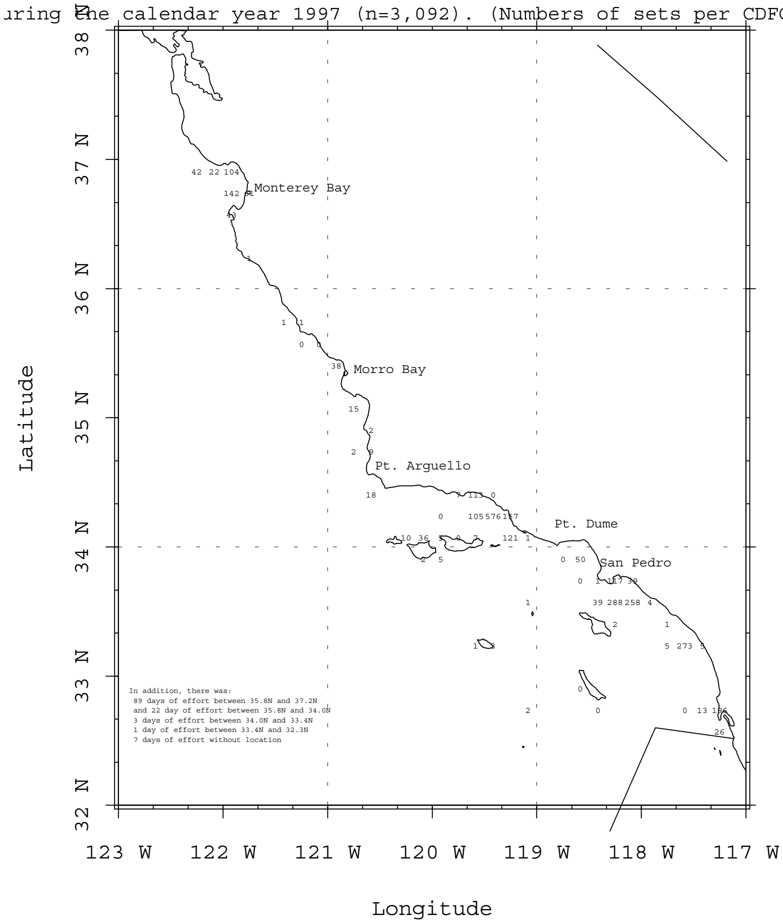
re 3. Approximate location of observed cetacean entangleme
the drift-net fishery during the calendar year 1997 (n=9



re 4. Approximate location of observed cetacean entangleme
the drift-net fishery during the calendar year 1998 (n=1



gure 5. Approximate location of days of effort in the set gillnet
uring the calendar year 1997 (n=3,092). (Numbers of sets per CDFG



gure 6. Approximate location of days of effort in the set gillnet
uring the calendar year 1998 (n=2,818). (Numbers of sets per CDFG