Preliminary Estimates of Cetacean Mortality in California/Oregon Gillnet Fisheries for 1999.
(International Whaling Commission Working Paper)

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ABSTRACT

Non-fish bycatch is estimated for two U.S. West Coast gillnet fisheries, the California/ Oregon swordfish/shark drift-net fishery and the California halibut/angel shark set-net fishery, for the calendar year 1999. 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 1999 are similar to those used in previous years with experimental gear modifications (1996-98), because the placement of acoustic warning devices (pingers) was modified on some observed sets to evaluate potential effects on entanglement rates. Estimated mortality and observed mortality (in parentheses) in the drift gillnet fishery included 228 (42) cetaceans, 40 (8) pinnipeds and 5 (1) turtles. Although drift gillnet mortality in 1997 and 1998 in nets with pingers was considerably lower than mortality in nets without pingers in previous years, cetacean mortality for January 1999 and the last 3 months of the 1999 fishing year is above pre-pinger levels. The set gillnet fishery has not been observed along most of the California coast since July 1994; however, a local observer program was reinstated in April 1999 in the Monterey Bay region because of concern over potential effects of changes in fishing effort in that area on harbor porpoise mortality. Mean per unit estimators, with fishing day as the sampling unit, were used to estimate 1999 mortality based on data from the 1999 observer program for the Monterey area and 1991-94 observer program data for all other geographic strata. Estimates were made separately within each of five geographic strata and were combined to provide total mortality estimates. Set gillnet mortality for harbor porpoise, *Phocoena phocoena*, was estimated to be higher in 1999 (133 animals) than in previous years, primarily due to increased fishing effort in the Monterey Bay region.

INTRODUCTION

Mortality estimates for the 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) describe these gillnet fishery 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.

The driftnet fishery has been observed continuously since 1990. Recent efforts to reduce cetacean mortality in the drift-net fishery have included an experiment to test the effectiveness of acoustic deterrent devices (pingers) 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. The mandatory pinger configuration consists of 20 pingers on the floatline and 20 pingers on the leadline for a typical 1000 fathom net. Analyses of the experimental data showed 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, Cameron 1999). Similar results were observed in other fisheries with frequent harbor porpoise entanglement (Gearin et al. 1996, Kraus et al. 1995, 1997, Larsen 1997). Although pingers were effective in this fishery, concerns were raised by the fishing community regarding the risk to crew during the process of attaching leadline pingers to the net, especially in rough seas. These concerns prompted a second experiment to test an alternate pinger configuration in which all 40 pingers are attached to the floatline. As in the previous experiment, sets were chosen at random (and immediately prior to the setting of the net) to use either the mandatory or alternate pinger configuration. The experiment began August 1999. To date, preliminary analyses of these data favor the mandatory configuration for sets included within this experimental protocol through January 2000. There were 12 cetacean entanglements for 190 sets using the mandatory configuration compared to 18 entanglements for 188 sets using pingers on the floatline only.

Observation of the halibut/angel shark set gillnet fishery was discontinued in July 1994, because total fishing effort had declined and bycatch of marine mammal species was at allowable levels under the MMPA. In April 1999, a local observer program was reinstated by NMFS in the Monterey Bay region, because of concern over potential effects of changes in fishing effort in that area on the mortality of harbor porpoise, *Phocoena phocoena* (Forney et al. 2000). Because most regions have not been observed since 1994, uncertainty is introduced in the estimation of 1999 mortality, particularly for species that are primarily entangled in regions not observed (Morro Bay and all southern California strata). Because of the high level of observer coverage achieved in 1999 Monterey Bay observer program (21%), estimates of mortality for harbor porpoise are expected to be more precise than in past years.

In this paper we present cetacean, pinniped, turtle, and seabird mortality estimates for both gillnet fisheries for the calendar year 1999, as well as information on catch of target and non-target fish species for the drift gillnet fishery.

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 (Read 1999a,b,c; 2000a,b). Effort is measured in effort-days, defined as one day of fishing for one vessel. CDFG combines fishing vessel logs, NMFS observer data (for the driftnet fishery), and sales receipts of landed fish to assign effort to a particular fishery, CDFG fishing block (typically 10' squares) and calendar quarter (Julian and Beeson 1998). Sources of variation in calculating estimates of total effort

were previously examined (Julian 1994). These variations were nominal, and calculating direction and magnitude of their biases is intractable using current procedures. Therefore, estimates of effort were assumed to be accurate, with the exception of the Monterey area set-gillnet fishery, for which an independent estimate of effort was available in 1999 from the NMFS observer program. This independent estimate was used to correct estimated effort in this region as described below.

Drift-net Fishery

In the drift-net fishery, effort targeting swordfish and shark with stretched mesh size of approximately 51 cm (20") was reported, and one set comprises an effort-day (1997-1998 average net length: 1,728 m, SD=180 m). Preliminary 1999 effort estimates for the four calendar quarters were; 368, 67, 455 and 1,613 days fished, respectively, for a preliminary total of 2,503 days fished (Read 1999a,b,c, 2000a). The revised final estimate of fishing effort for the full calendar year 1999 is 2,634 days (Read 2000b). Because no quarterly stratification is included in the driftnet analysis, the total annual estimate (2,634 effort-days) is used for mortality estimation. The experimental configuration of pingers was used on 218 of these effort-days.

Set-net Fishery

In the set-net fishery, effort targeting halibut and angel shark with mesh size of at least 21.6 cm (8.5") was reported, and, historically, three sets constitute an effort-day in the coast-wide set-net fishery (1990-1994 average net length: 477 m, SD=173.4 m; Julian and Beeson 1998). In the Monterey Bay region, the number of sets per day has historically been lower, or about 1.5 sets per effort-day. Preliminary 1999 effort estimates for the four calendar quarters were; 1,142, 1,278, 995 and 551 days fished, respectively, for a preliminary total of 3,966 days fished (Read 1999a,b,c, 2000a). The revised final estimate of fishing effort for the full calendar year 1999 is 4,069 (Read 2000b), of which an estimated 677 days took place in the Monterey Bay region. Effort estimates for other geographic strata are: 1,803 days in Southern California, 1,372 days in Ventura, 119 days in the Channel Islands, and 98 days in Morro Bay. The local NMFS observer program in the Monterey Bay area setnet fishery has provided an independent estimate of fishing effort in this region. This independent estimate is higher (781 effort-days) and is expected to be more precise, because there are only 16 vessels fishing in three local ports (usually only 2-6 are active), and the two NMFS observers were able to keep track of the daily fishing status of all vessels via dock rounds and direct phone contact with the fishermen. The NMFS estimate of fishing effort for Monterey Bay has fewer potential sources of downward bias, and no likely source of significant upward bias, and therefore, the difference in total estimated effort was added to the CDFG effort estimate to produce the following corrected estimates of set-net fishing effort: 4,173 total effort days, with 781 days in the Monterey Bay region.

Analytical Methods

Drift-net Mortality Estimates

As in previous years (Julian and Beeson 1998; Cameron and Forney 1999), ratio estimation is used. Since the sampling unit is a multi-day “trip”, a ratio estimator is used with days per trip as the auxiliary variable to obtain an approximate analytical variance estimator (Cochran 1977, p. 155). The pinger configuration experiment poses a problem for the calendar year 1999 mortality estimates due to the potential difference in entanglement rate for the two configurations; hence, two methods of estimation are used. Method 1 uses all 526 sets of the observed data to estimate a rate of mortality. Total mortality is given as the product of the mortality rate and total estimated effort (2,634 fishing days). Method 2 stratifies by and accounts

for differences in pinger configuration, and is identical to the methods used during the 1996/1997 pinger experiment (Julian 1997, Cameron and Forney 1999). In Method 2, the rate of mortality for a given species is estimated using the 308 observed sets with the mandatory pinger configuration (excluding the 218 sets with the experimental float-line only configuration. Total mortality is given as the sum of mortality observed for the 218 sets with pingers on the floatline only, plus the product of the mortality rate and fishing effort using the mandatory pnger configuration (2,416 = 2,634 - 218 fishing days).

For each species, Method 1 produces a mortality estimate with less variability but potentially more bias. If pinger configuration truly affects entanglement rates for a given species, Method 2 would be the appropriate analysis because the estimated rate based on the float and leadline configuration (and used to extrapolate for unobserved sets) would be less biased than if the rate were based on all sets. On the contrary, if there were no difference due to pinger configuration, Method 2 would be less precise than Method 1; hence, method 1 would be the appropriate analysis.

Although sample sizes are very small, and statistical power to detect effects of pinger configuration on entanglement rates is low, preliminary analyses indicate a significant difference only for common dolphins, which are most frequently entangled. Based on the results of previous pinger experiments (Cameron 1999), it is likely that the response of other delphinids is similar to that of common dolphins, and thus the stratified analysis Method 2 would provide the best mortality estimates for delphinid species. In contrast, there is insufficient evidence to evaluate a pinger configuration effect for all other species (including beaked whales, sperm whales, baleen whales, pinnipeds, and turtles). Therefore, at the present time, Method 1 is preferred for non-delphinid species because this maximizes precision. In this report, mortality estimates using both methods are presented for completeness, but the estimates made with the 'best' method for each species are emphasized in the results.

Set-net Mortality Estimates

As in previous years (Julian and Beeson 1998; Cameron and Forney 1999), a mean-per-unit estimator was used with effort-days as the sampling unit. The set-net fishery was observed only in the Monterey Bay region in 1999. The geographical strata developed for the 1997-98 analyses (Cameron and Forney 1999) were used in present analysis. As in previous analyses, mortality rates are stratified by geographic area, and by calendar quarter for Southern California and Ventura. The mortality estimates for the individual strata are combined to arrive at total mortality estimates. For the Monterey Bay stratum, entanglement rates were based on the observed trips during 1999. For all other strata (Southern California, Ventura, Channel Islands, and Morro Bay), entanglement rates are based on observer program data for 1991-94. In previous analyses (Julian 1997, Julian and Beeson 1998, Cameron and Forney 1999), the 1990 observer data were also included when estimating entanglement rates. They have been excluded in the present analysis because 1990 was only a partially observed year (July-December), and because fishing regulations in central California changed at the end of 1990. This is expected to improve the accuracy of the mortality estimates for the unobserved regions, although there is still considerable uncertainty associated with the ban on nearshore fishing in Southern California at the end of 1994. The total mortality estimates for the setnet fishery is calculated as the sum of the mortality estimates for all strata. Mortality estimates were calculated for the following species observed taken in 1999 or regularly entangled in past years: harbor porpoise, unidentified cetacean, California sea lion, harbor seal (*Phoca vitulina*), northern elephant seal, unidentified pinniped, sea otter (*Enhydra lutris),* Common Murre (*Uria aalge*), Brandt's Cormorant *(Phalacrocorax penicillatus)*, and unidentified cormorants *(Phalacrocorax sp.).*

RESULTS

Drift-net Fishery

In 1999, 526 sets (116 trips) out of an estimated 2,634 sets (1 set = 1 effort-day) were observed for a coverage rate of 20%. As in previous years, more than one-half of the observed sets occurred south of San Pedro. However, this year the bulk of the remaining sets occurred off Point Arguello rather than between Monterey Bay and Morro Bay (Figure 1). The geographic distribution of observed entanglements appears to match the distribution of observed sets (Figure 2). There were 29 nets with cetacean entanglement containing 42 cetaceans. Four of the observer cetacean identifications were changed as a result of DNA testing: 2 long-beaked common dolphin and 2 unidentified common dolphin were changed to short-beaked common dolphin. 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 cetacean species, stratified by month. Observed catch/bycatch of other selected species is also included.

Set-net Fishery

In 1999, this fishery was observed only in the Monterey Bay area, where a total of 165 trips (232 sets) were observed between April 1 and December 31 (Figure 3). During these first three quarters, the number of estimated trips was 714, yielding a coverage rate of 23%. An additional 67 trips were estimated to have taken place in the first calendar quarter, which was not observed, yielding a total 1999 estimate of 781 trips and 21% annual coverage in the Monterey Bay area. No trips were observed in other areas along the California coast. There were 21 trips with cetacean entanglement containing 28 cetaceans. The CDFG effort estimate, corrected based on additional trips identified by NMFS observers in Monterey Bay, is 4,173 days of fishing effort. The distribution of overall set-net effort was provided by CDFG based on logbooks and landing receipts (Figure 4). Since January 1, 1995, California law requires gillnet fishing to be at least three miles from the mainland south of Pt. Arguello (approximately 34^{B}36'N) and one mile from the Channel Islands. 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, Santa Cruz Island, San Pedro/Long Beach, and San Diego.

Mortality estimates were determined for harbor porpoise, sea otters, pinnipeds, and seabirds (Table 3). One unidentified cetacean, which fell out of the net and disappeared before it could be identified, was recorded in the 1999 Monterey Bay observer program. This animal was almost certainly a harbor porpoise, because this is the only cetacean species that has been observed entangled in the set-net fishery in this region, and a second animal in the net was identified as a harbor porpoise. Total harbor porpoise mortality is presented both including and excluding this animal.

DISCUSSION

Despite continued use of pingers in the drift-net fishery, cetacean mortality has increased to pre-pinger levels in 1999. Estimated cetacean mortalities since 1996 are: 418 (1996), 209 (1997), 54 (1998) and 222 (1999). There was early warning of greater entanglement in January 1999 in which one cetacean entanglement occurred every five sets on average. Entanglement dropped to 1998 levels for the months of August through October, but increased dramatically for November and December of 1999. Entanglement rates for January 2000 are almost identical to those of January 1999. Some preliminary analyses have been undertaken to determine possible causes of the increased entanglement rate. Increases do not appear to be related to changes in

either fishing location or fishing operation. Changes in bycatch rates due to experimental changes in pinger placement do not appear sufficient to account for this increase. Seasonal stratification may be warranted in future analyses.

Estimates of mortality in the 1990-94 setnet fishery used current year observer data. However, since 1995, mortality estimates have been based on prior-year observer data due to the discontinuation of the observer program. The reinstatement of an observer program in Monterey Bay has improved our ability to estimate mortality for this region accurately, but mortality estimates for other areas of the coast have large uncertainty. Mortality estimates for the marine mammal species of greatest concern (harbor porpoise, and southern sea otter, a 'Threatened Species' under the U. S. Endangered Species Act), are considered relatively accurate because these species are entangled mainly in the Monterey Bay area, where observer coverage was 21%. The 1999 estimate of mortality for harbor porpoise (133 animalas) is considerably higher than in past years, and exceeds the maximum level allowed under the MMPA (42) by a factor of 3.2. Since a November 1999 skipper workshop, the majority of fishermen in the Monterey Bay area have agreed to voluntarily use pingers. Although it is presently too early to evaluate the effects of these pingers, it is hoped that they will reduce harbor porpoise bycatch, as they have in other regions and fisheries (Gearin et al. 1996, Kraus et al. 1997, Larsen 1997).

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Table 1. Observed cetacean, pinniped and turtle entanglements (mortalities and injuries) stratified by species and month for the drift gillnet fishery for the calendar year 1999. Observed catch of selected target and non-target fish is included as well as species entangled and returned uninjured.

	Jan	Aug	Sep	Oct	Nov	Dec	Total
Observed days	49	9	47	229	112	80	526
Observed Trips	14	2	16	40	24	20	116
Total Cetaceans	12	0	0	5	12	13	42
Total Pinnipeds	0	0	0	4	3	2	8
Total Turtles	0	0	0	0	1	0	1
Long-beaked Common Dolphin	1	0	0	0	0	0	1
Short-beaked Common Dolphin	10	0	0	3	9	12	34
Unidentified Common Dolphin	0	0	0	0	2	0	2
Northern Right Whale Dolphin	0	0	0	2	0	1	3
Fin Whale	0	0	0	0	1	0	1
Gray Whale	1	0	0	0	0	0	1
Northern Elephant Seal	0	0	0	2	0	0	2
California Sea Lion	0	0	0	2	3	1	6
Green/Black Turtle	0	0	0	0	1	0	1
Swordfish	33	0	52	674	237	37	1033
Common Thresher Shark	8	0	1	14	70	45	138
Big-eye Tresher Shark	0	0	2	2	2	4	10
Mako Shark	17	0	28	141	113	27	326
Blue Shark	43	1	167	1590	536	111	2448
Bluefin Tuna	38	4	27	114	18	20	221
Albacore	22	34	841	1538	334	86	2855
Skipjack Tuna	14	2	15	3	3	1	38
Pacific Mackerel	13	3	0	7	2	1	26
Opah	18	7	18	54	16	84	197
Ocean Sunfish	504	9	73	349	498	278	1711
The following were entangled and released uninjured.							
Minke Whale	0	0	0	0	1	0	1
Humpback Whale	0	0	0	0	1	0	1
Leatherback Turtle	0	0	0	1	0	1	2
Olive Ridley Turtle	0	0	0	0	1	0	1

Table 2. Estimates of cetacean, pinniped, and turtle mortality (M) for the California swordfish/shark drift gillnet fishery for calendar year 1999. For each estimation method, the kill per set (R), standard error and coefficient of variation of the mortality estimate (se and cv respectively) are shown along with the observed mortality for sets with pingers on the floatline only ("Float Only") and pingers on both floatline and leadline, and the total observed killed to date. Method 1 does not stratify by pinger configuration whereas Method 2 does. For each species, mortality is also shown for the method judged to be best ('BEST' M) based on considerations of precision and bias and apparent differences in entanglement rates by pinger configuration.

		METHOD 1				METHOD 2				OBSERVED MORTALITY		
SPECIES	'BEST' M	M1 (R1)*2634	se(M1)	cv(M1)	R1 ((1)+(2))/526	M2 (1)+(R2)*2416	se(M2)	cv(M2)	R2 (2)/308	FLOAT ONLY n=218 (1)	FLOAT LEAD n=308 (2)	OBS. KILLED 7/90-1/00
All Cetaceans	228	210	46.6	0.22	0.0799	234	61.5	0.28	0.0909	14	28	486
Common Dolphin (long-beaked)	8	5	4.5	0.90	0.0019	8	7.3	0.93	0.0032	0	1	18
Common Dolphin (short-beaked)	191	170	39.7	0.23	0.0646	191	55.8	0.31	0.0747	11	23	251
Common Dolphin (unidentified)	2	10	9.0	0.90	0.0038	2	---	---	0	2	0	40
N. Right Whale Dolphin	17	15	10.0	0.66	0.0057	17	10.4	0.66	0.0065	1	2	45
Fin Whale	5	5	4.5	0.90	0.0019	8	7.4	0.94	0.0032	0	1	1
Gray Whale	5	5	4.5	0.90	0.0019	8	7.3	0.93	0.0032	0	1	2
All Pinnipeds	40	40	13.6	0.34	0.0152	35	14.3	0.46	0.0130	4	4	215
N. Elephant Seal	10	10	6.2	0.61	0.0038	9	7.3	0.93	0.0032	1	1	156
California Sea Lion	30	30	10.7	0.36	0.0114	27	12.6	0.53	0.0097	3	3	1041
Green/Black Turtle	5	5	4.5	0.90	0.0019	1	---	---	0	1	0	3

Table 3. Estimated cetacean, pinniped, and seabird mortality and mortality rates in the California halibut/angel shark set gillnet fishery during 1999, reported to the nearest individual. Estimated total effort in this fishery during 1999 was 4,173 days, with 165 out of 781 effort-days in the Monterey Bay area observed. Entanglement rates for all other areas are based on 1991-94 observer data (2,284 days observed). Mortalities are estimated separately for the five geographic strata (Southern California, Ventura, Channel Islands, Morro Bay and Monterey Bay) and then combined to estimate total 1999 mortality. The unidentified cetacean was almost certainly a harbor porpoise (see Results), and harbor porpoise estimates are therefore presented both including and excluding this animal.

	1999 Monterey Bay Observer Program			1991-94 Observer Program (excluding Monterey Bay stratum)			1999 MORTALITY ESTIMATES		
SPECIES	**Observed Killed**	**Rate, Mortality Per Effort-day**	**Std. Error of Mortality Rate**	**Observed Killed**	**Rate, Mortality per Effort-day**	**Std. Error of Mortality Rate**	**Total Estimated Mortality**	**Std. Error of Mortality Estimate**	**C.V. of Mortality Estimate**
Harbor Porpoise,									
including unidentified cetacean	28	0.170	0.040	0	0	--	**133**	31.0	0.23
excluding unidentified cetacean	27	0.164	0.039	0	0	--	**128**	30.7	0.24
Southern sea otter	1	0.006	0.006	0	0	--	**5**	4.5	0.99
California Sea Lion	13	0.079	0.026	778	0.341	0.023	**1,360**	91.5	0.07
Northern Elephant Seal	10	0.061	0.022	18	0.008	0.002	**76**	18.6	0.25
Harbor Seal	57	0.345	0.052	213	0.093	0.012	**662**	64.6	0.10
Unidentified pinniped	3	0.018	0.010	16	0.007	0.003	**38**	12.2	0.32
Common Murre	498	3.018	0.454	1	<0.001	<0.001	**2,359**	354.9	0.15
Brandt's Cormorant	0	0	--	66	0.029	0.007	**101**	24.4	0.24
Unidentified Cormorant	0	0	--	26	0.011	0.007	**59**	34.1	0.58

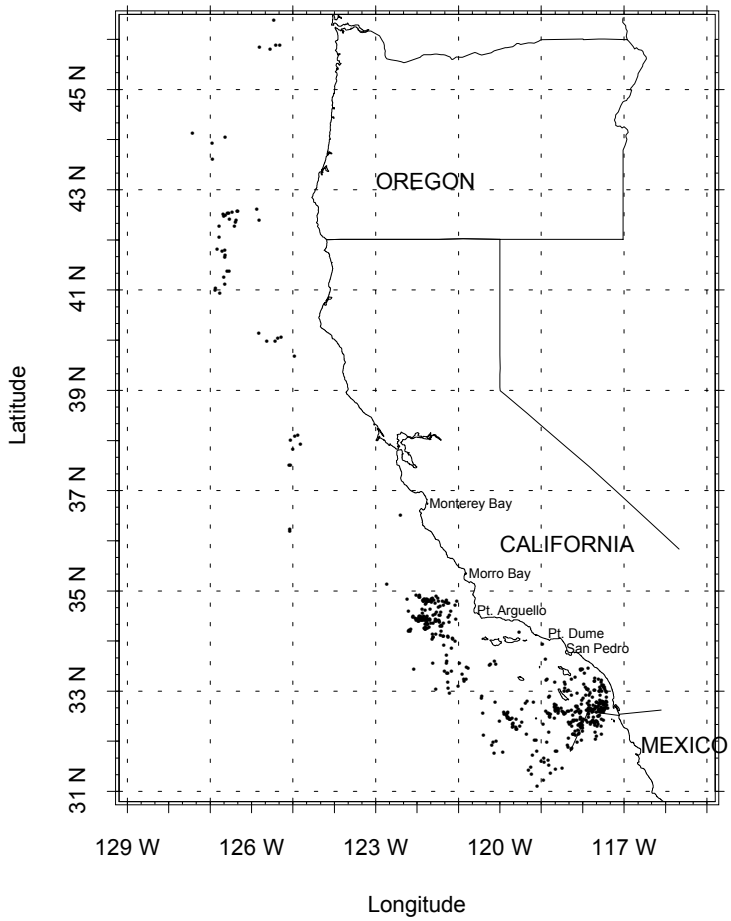

Figure 1. Approximate location of observed sets from the drift-net fishery during the calendar year 1999 (n=526).

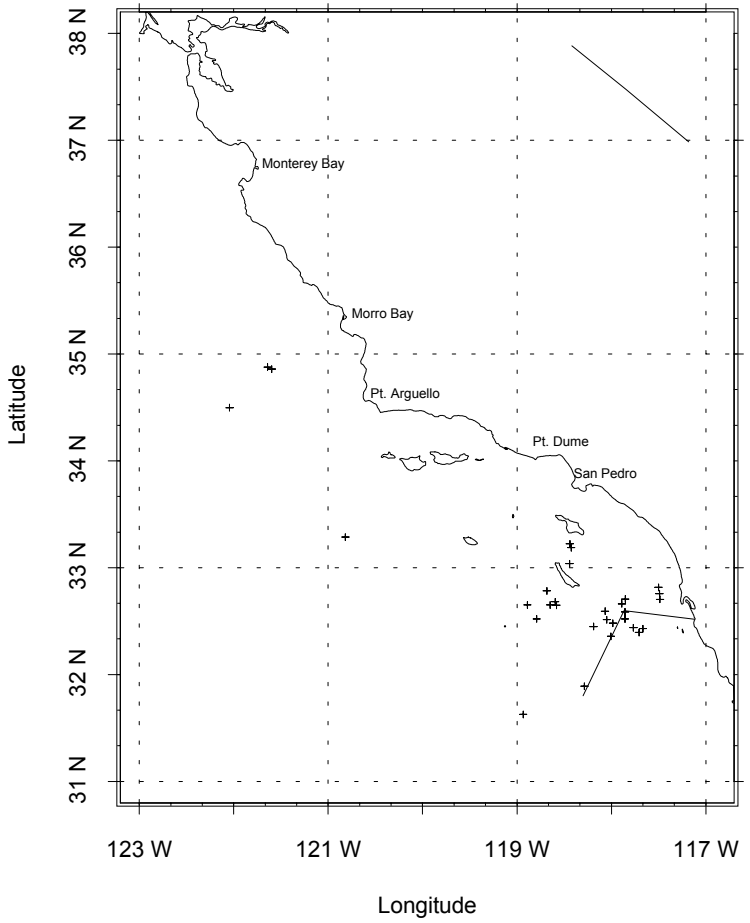

Figure 2. Approximate location of observed cetacean entanglements from the drift-net fishery during the calendar year 1999 (n=42).

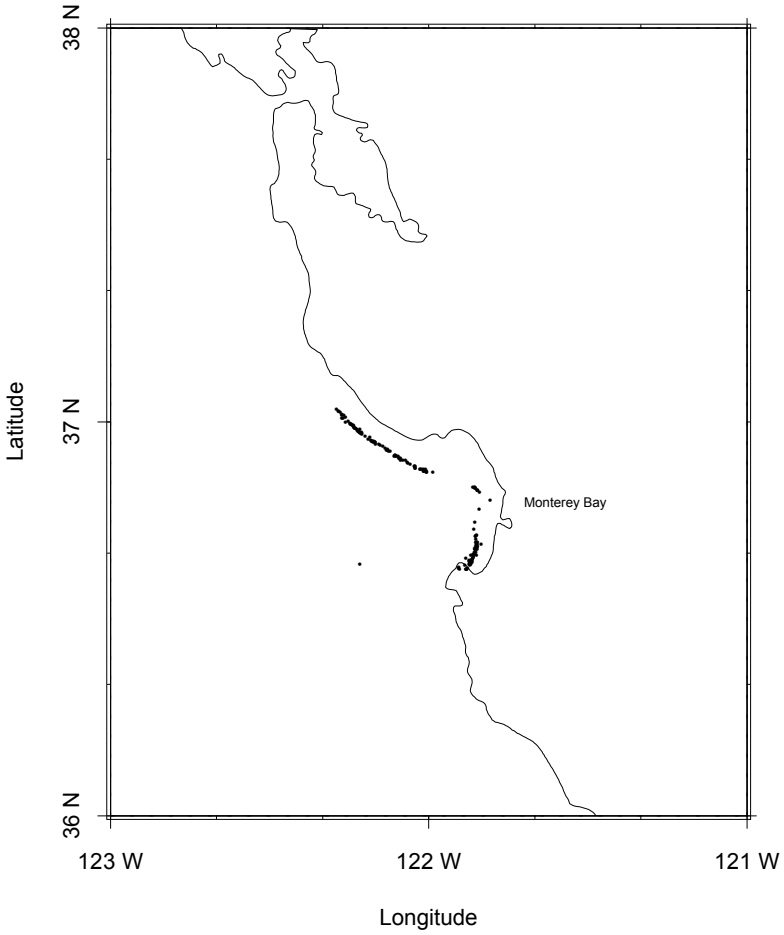

Figure 3. Approximate location of observed days of effort in the set gillnet fishery during the calendar year 1999 (n=165).

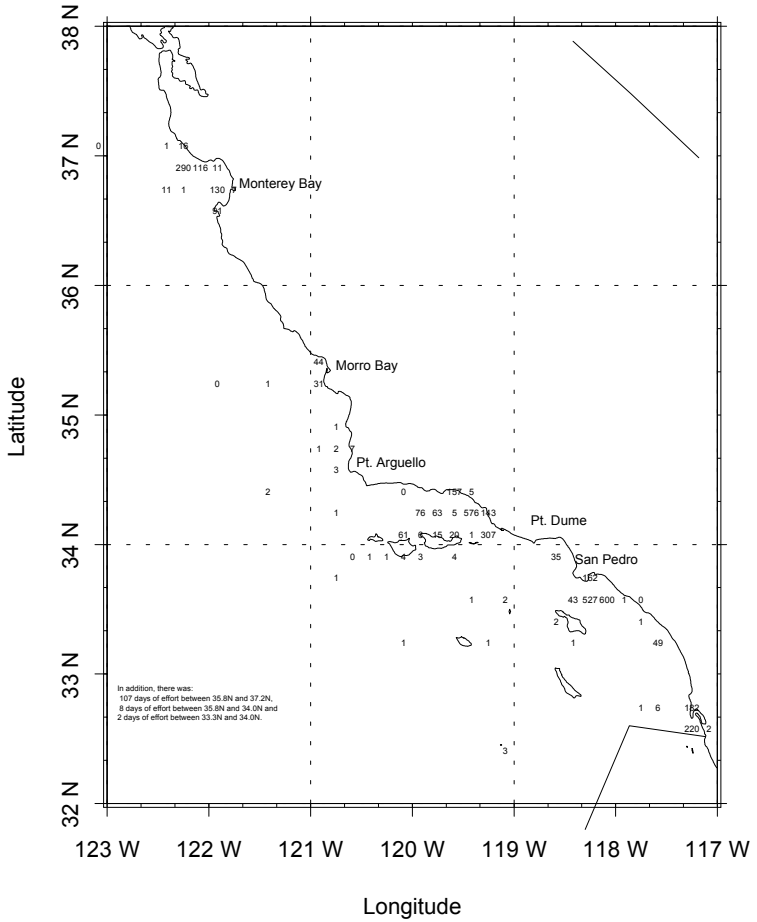

Figure 4. Estimated distribution of effort for the set gillnet fishery during the calendar year 1999 (n=4,173). (Numbers indicate effort-days by CDFG block)