National Marine Fisheries Service
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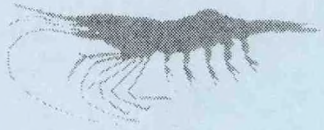

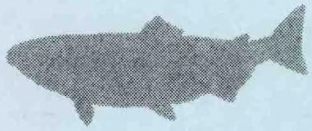

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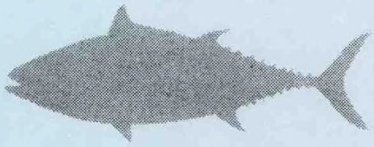
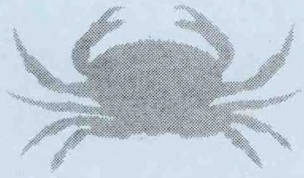
Doyle A. Hanan, Sandra L. Diamond, and John P. Scholl





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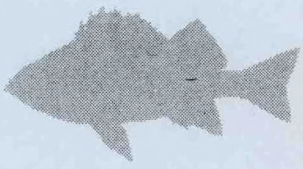

An Estimate of Harbor Porpoise Mortality in California Set Net Fisheries April 1, 1984 through March 31, 1985

by

Doyle A. Hanan
California Department of Fish and Game
C/O Southwest Fisheries Center
P.O. Box 271
La Jolla, California 92038

Sandra L. Diamond

and

John P. Scholl
California Department of Fish and Game
1301 West Twelfth Street
Long Beach, California 90813

Final Report submitted to:

National Marine Fisheries Service
Southwest Region
300 South Ferry Street
Terminal Island, California 90731

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ABSTRACT

Harbor porpoise were taken incidentally in the halibut/flounder/shark set net fishery off central California during the 1984-85 fishing year. Total fishing effort was determined by area and applied to observations of porpoise caught to estimate the total number killed. Three separate calculation methods revealed that about 200 (±50 SE) porpoise were killed during the year.

INTRODUCTION

Although the take of harbor porpoise, Phocoena phocoena, is not permitted under the Marine Mammal Protection Act of 1972, some are taken incidentally in the nets fishing off California. It is estimated that 300 ±95 (SE) harbor porpoise were killed incidentally in set nets off central California during the 1983-84 fishing season (Diamond and Hanan, 1986). Little is known of the biology, abundance, and distribution of these porpoise; or whether the population can withstand the loss of several hundred individuals each season. To address these questions, research into harbor porpoise biology was intensified and population surveys were initiated.

This study was commissioned by the National Marine Fisheries Service, Southwest Region. Its primary purpose is to determine the number of harbor porpoise netted incidentally during the 1984-85 fishing season (April 1, 1984 to March 31, 1985) and to compare this number with that obtained for the 1983-84 season. The procedure for estimating porpoise mortality is described in Diamond and Hanan (1986); the total effort was calculated and then applied to the observations of porpoise taken in the nets.

Legally, "incidental take" means harassing, injuring, or killing marine mammals; in this report it means accidental mortality caused by fishing nets. Porpoise caught in nets and released alive or taken intentionally are not included.

Observations by personnel of the California Department of Fish and Game (DFG) for the 1983-84 and 1984-85 fishing seasons indicated that harbor porpoise were taken only in nearshore set nets. Based on this criterion, additional field observations, and the knowledge that harbor porpoise range south as far as Point Conception, California (Dohl et al. 1983), the only fishery that might take harbor porpoise is the halibut/flounder/shark set net fishery of central California. For sampling and analysis, this fishery was divided into three areas: the San Francisco area (Sonoma-Mendocino county line to Pigeon Point), the Monterey Bay area (Pigeon Point to Point Sur), and the Morro Bay area (Point Sur to Point Arguello, Figure 1). Since each area is characterized by its own fishing fleet and specific fishing methods, three separate sampling programs were developed and implemented by DFG. The data obtained from these programs were summarized by fishing area for this report. The terms "fleet" and "area" will be used interchangeably when fishing is discussed during the analysis of a particular sampling program.

The halibut/flounder/shark set net fisheries utilize vertical walls of netting which are anchored at each end and referred to as set nets. There are three types:

1) gill nets, constructed of one wall made of approximately 6-8 inch (152-203 mm) webbing hung between

the lead and cork lines with very little vertical slack;

2) trammel nets, constructed of two or three walls of webbing hung between the same lead and cork lines; the loosely hung inner panel is made of approximately 8 inch (203 mm) mesh and the tautly hung outer panels consist of 24 to 32 inch (610 to 812 mm) mesh;

3) suspendered gill nets, constructed with vertical lines (called suspenders) attached periodically (6-12 ft, 1.83-3.66 m) from the lead line to the cork line. The suspenders decrease the distance from the lead line to the cork line and increase vertical slack in the net. Legally, any gill net with vertical slack is a trammel net (California Fish and Game Code, Section 8700), but in this report suspendered gill nets are analyzed separately.

METHODS OF OBSERVATION

Observations were made in three ways: aboard the fishing vessel, alongside the fishing vessel from a skiff, and from shore using high-powered telescopes. Observations in the San Francisco area were made aboard the vessel, with observers riding for an entire fishing trip. Most observations in the Monterey Bay area were made from a skiff pulled alongside the fishing vessel; although some observations were made from shore along the coast south of Monterey Bay. The lack of cooperation in the Morro Bay area was a problem and a large number of observations were made with shore-based telescopes and some observations were made alongside and onboard fishing vessels.

In each area, there were instances when only part of the net was observed as it was being hauled aboard. This was especially common during telescope observations, when the position of the sun and the fishing vessel relative to the observer caused extremely variable sighting conditions. Each partial observation was treated as a percentage of net observed and used in the analysis.

ESTIMATES OF TOTAL EFFORT

A unit of effort is defined as one net deployed to fish and then retrieved (a set). Total effort is the total number of sets during the fishing year and was obtained from three data sources: fishing logs, landing receipts (pink tickets), and observations of fishing activities. Fishing logs were used as the primary data base and were supplemented by landing receipts and observations.

Fishing effort was divided into two categories: 1) logged days (as reported on the daily fishing logs) and 2) unlogged days, which were estimated from observed fishing (without corresponding logs) and from landing receipts (without corresponding logs). Logged days were added to unlogged days to obtain the total number of days fished in an area. The mean sets per day per boat (many boats fish more than one net) was obtained by dividing total net length per boat (as reported on the fishing logs) by average net length (from onboard or alongside observations). Total effort (in sets) was then total days fished multiplied by mean number of sets per boat per day.

Total effort (sets) for the fishing year was calculated as:

Total effort= Total days (logged + unlogged) X mean #sets/day.

ESTIMATES OF HARBOR PORPOISE TAKE

Contagion or Clustering of Harbor Porpoise Take

Chi-square tests were used to measure for contagion or clustering of the observed porpoise take by fishing parameters including: season, fishing location, water depth, net length, net type, net material, observation type, and soak time. A significant Chi-square value indicated a need to stratify effort and porpoise take by the significant parameter when estimating total mortality.

Calculations of Total Take

In the 1983-84 harbor porpoise mortality estimate, three separate calculation methods (straight ratio, poisson, and bootstrap) were used to estimate harbor porpoise mortality (Diamond and Hanan 1986). Each method calculated a subtotal by area and then the subtotals were combined to obtain the total California take. We used the same methods in this paper except for areas with observed sets with two or more porpoise taken. These multiple catches made the poisson distribution inappropriate for describing porpoise take, since the poisson distribution assumes that the presence of one animal in a net will not influence the chance of catching others. For those areas

with multiple catches the negative binomial distribution, which allows for multiple catches, was used. The negative binomial was applied to the data as follows:

a) a mean take per set (m) was calculated using the total number of animals killed divided by the number of sets observed,

b) a dispersion value (k) was calculated using Fisher's maximum likelihood method (Bliss and Fisher 1953), and

c) a probability of take was generated by computer (Mark Mangel, U. C. Davis, pers com.) using the formulae of Bliss and Fisher (1953):

$$P_x = (k+x-1)!\ R^x / x!(k-1)\ q^k$$

$$T_i = P_i * S_i$$

where (for area i):

P = probability of taking x animals in a net
x = number of animals in a set (0,1,2, or more)
k = dispersion parameter
m = mean number of animals per net
R = m/(k+m)
q = 1+ m/k
T = total number of animals killed
S = estimated total number of sets

Subtotals for each area were calculated and then the subtotals were summed for the 1984-85 estimate of harbor porpoise take.

RESULTS

San Francisco Area

We compared fleet effort, sampling effort, and harbor porpoise take by month fishing block, water depth, soak hours, net length, net type, and net material (Figures 2-8). Chi-square analysis showed that the incidental take of harbor porpoise was clustered by area ($P<.025$) and water depth ($P<.025$); i.e. the observed take was significantly higher in the Bodega Bay subarea (Fish and Game Blocks 422-439, Appendices I and II) and in water deeper than 15 fathoms (fm). Therefore, two series of calculations for estimating the kill were made, an unstratified estimate and an estimate stratified by subarea and water depth. Negative binomial distributions were used for the unstratified estimate, the estimate for the Bodega Bay subarea at 15 fms or less, and the Bodega Bay subarea at deeper than 15 fms. Poisson distribution was used for the San Francisco/Half Moon Bay subarea at 15 fm or less. This subarea at deeper than 15 fms had only 1 observation, with no observed kill.

Total fishing effort was estimated at 4117 $\pm$269 (SE) sets (Table 1) and approximately 7.3 percent of the estimated effort was observed by DFG (Table 2). When total effort was applied to the observed mortality rate, the unstratified estimates of porpoise take using the three methods of calculating (straight ratio, Poission/negative binomial, and bootstrap) were 193, 166, and 192 respectively, with 95% confidence levels ranging from 66 to 309 porpoise depending on calculation method used (Table 3). The stratified estimates totaled 165, 143, and 170 with 95% confidence levels ranging from 10 to 320 porpoise taken depending on calculation method used.

Monterey Bay Area

Fleet effort, sampling effort, and harbor porpoise take were compared by month, fishing block, water depth, soak hours, net length, net type, and net material (Figures 9-16). The take of porpoise was proportional to sampling effort for all fishing parameters examined. Total fishing effort was estimated at 1606 $\pm$139 (SE) sets (Table 1) with approximately 7.8 percent of the sets observed. When effort was applied to the observed porpoise mortality rate for the Monterey Bay area, the estimates of take were 25 or 26 with 95% confidence levels ranging from 0 to 62 porpoise depending on calculation method used (Table 3).

Morro Bay Area

Fleet effort, sampling effort, and harbor porpoise take were compared by month, fishing block, water depth, soak hours, net length, net type, and net material (Figures 17-24). Chi-square analysis showed no clustering of take by any of those fishing

parameters, but did reveal a tendency for fewer observed porpoise in telescope data than in the onboard and alongside data ($.05<P<.10$).

Total fishing effort was estimated at 4115 $\pm$293 (SE) sets (Table 1), approximately 9.1 percent of which were observed. When that effort was applied to the harbor porpoise mortality rate, the estimates of take were 27 or 33 with 95% confidence levels ranging from 3 to 57 porpoise depending on calculation method used (Table 3).

California Totals

Total effort during the fishing year was approximately 9,838 sets and the unstratified estimates of take were 251, 224, and 255 respectively with 95% confidence levels ranging from 108 to 380 porpoise depending on calculation method used (Tables 1 and 3). The stratified estimates were 223 or 200 with 95% confidence levels ranging from 99 to 336 porpoise taken depending on calculation method used.

DISCUSSION

This paper presents estimates of the number of harbor porpoise killed during the 1984-85 fishing year. They are lower than the 1983-84 estimates (Diamond and Hanan, 1986) but within the same general range. Total fishing effort increased slightly from the 1983-84 to the 1984-85 fishing year (9122 to 9838 sets) and there was some redistribution by area. The number of observations and the percentage of fleet effort observed increased between years (5.1% in 1983-84 to 8.1% in 1984-85), but the observed porpoise take remained at about the same level (14 in 1983-84 and 19 in 1984-85). In 1983-84, there was no clustering of porpoise take by area but in 1984-85 there was a significantly higher take in the Bodega Bay region of the San Francisco area. Changes in fishing regulations, fishing conditions, observation methods, and perhaps even porpoise behavior between the two years might account for the slight decrease in total harbor porpoise taken; however, at this time we cannot quantify the possible influences of these factors.

ACKNOWLEDGEMENTS

We sincerely thank Marija Vojkovich and Rhonda Reed (DFG) for valuable computer assistance; Paul Wild, Robert Hardy, Charles Haugen, and Fred Wendell (DFG) for use of their observational data and advice about the fisheries in their study areas; and Alec MacCall (NMFS) for advice and expertise in the calculations. We also thank Rocky French, Vidal Torres, and Sallie Beavers for their help in this study. We thank Hal Clemens for his editorial advice.

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TABLE 1. Estimates of total effort by area (SF= San Francisco, MntB= Monterey Bay, MB= Morro Bay) based on fishing logs, landing receipts, and DFG observations during 1984-85.

AREA	LOGGED DAYS	#LAND-INGS	UN-LOGGED DAYS	TOTAL DAYS	#SETS/ DAY (±SE)	TOTAL EFFORT (±SE)
SF	1100	354	43	1497	2.75 ±.18	4117 ±269
MntB	496	168	31	695	2.31 ±.20	1606 ±139
MB	1157	93	24	1274	3.23 ±.23	4115 ±293
TOTAL						9838 ±421
SF (stratified by subarea and water depth)						
Bodega Bay	≤15 fm					1182
	>15 fm					436
SF and Halfmoon Bays	≤15 fm					2404
	>15 fm					103

TABLE 2. DFG sampling effort by area for 1984-85. The number of samples represents the sum of the percentage of observed nets rounded to the nearest integer.

AREA	#SAMPLES	#HARBOR PORPOISE TAKEN	%EFFORT OBSERVED
San Francisco	299	14	7.3%
Monterey Bay	126	2	7.8%
Morro Bay	374	3	9.1%
TOTAL	799	19	8.1%

TABLE 3. Estimates of the number of harbor porpoise taken by set net fisheries off California for 1984-85.

AREA	METHOD:	MEAN KILL ESTIMATE ±SE RATIO	POISSON/ NEGATIVE BINOMIAL	BOOTSTRAP
San Francisco		193 ±59	166 ±51	192 ±54
95% CI Range		77-309	66-266	86-298
Monterey Bay		26 ±18	25 ±18	26 ±19
95% CI Range		0-62	0-61	0-64
Morro Bay		33 ±19	33 ±19	27 ± 9
95% CI Range		12-54	12-54	3-57
San Francisco Area stratified by subarea and water depth				
Bodega	≤15 fm	83 ±33	73 ±29	83 ±36
95% CI RANGE		18-148	14-130	10-156
	>15 fm	66 ±34	54 ±28	65 ±34
95% CI RANGE		0-134	0-109	0-132
SF and Halfmoon	≤15 fm	16 ±16	16 ±16	22 ±12
95% CI RANGE		0-48	0-48	0-46
	>15 fm	1 OBSERVATION/ NO TAKE/ EFFORT=103		
AREA SUBTOTAL		165 ±50	143 ±43	170 ±51
		115-215	100-186	119-221
ESTIMATED CALIFORNIA TOTALS				
UNSTRATIFIED		251 ±65	224 ±58	255 ±60
95% CI RANGE		122-380	108-339	135-375
STRATIFIED		223 ±56	200 ±50	226 ±54
95% CI RANGE		111-336	99-301	108-334

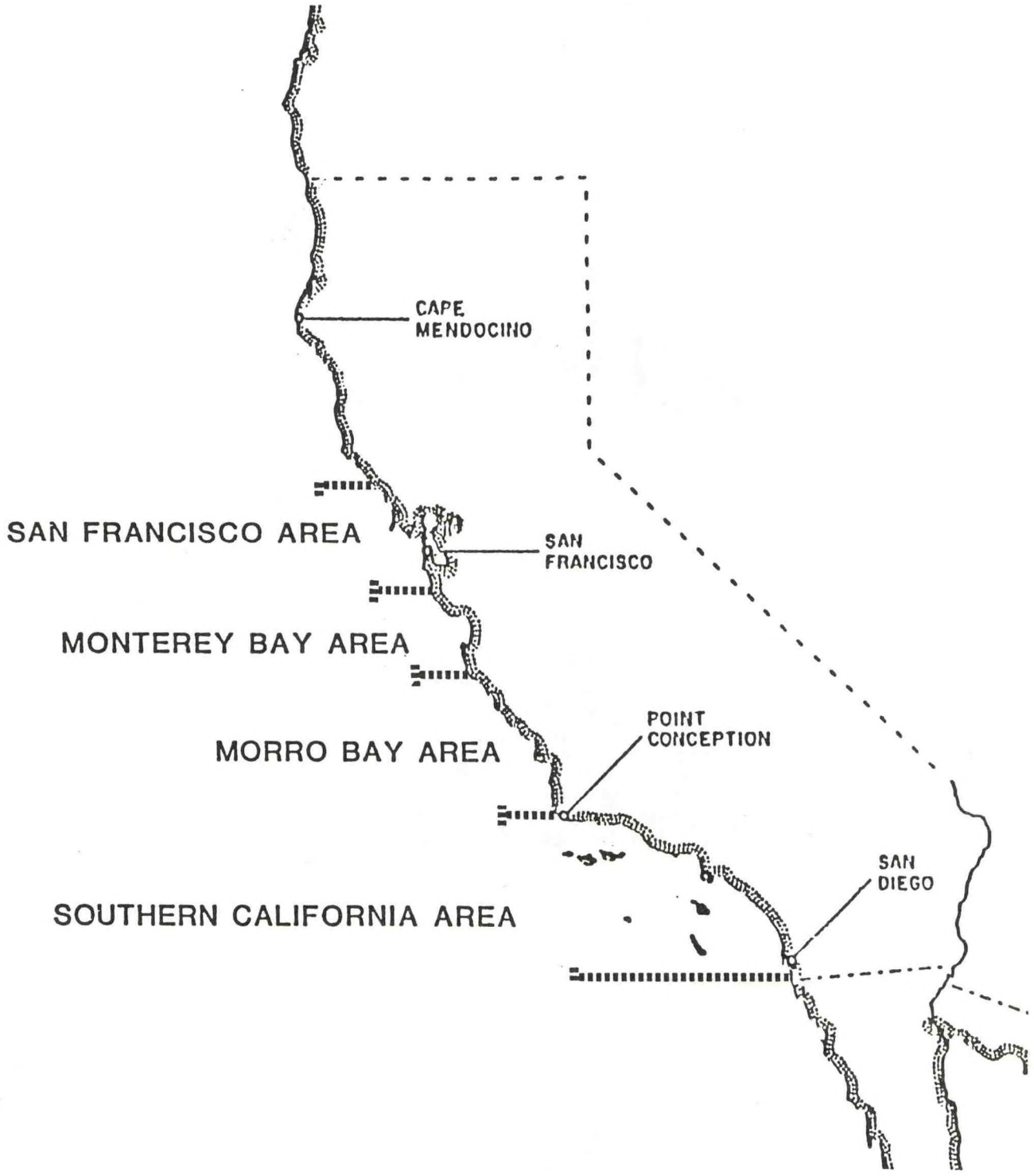

Figure 1. California set net fleets or areas. During 1984-85, harbor porpoise were taken incidentally to fishing in the San Francisco, Monterey Bay, and Morro Bay areas.

SAN FRANCISCO

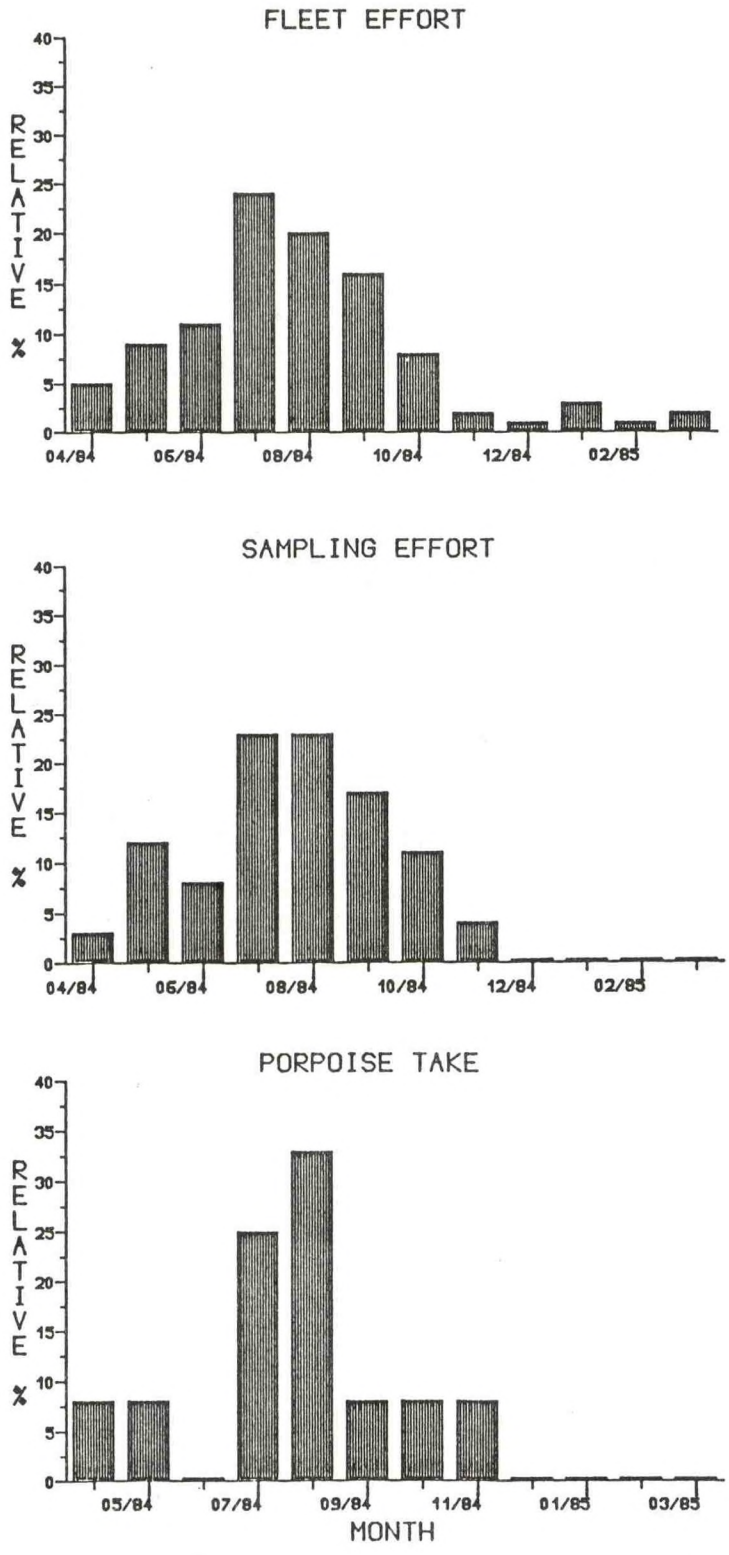

Figure 2. Relative percentages of fishing effort, sampling effort, and harbor porpoise incidental take by month in the San Francisco area, April 1984 to March 1985.

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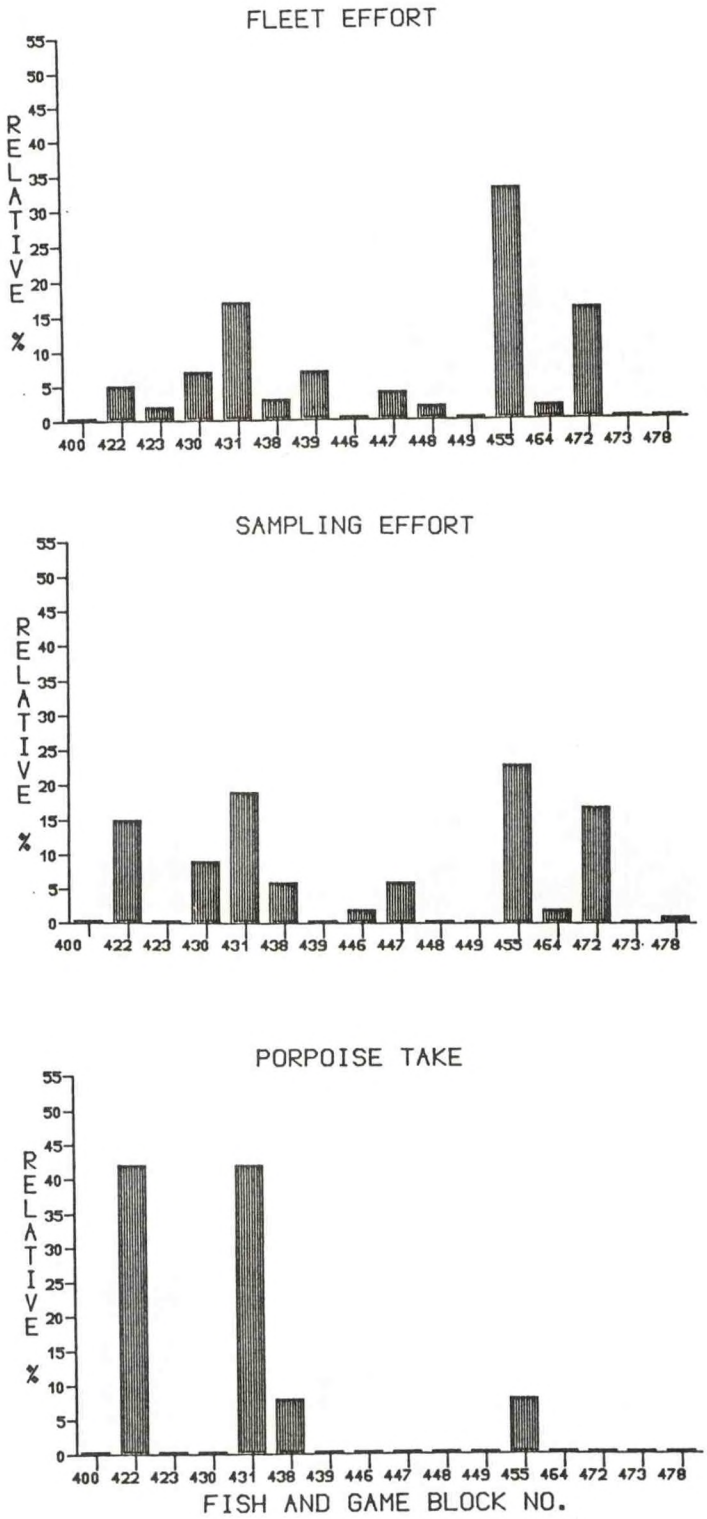

Figure 3. Relative percentages of fishing effort, sampling effort, and harbor porpoise incidental take by Fish and Game block number (see Appendices I and II) in the San Francisco area, April 1984 to March 1985.

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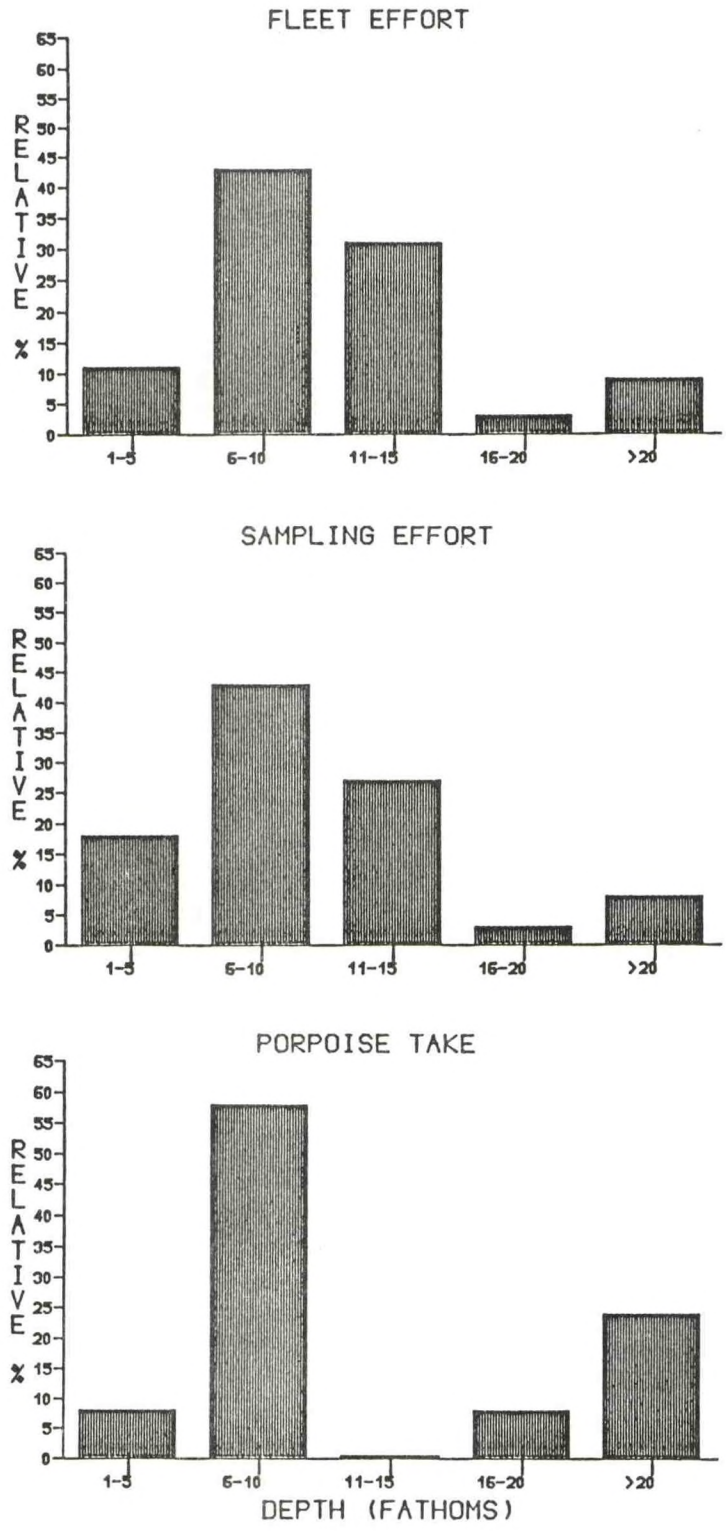

Figure 4. Relative percentages of fishing effort, sampling effort, and harbor porpoise incidental take by water depth in the San Francisco area, April 1984 to March 1985.

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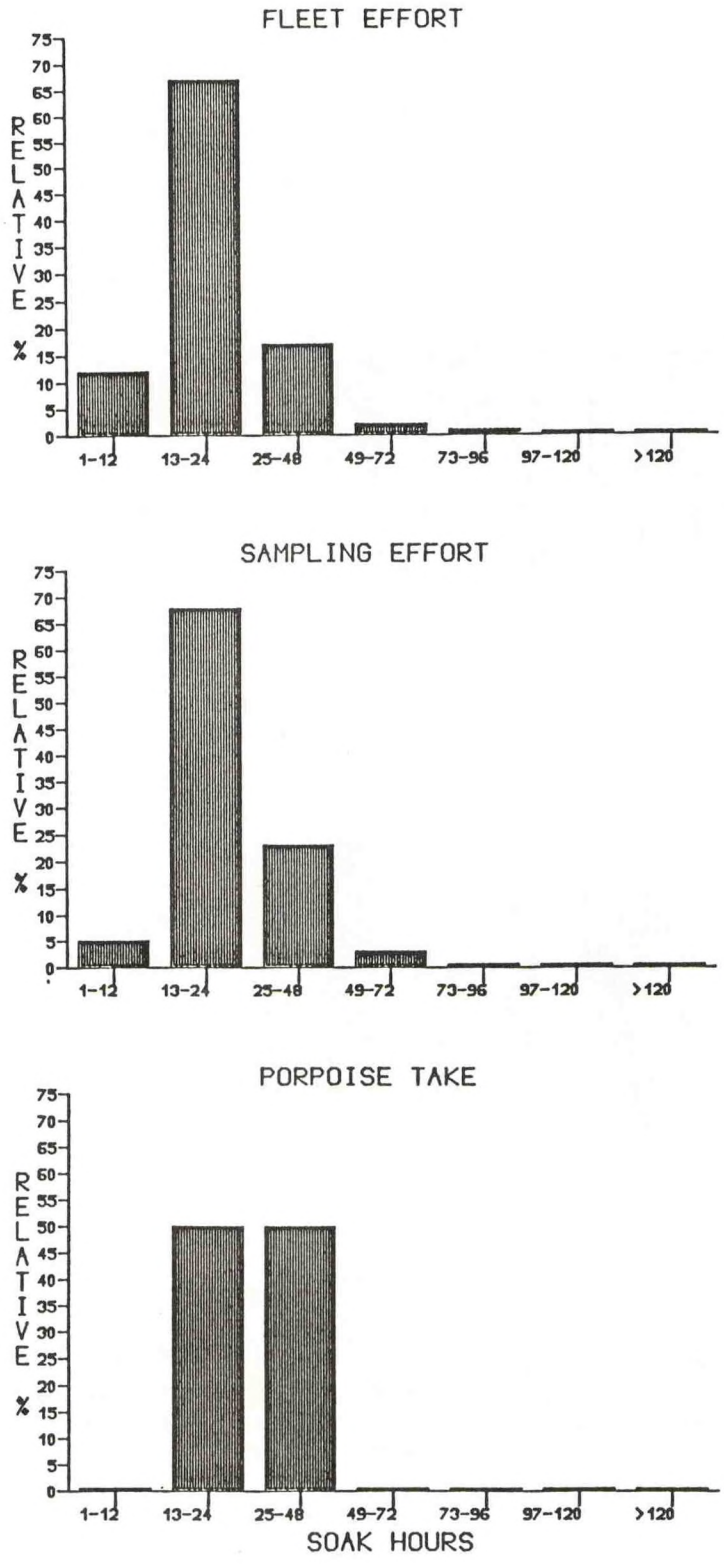

Figure 5. Relative percentages of fishing effort, sampling effort, and harbor porpoise incidental take by soak hours in the San Francisco area, April 1984 to March 1985.

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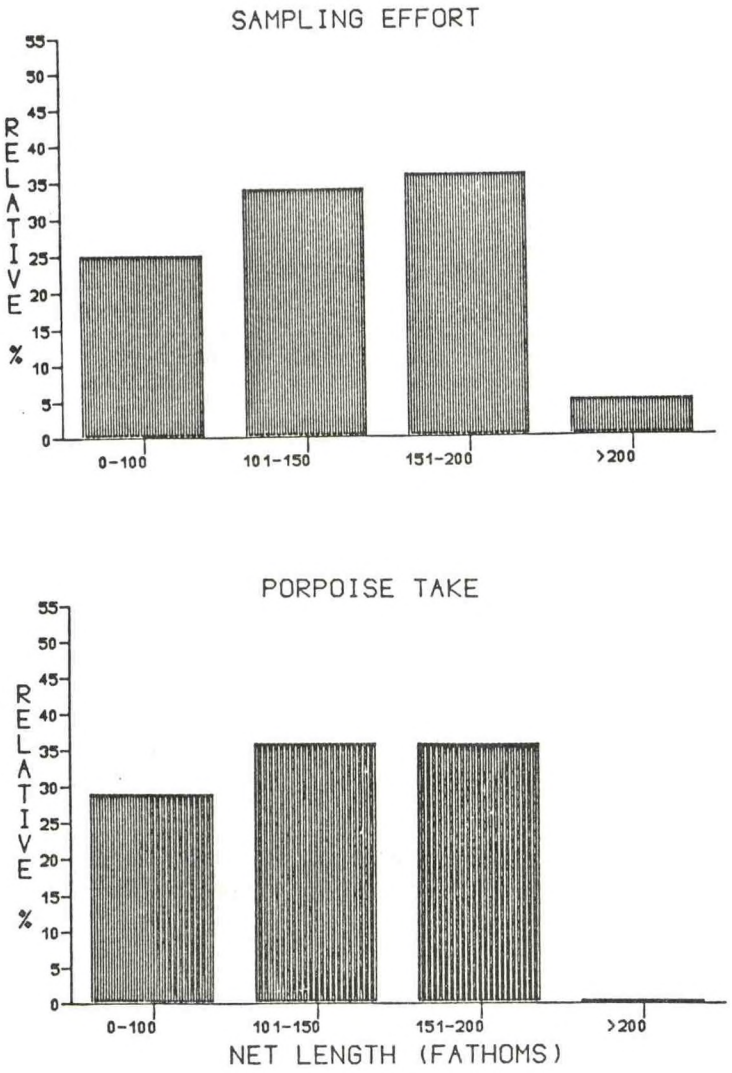

Figure 6. Relative percentages of sampling effort, and harbor porpoise incidental take by net length in the San Francisco area, April 1984 to March 1985.

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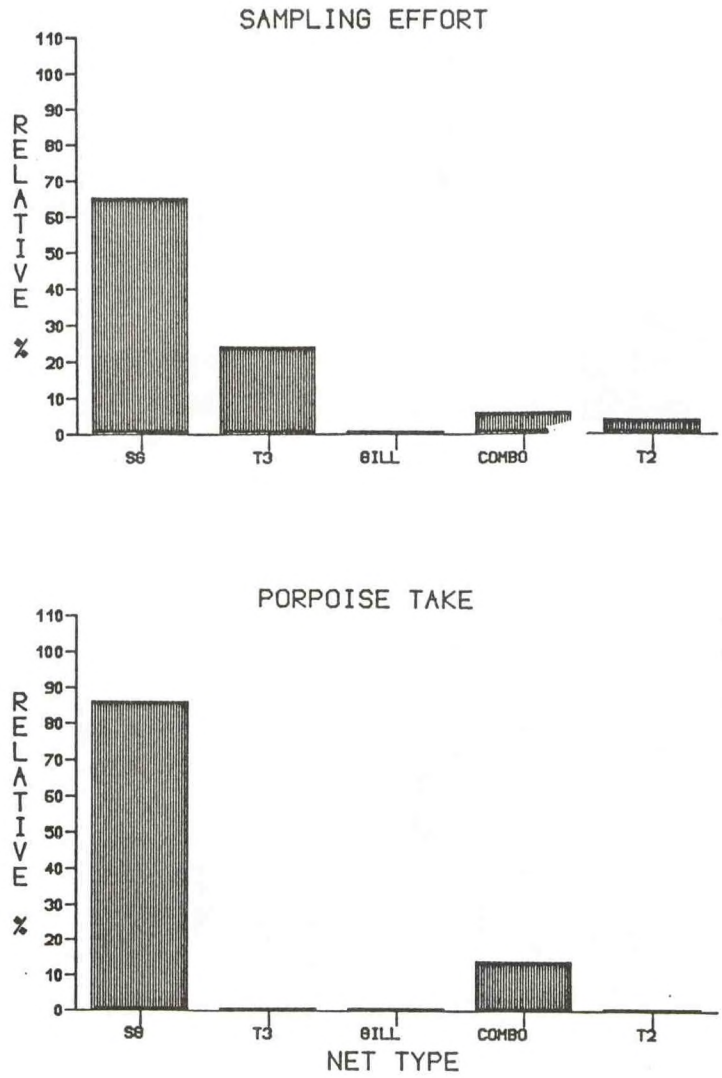

Figure 7. Relative percentages of sampling effort, and harbor porpoise incidental take by net type in the San Francisco area, April 1984 to March 1985. SG = suspendered gill net, T3 = 3-walled trammel net, Gill = gill net, Combo = combination of net types, T2 = 2-walled trammel net.

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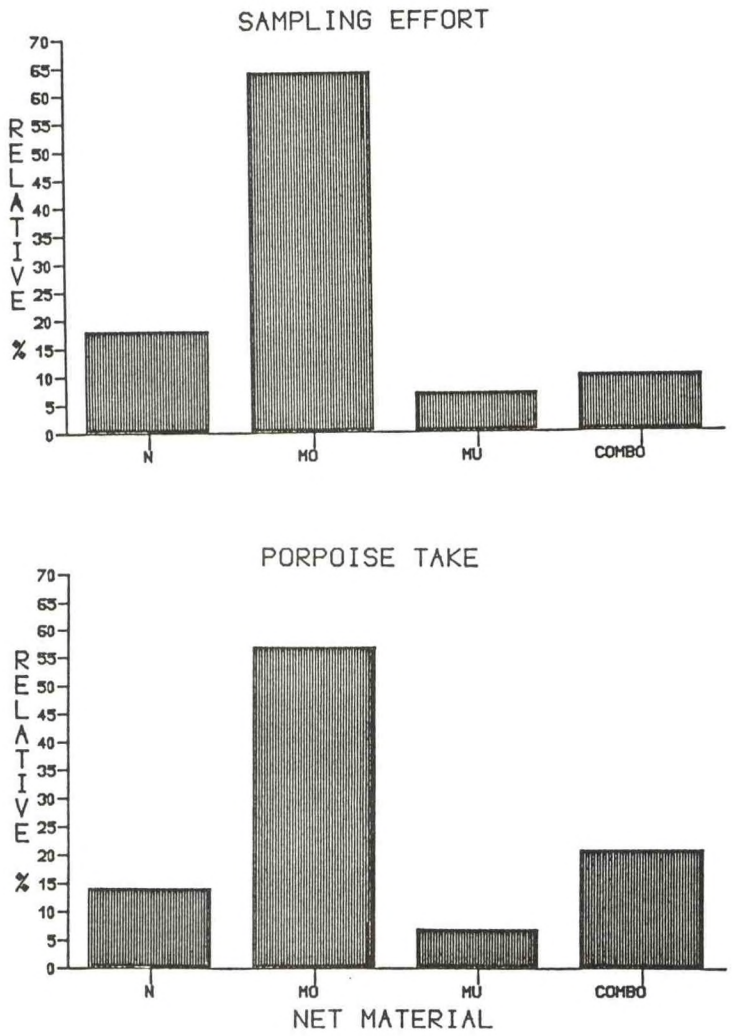

Figure 8. Relative percentages of sampling effort and harbor porpoise incidental take by net material in the San Francisco area, April 1984 to March 1985. N = multi-filament (nylon), MO = monofilament, MU = multi-monofilament, COMBO = combination of net materials.

MONTEREY

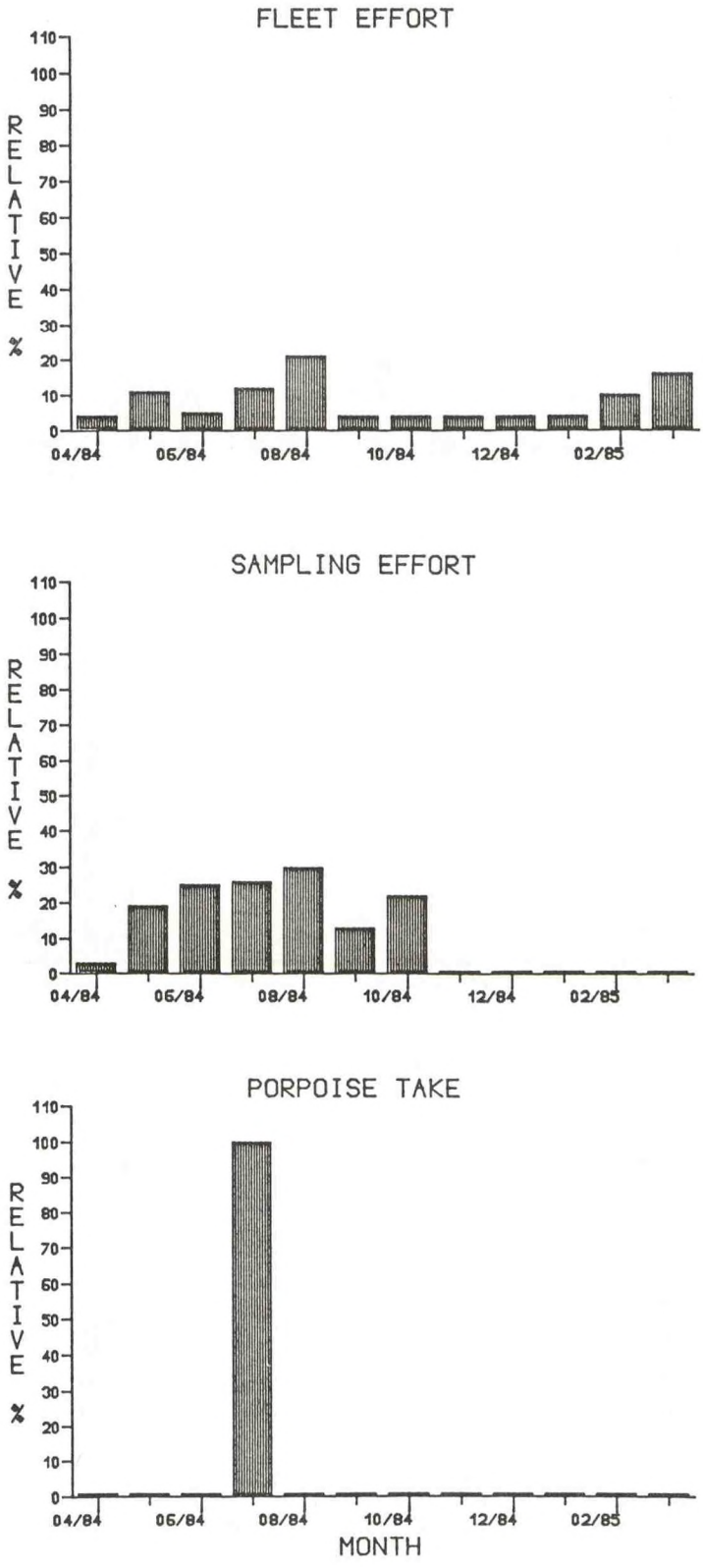

Figure 9. Relative percentages of fishing effort, sampling effort, and harbor porpoise incidental take by month in the Monterey area, April 1984 to March 1985.

MONTEREY

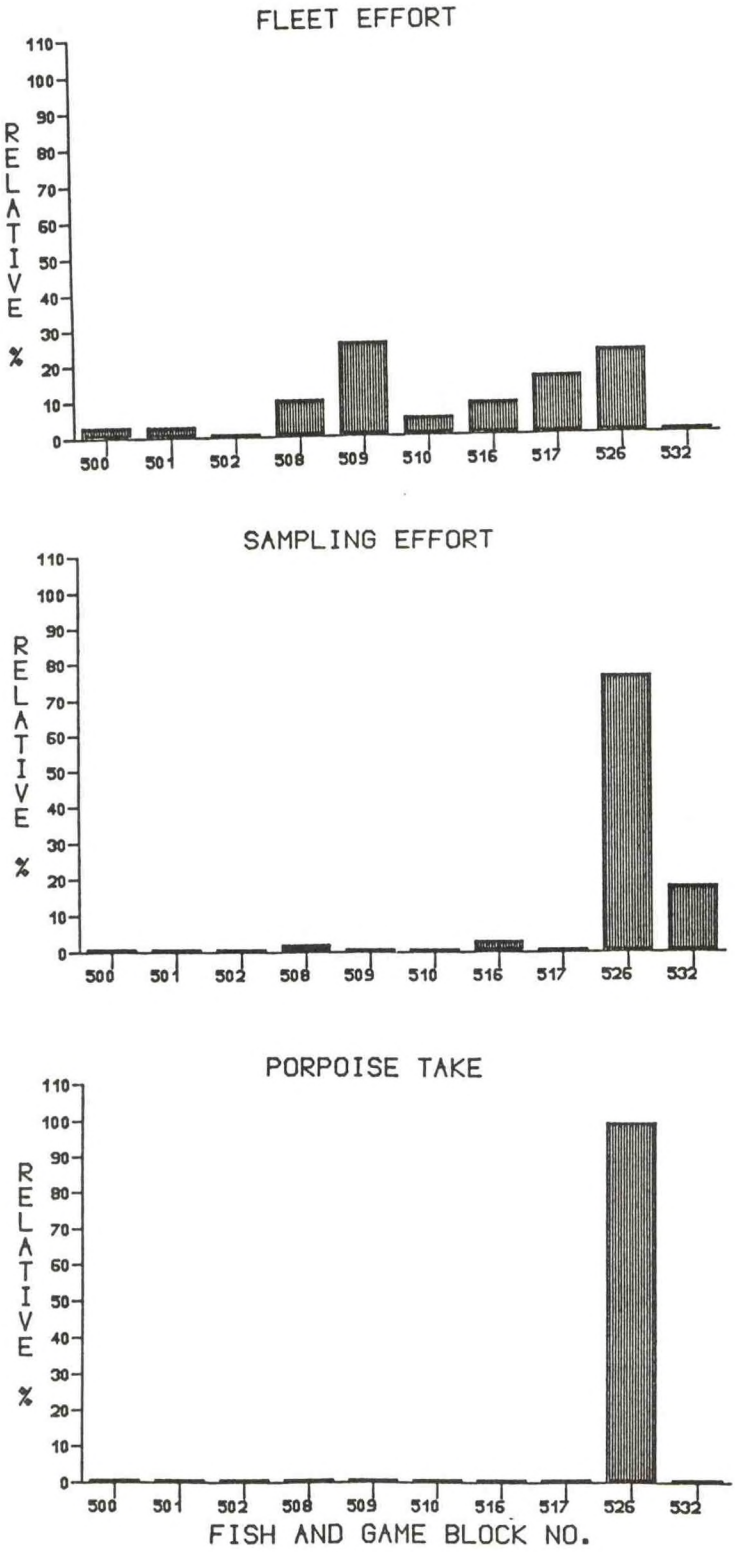

Figure 10. Relative percentages of fishing effort, sampling effort, and harbor porpoise incidental take by Fish and Game block number (see Appendices I and II) in the Monterey area, April 1984 to March 1985.

MONTEREY

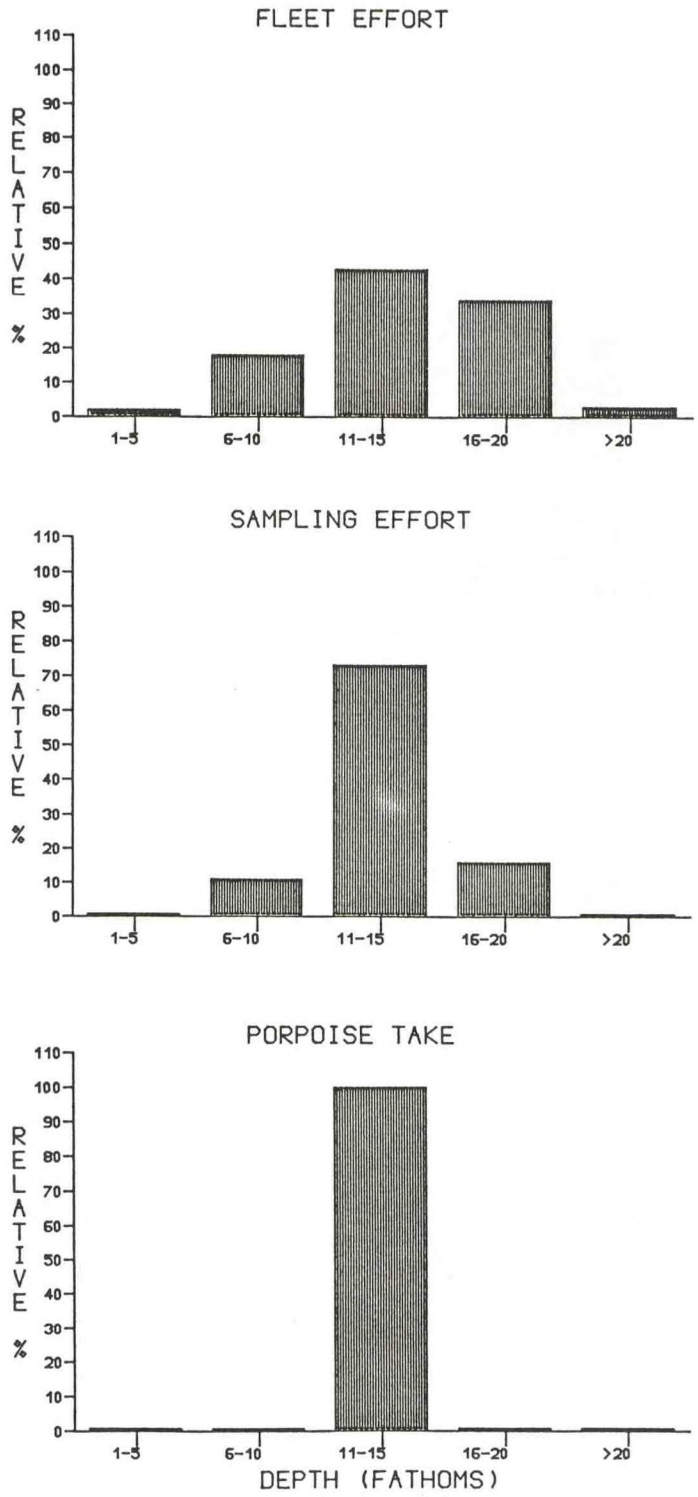

Figure 11. Relative percentages of fishing effort, sampling effort, and harbor porpoise incidental take by water depth in the Monterey area, April 1984 to March 1985.

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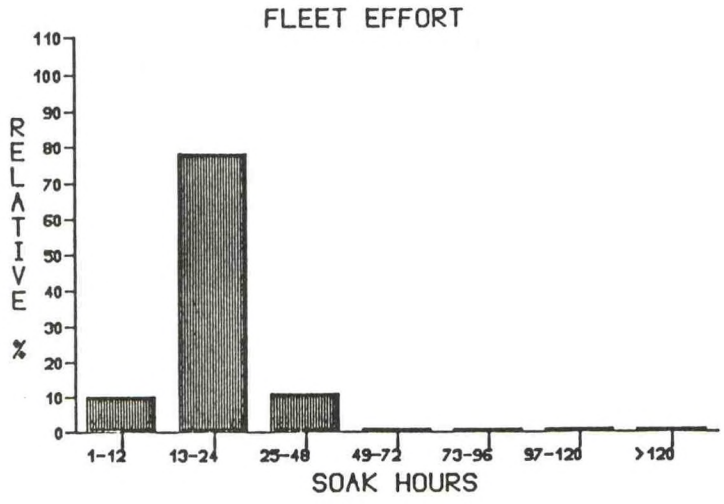

Figure 12. Relative percentages of fishing effort by soak hours in the Monterey area, April 1984 to March 1985.

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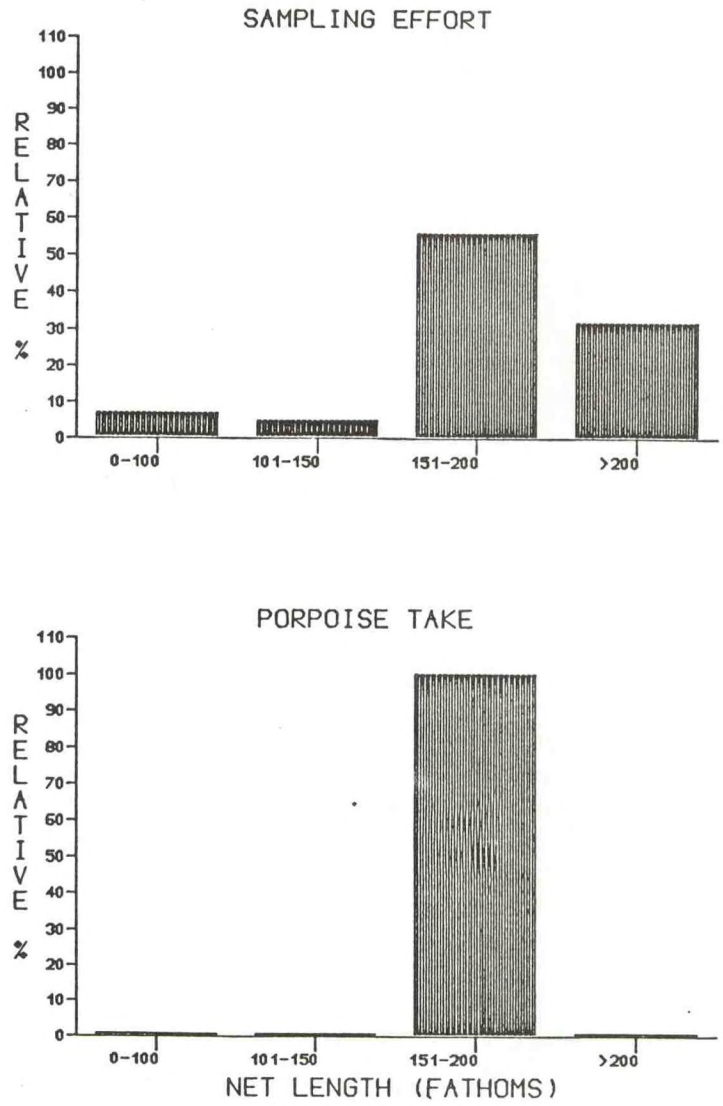

Figure 13. Relative percentages of sampling effort, and harbor porpoise incidental take by net length in the Monterey area, April 1984 to March 1985.

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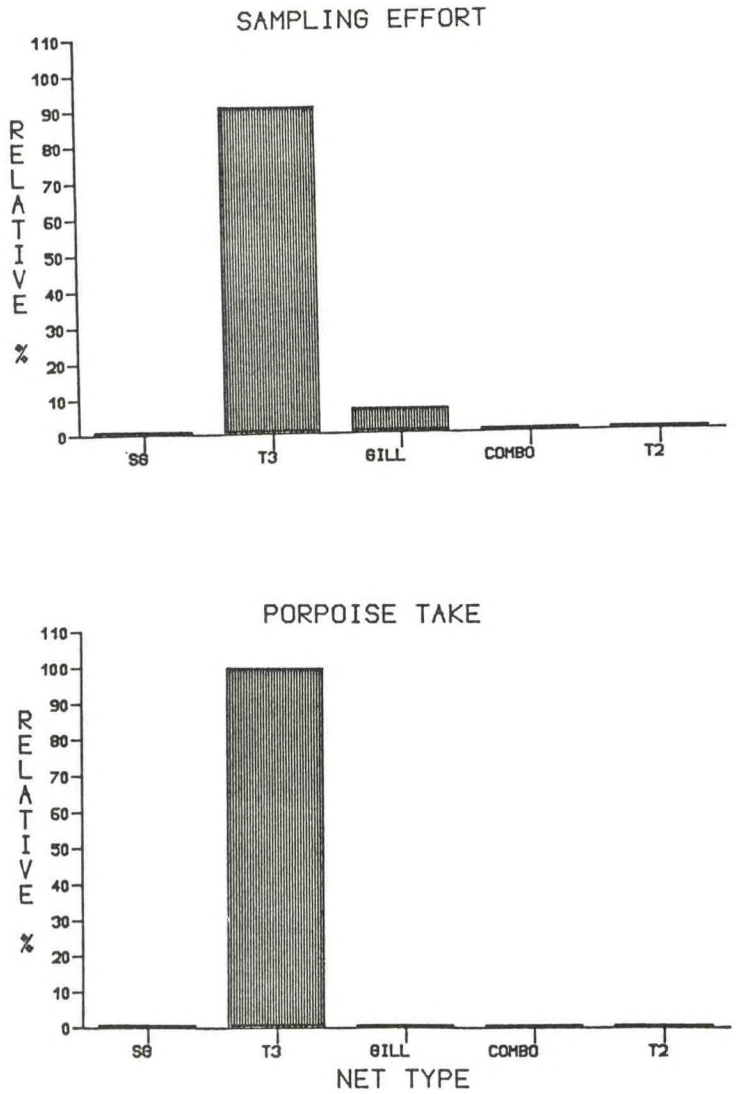

Figure 14. Relative percentages of sampling effort, and harbor porpoise incidental take by net type in the Monterey area, April 1984 to March 1985. SG = suspendered gill net, T3 = 3-walled trammel net, Gill = gill net, Combo = combination of net types, T2 = 2-walled trammel net.

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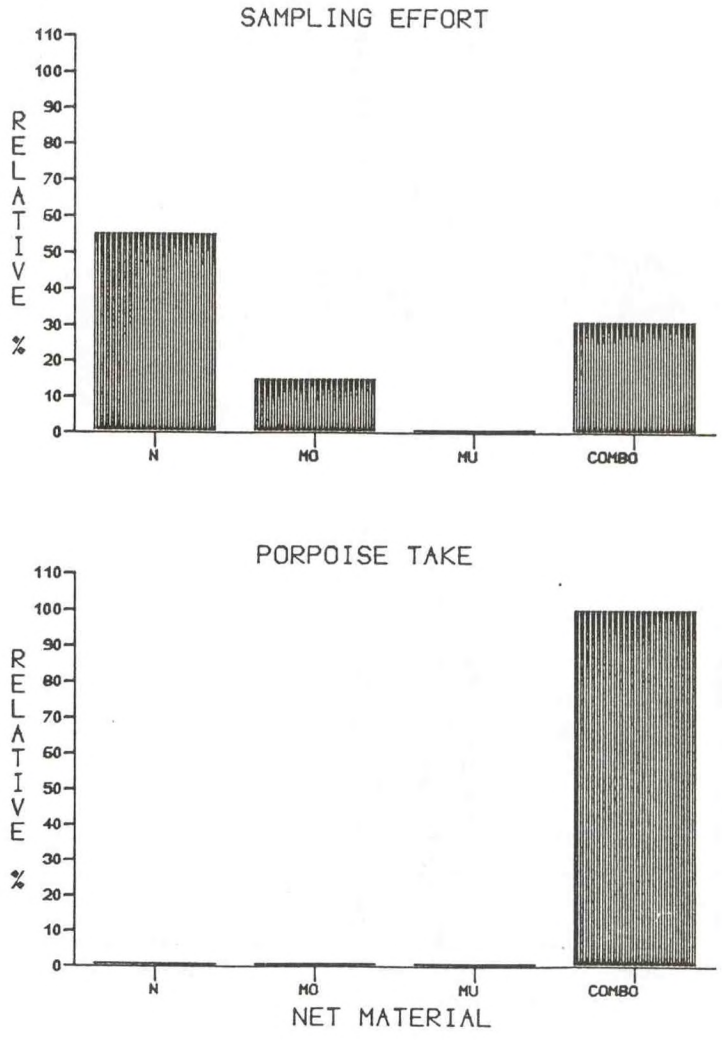

Figure 15. Relative percentages of sampling effort and harbor porpoise incidental take by net material in the Monterey area, April 1984 to March 1985. N = multifilament (nylon), MO = monofilament, MU = multi-monofilament, COMBO = combination of net materials.

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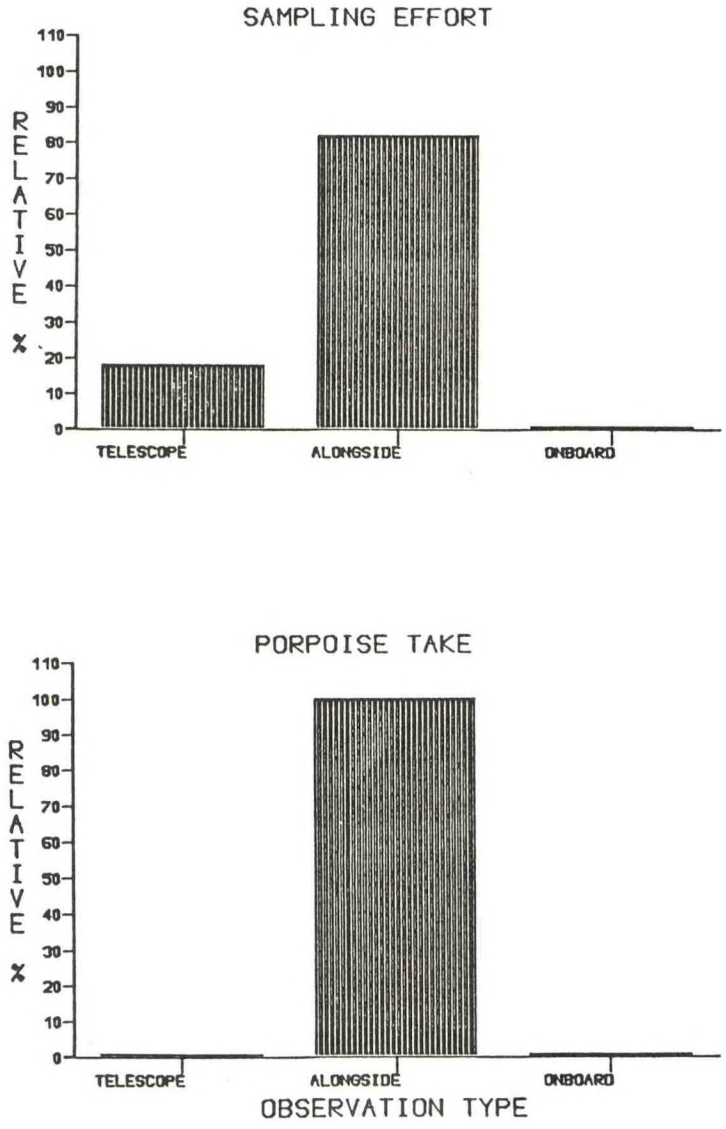


Figure 16. Relative percentages of sampling effort, and harbor porpoise incidental take by observation type in the Monterey area, April 1984 to March 1985.

MORRO BAY

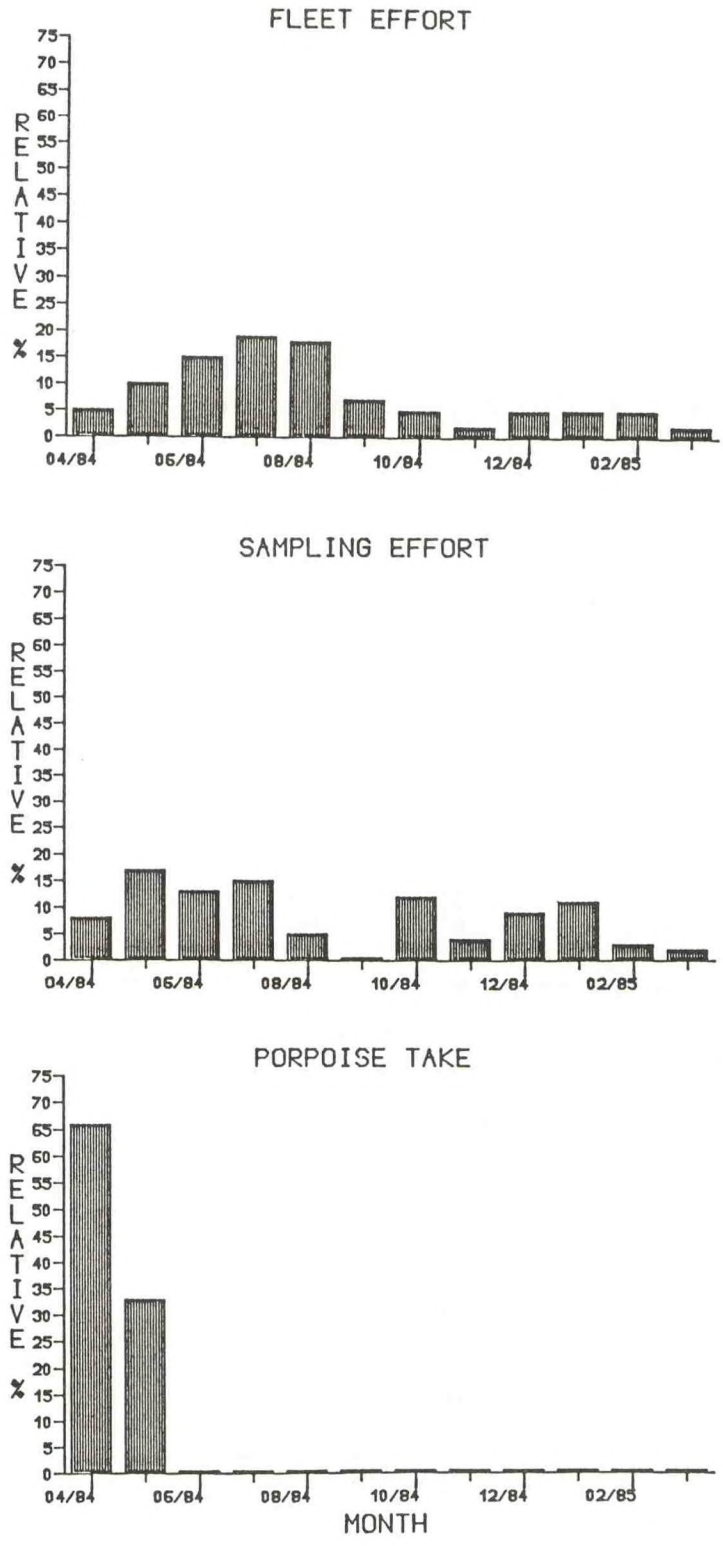


Figure 17. Relative percentages of fishing effort, sampling effort, and harbor porpoise incidental take by month in the Morro Bay area, April 1984 to March 1985.

MORRO BAY

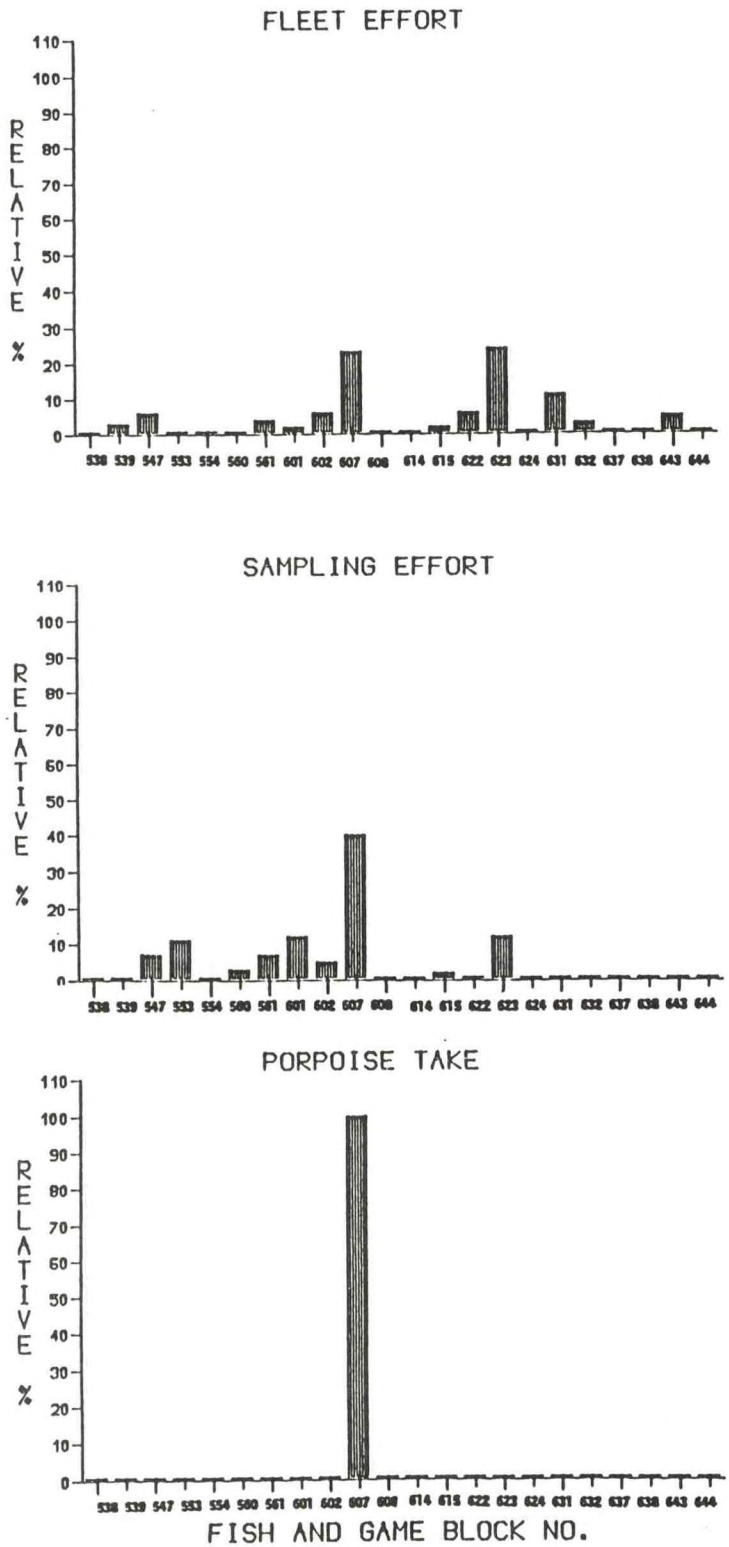


Figure 18. Relative percentages of fishing effort, sampling effort, and harbor porpoise incidental take by Fish and Game block number (see Appendices I and II) in the Morro Bay area, April 1984 to March 1985.

MORRO BAY

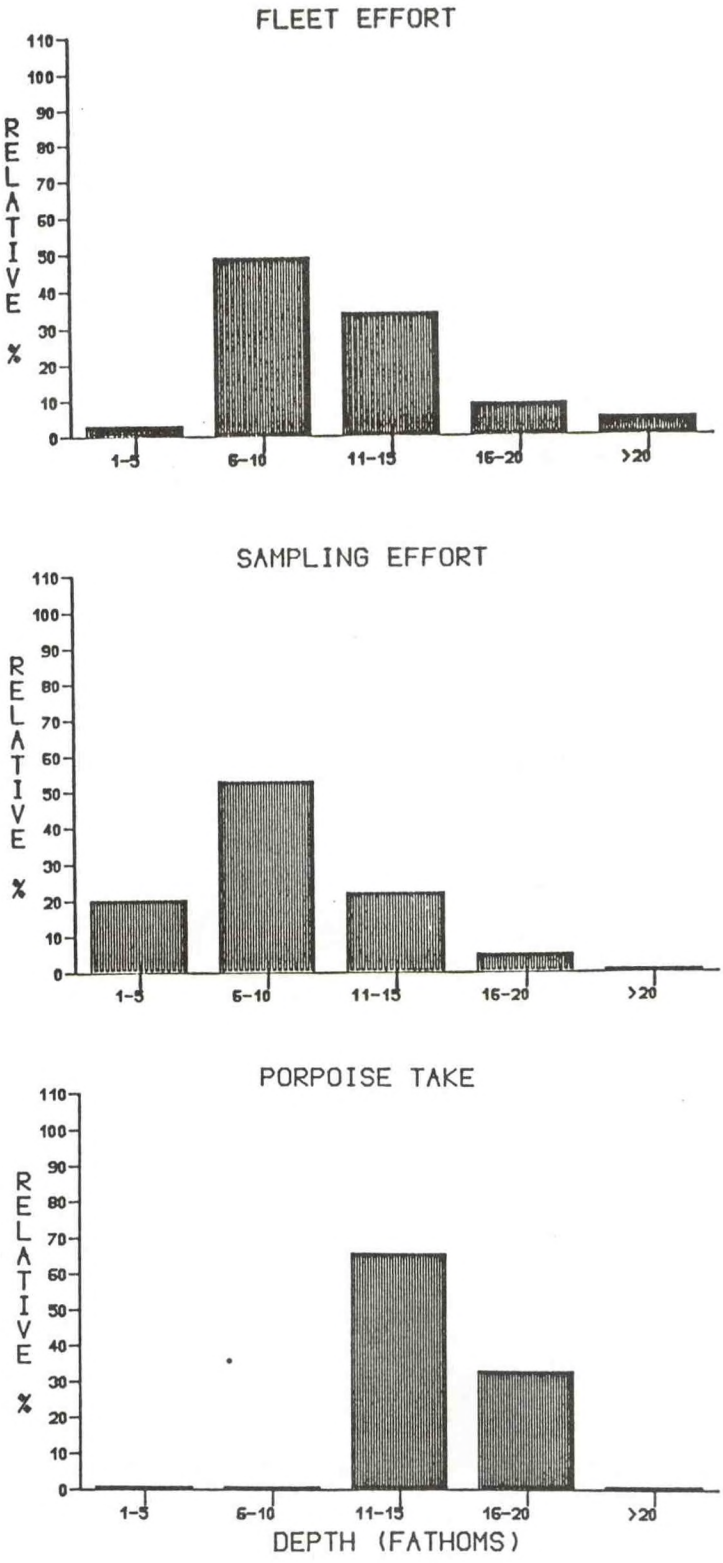


Figure 19. Relative percentages of fishing effort, sampling effort, and harbor porpoise incidental take by water depth in the Morro Bay area, April 1984 to March 1985.

MORRO BAY

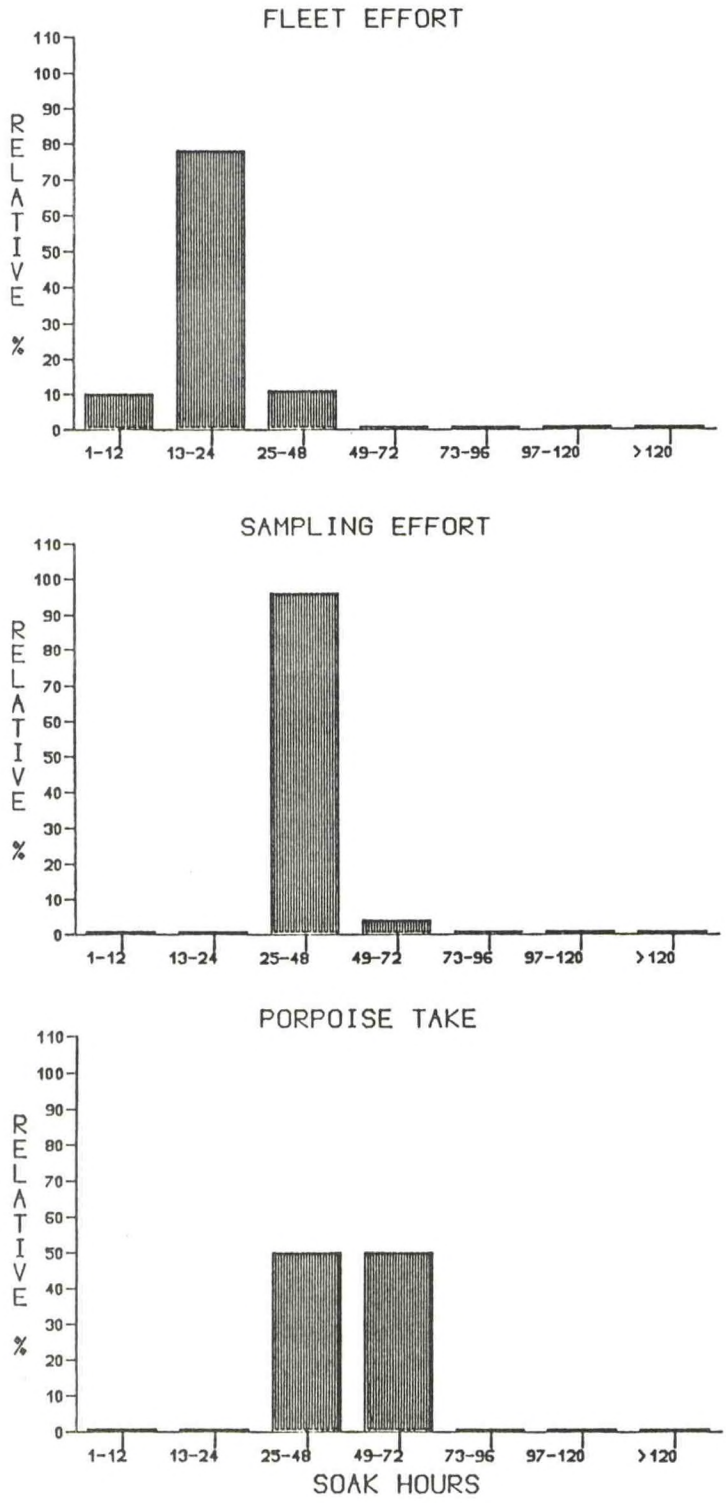


Figure 20. Relative percentages of fishing effort, sampling effort, and harbor porpoise incidental take by soak hours in the Morro Bay area, April 1984 to March 1985.

MORRO BAY

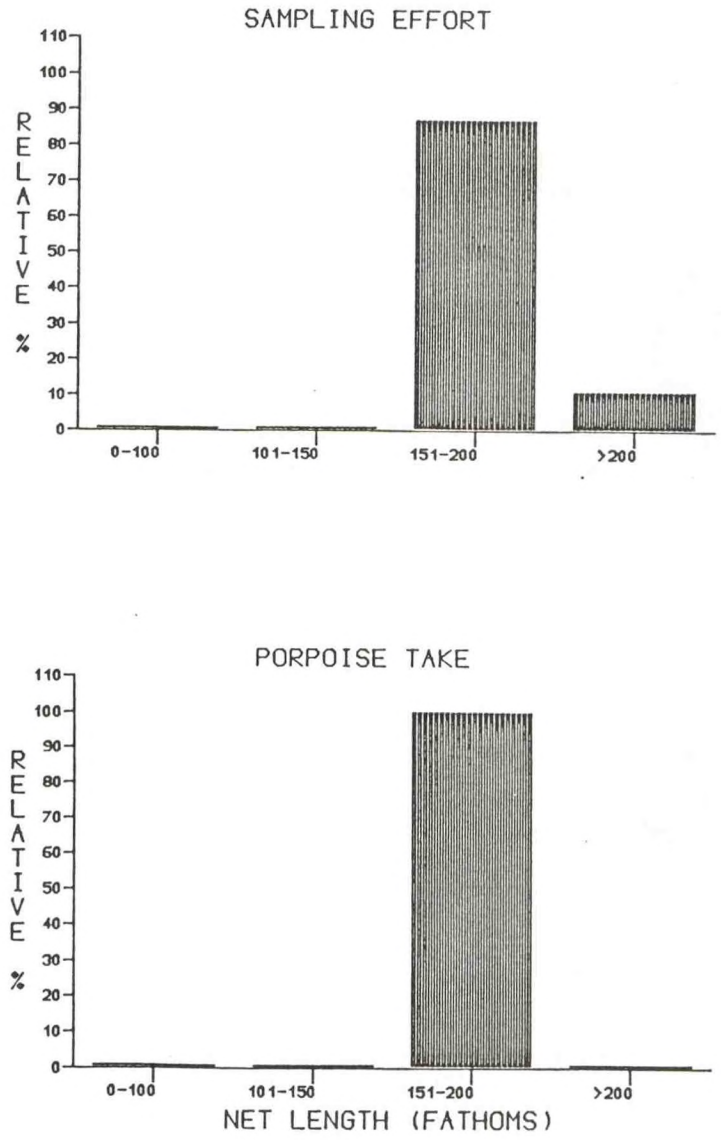


Figure 21. Relative percentages of sampling effort, and harbor porpoise incidental take by net length in the Morro Bay area, April 1984 to March 1985.

MORRO BAY

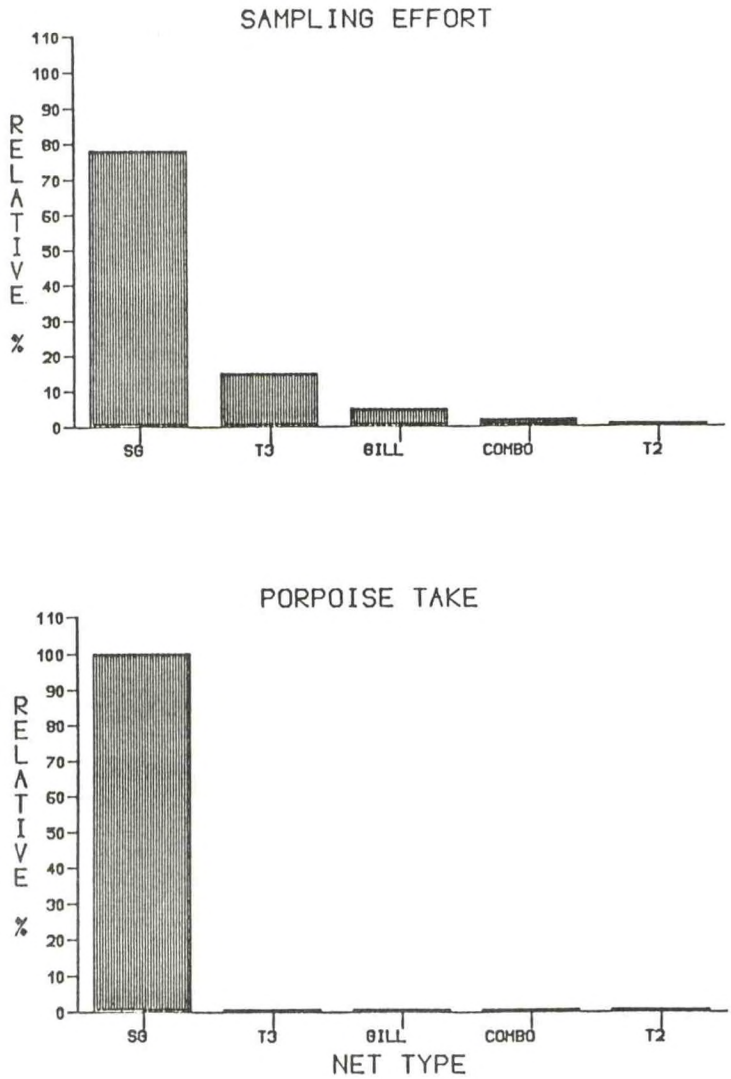


Figure 22. Relative percentages of sampling effort, and harbor porpoise incidental take by net type in the Morro Bay area, April 1984 to March 1985. SG = suspendered gill net, T3 = 3-walled trammel net, Gill = gill net, Combo = combination of net types, T2 = 2-walled trammel net.

MORRO BAY

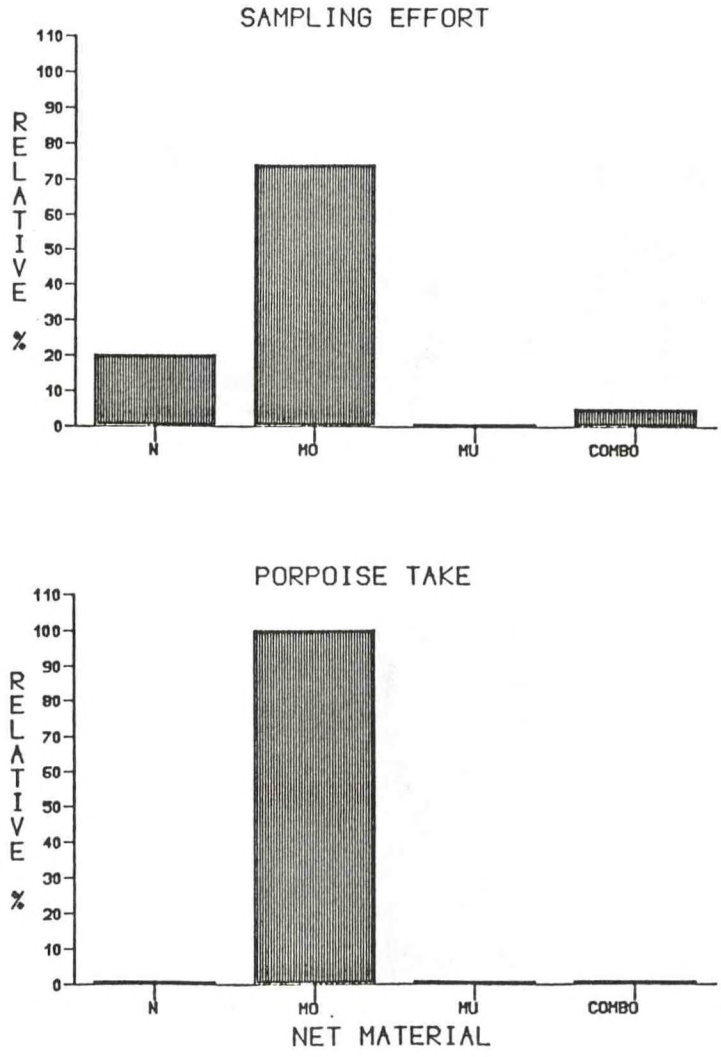


Figure 23. Relative percentages of sampling effort and harbor porpoise incidental take by net material in the Morro Bay area, April 1984 to March 1985. N = multifilament (nylon), MO = monofilament, MU = multi-monofilament, COMBO = combination of net materials.

MORRO BAY

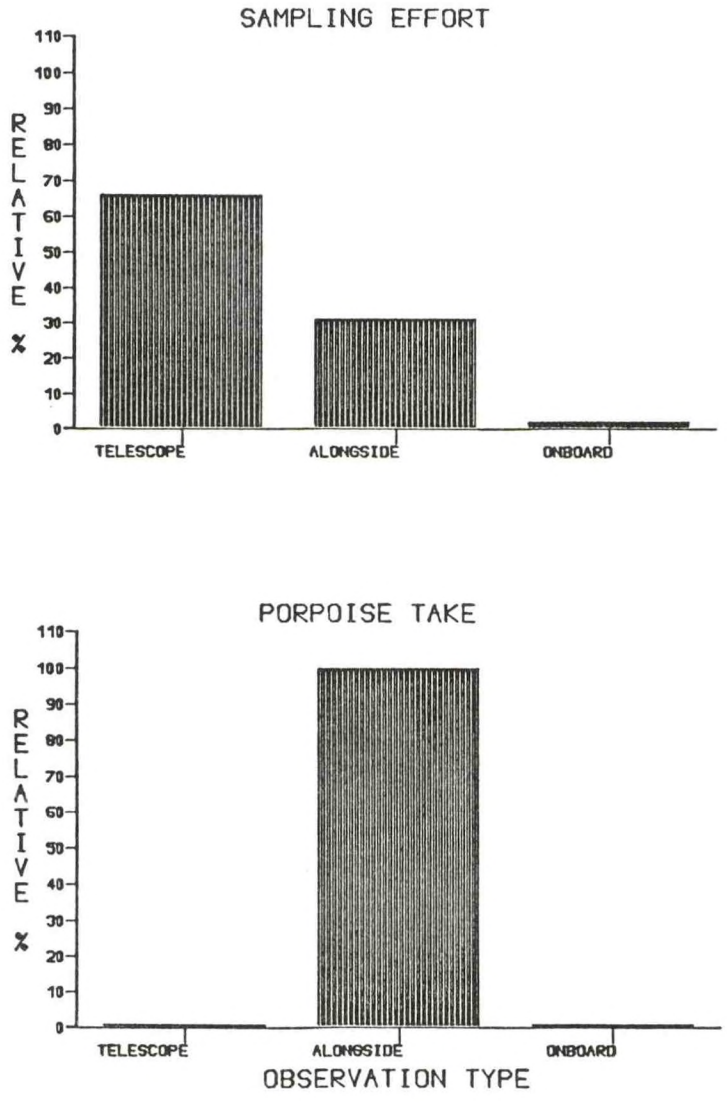
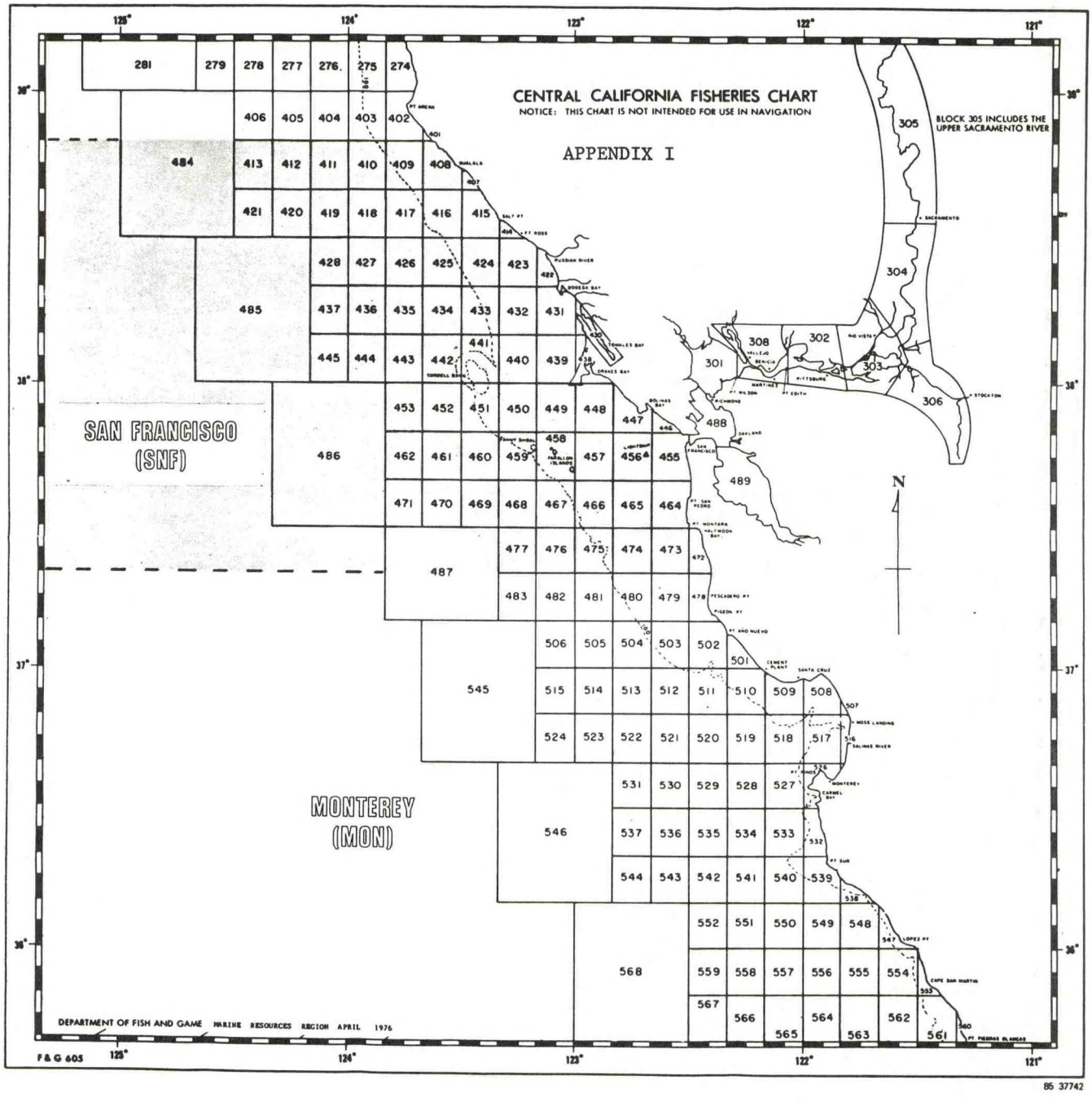
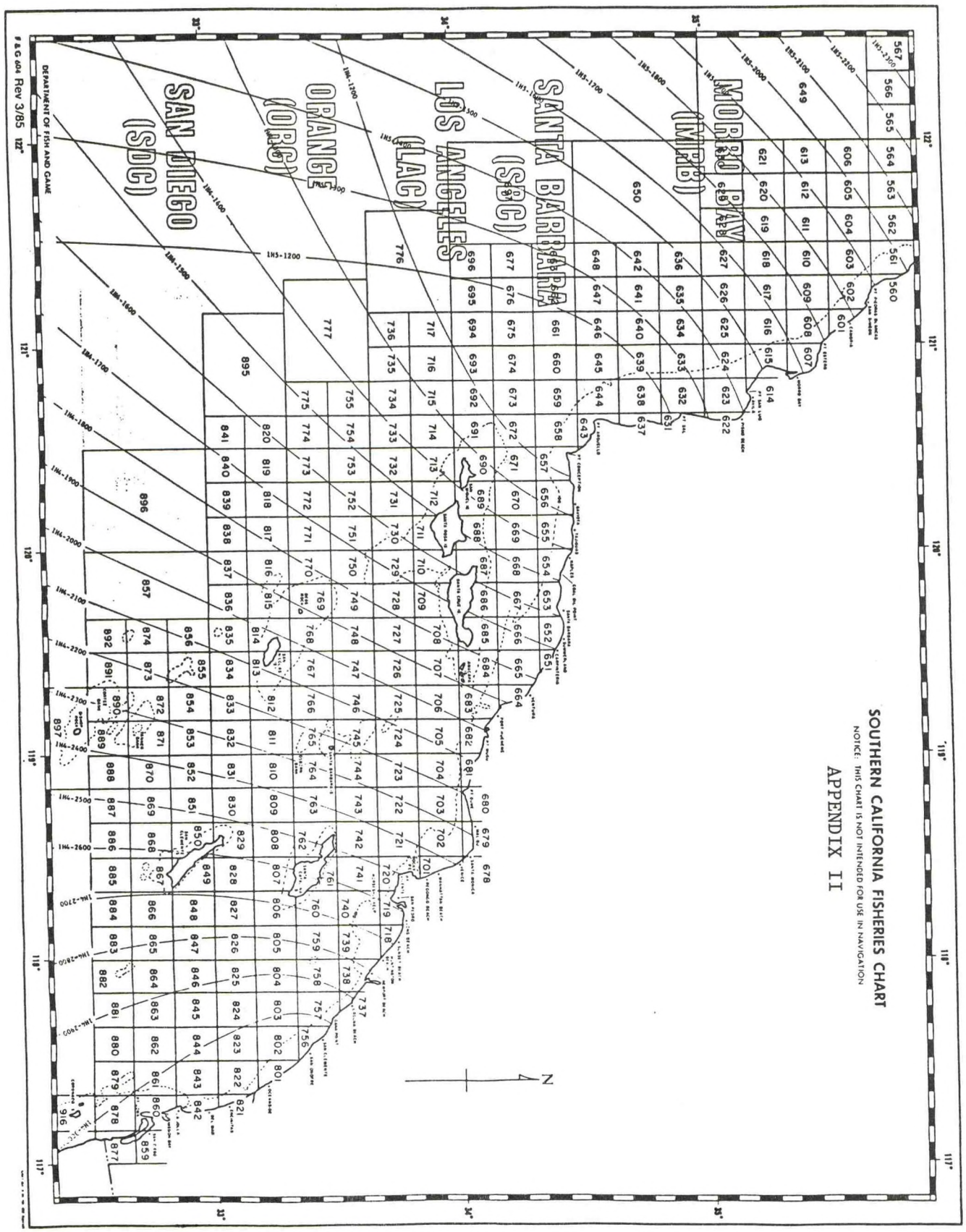


Figure 24. Relative percentages of sampling effort, and harbor porpoise incidental take by observation type in the Morro Bay area, April 1984 to March 1985.


CENTRAL CALIFORNIA FISHERIES CHART
NOTICE: THIS CHART IS NOT INTENDED FOR USE IN NAVIGATION
APPENDIX I
BLOCK 305 INCLUDES THE UPPER SACRAMENTO RIVER
SAN FRANCISCO (SNF)
MONTEREY (MON)
DEPARTMENT OF FISH AND GAME MARINE RESOURCES REGION APRIL 1976
F & G 605
85 37742


SOUTHERN CALIFORNIA FISHERIES CHART
NOTICE: THIS CHART IS NOT INTENDED FOR USE IN NAVIGATION
APPENDIX II
MORRO BAY (MRBC)
SANTA BARBARA (SBC)
LOS ANGELES (LAC)
ORANGE (ORC)
SAN DIEGO (SDC)
DEPARTMENT OF FISH AND GAME
F&G 604 Rev 3/85