

**THE EFFECTS OF OPERATIONS OF THE
SAN ONOFRE NUCLEAR GENERATING STATION
ON FISH**

**FINAL REPORT
(Vol. 2 of 2)**

**Prepared for the
Marine Review Committee
of the
California Coastal Commission**



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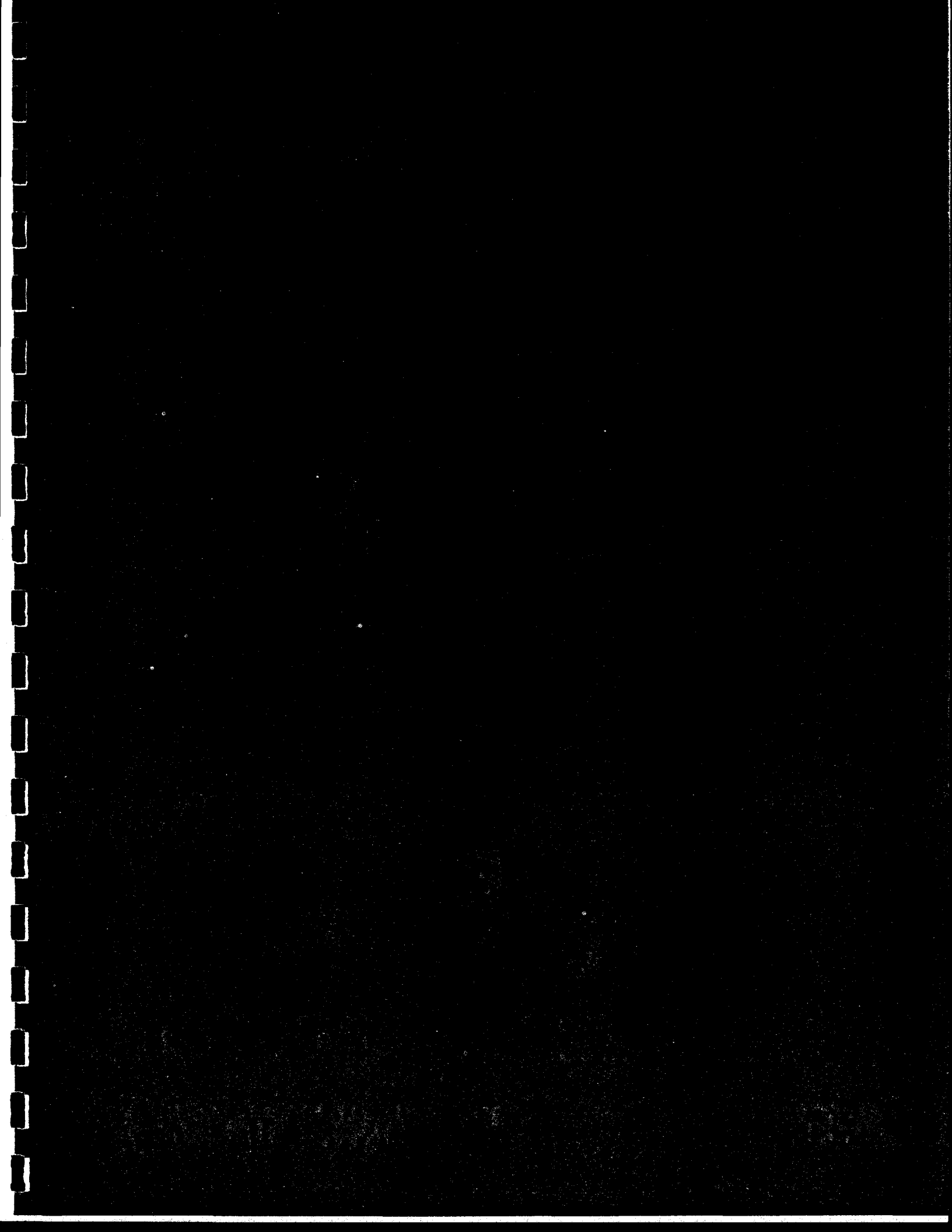


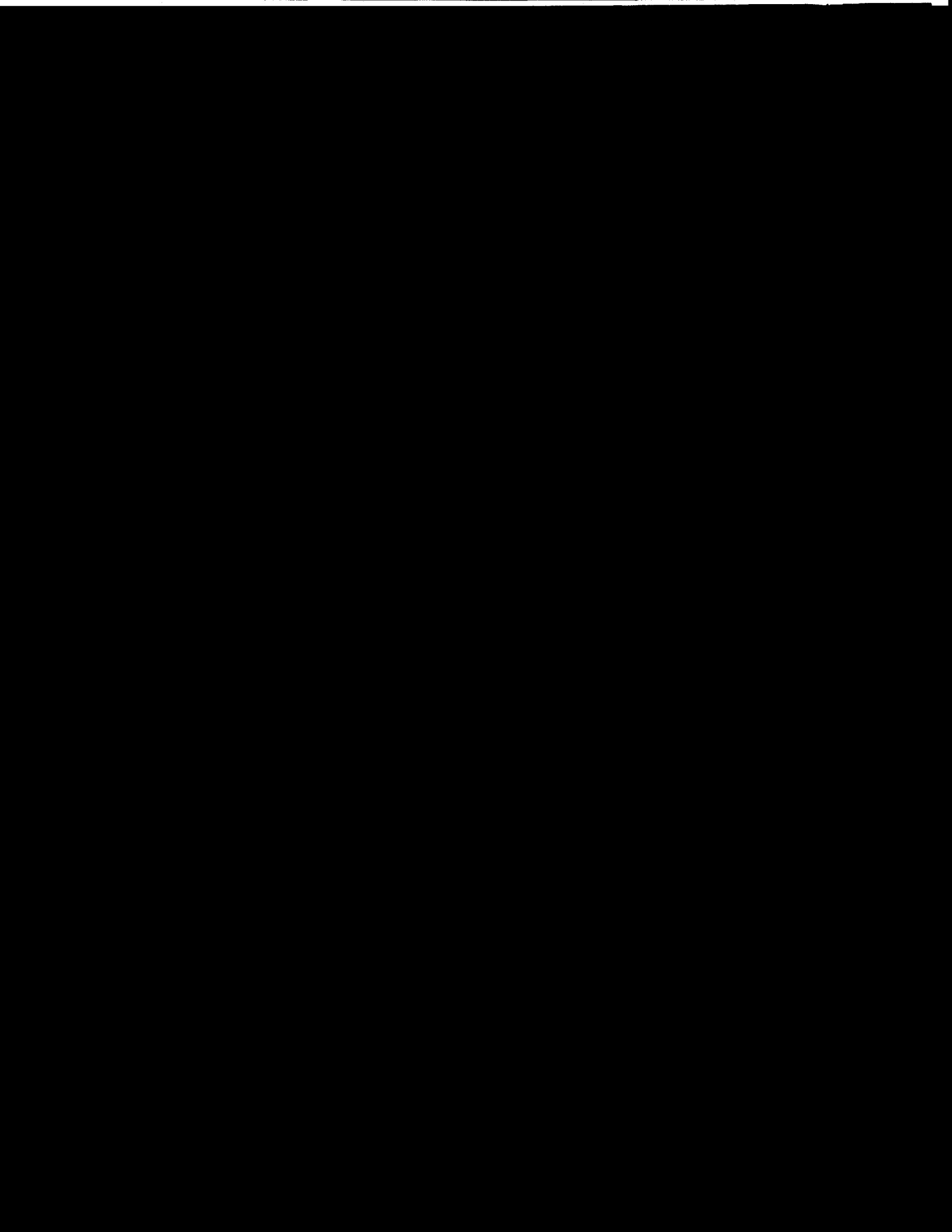
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APPENDIX A -- Net Gear, Sampling and Analysis Protocols
for Midwater and Benthic Fishes

APPENDIX A

PART 1. NET GEAR AND SAMPLING PROTOCOLS FOR MIDWATER FISHES

Introduction

A lampara seining task was initiated in September 1979. Lampara seining is the least biased (Thomas et al. 1979; Allen and DeMartini 1983) netting technique for estimating the relative abundances (CPUE = catch per unit of effort) of coastal, pelagic ("midwater") fishes. These small fishes, principally queenfish and white croaker, together with northern anchovy, dominate the nearshore, midwater habitat in numbers and biomass (Allen and DeMartini 1983). Preoperational (Before) sampling of these fishes was completed at the end of May 1982. Interim monitoring began in June 1982 and continued at reduced effort through March 1984. Operational-phase (After) sampling began in April 1984 and concluded in August 1986.

A same type and size of net and associated gear, and the same team of net-deployment personnel were maintained from the start of pre operational sampling to assure consistency in fishing operations. The shipboard sampling protocols of biological personnel were periodically checked to assure further consistency.

On each cruise, three fixed longshore locations (two Impact, one Control; Appendix A, Fig. 1) were sampled with a single (unreplicated) net-set within each of two fixed depth blocks; particular subblocks were selected randomly on each cruise from within each depth block at each location. The single most important aspect of this design was that all depths at all locations were sampled with equal effort on each cruise. Pilot lampara data demonstrated the necessity of such a design, in order to factor out the strong date effects exhibited by the highly vagile fishes in this assemblage. All lampara samplings were performed at night because catch data are less variable at night. (Many midwater midwater fishes

aggregate in resting schools during the day and disperse to feed at night: Allen and DeMartini 1983. Visual net avoidance is also less at night.)

Gear Specifications and Fishing Protocols

A lampara seine (round semipursing net, Scofield 1951) of standard dimensions was deployed and retrieved in consistent fashion by the crew of the commercial live-bait tender City of Oceanside for the September 1979-May 1982 baseline sampling and for interim-phase sampling through early winter 1983. Accidental loss of this vessel in February 1983 necessitated outfitting a sister ship (Trojan) with identical net and gear during winter-spring 1983. Interim sampling resumed in August 1983 and continued unchanged throughout the operational period. Specifications of the net, associated gear, and fishing techniques used are as follows: wings (2)--each 118 m long x 24 m deep of 15-cm stretch mesh at their free ends and tapering to a bag of 1.25-cm stretch mesh; set time--2 min; retrieval time-- $7.9 \pm .1$ min; net retrieved by three nonbiologists with the aid of a hydraulic winch; catch brailed from bag at shipside (bag not lifted aboard); estimated area (approx. circular) enclosed by net-- $4,584 \pm 38$ ($n = 40$ sets) m^2 ; biological sampling crew of three UCSB personnel.

Specific Sampling Design and Rationale

All lampara catches whose data were used for Before/After comparisons of numerical abundances at Impact and Control locations were completed at "night" (1-6 hr after sunset) at twice-weekly to once-monthly intervals during baseline and operational periods (Appendix A, Table 1). On each cruise each of three longshore locations was sampled with one net-set within each of two depth blocks (shallow, S, = 5-10 m; mid-depth, M, = 11-16 m). Each depth block was approximately 1 km onshore/offshore x 1 km longshore (Appendix A, Fig. 1) and was subdivided into twenty-five 200-m x 200-m subblocks from which the one subblock to be sampled on a particular cruise was randomly chosen. The three longshore locations sampled on each cruise were a Near Impact (NI) area ($\pm 1/2$ km of the SONGS Unit 1 line); a Far Impact (FI) area (2-3 km downcoast of Unit 1); and a Control (C) area (18-19 km downcoast of Unit 1; Appendix A, Fig. 1).

All six combinations of depth blocks and locations were sampled during a single 6-hr period to minimize the effects of both the likely interday and known

diel (Hobson and Chess 1976; DeMartini Allen, Fountain, and Roberts 1985) changes in the distribution and abundance of species such as queenfish. Both daytime and nighttime surveys of coastal pelagics were conducted during the early baseline period from September 1979 through April 1981. These day/night surveys conclusively demonstrated that many of the major species of coastal pelagics make diel onshore and offshore migrations (DeMartini and Larson 1980a; DeMartini et al. 1981a; Allen and DeMartini 1983). The two (S,M) depth blocks were established during the summer of 1979 after analyses of pilot lampara data for May 1978-August 1979 (DeMartini and Larson 1980a) indicated that there was only one major break point (at ~ 10-m bottom depth) in the distribution and composition of coastal, pelagic fishes between 5- and 30-m depths.

Concurrent samples were taken in both S and M blocks at the FI and C locations and in the M block at the NI location on each cruise beginning in September 1979. Because of the presence of buoys and other construction hazards, however, nighttime samples in S block at the NI location were possible only after most of these obstacles were removed when SONGS offshore construction was completed in spring 1981. Hence the baseline data for shallow depths immediately near ($\leq 1/2$ km of) the SONGS Unit 1 offshore intake structure spans only about one year from April 1981 to May 1982.

Numerical CPUE data collected during fall (October-December) months were found to inflate the variances of baseline deltas (location differences in catches) for major species of coastal, pelagic fishes (DeMartini et al. 1981c). This was due to longshore differences in the timing of the semiannual onshore and offshore migrations made by these fishes during the fall-winter period (DeMartini and Larson 1980a; DeMartini et al. 1981a; Allen and DeMartini 1983). Deletion of these fall data reduces variances of the deltas (DeMartini et al. 1981c). Hence all seine data for October-December periods have been omitted from our impact-test comparisons between baseline and operational periods.

Types of Biological Data

All of the fishes present in each catch of average or lesser magnitude were brailled aboard ship and held in bait receivers. All fishes were counted by species with the exception of the atherinid (silverside) and Anchoa species complexes, for which it was too time-consuming to identify individuals to species.

A maximum of two aliquots of about 50 individuals each of queenfish (and, since March 1982, white croaker) were sacrificed for sex- and length-frequency analyses. All other fishes were returned overboard as they were counted. In the laboratory, sex-specific lengths (± 1 mm, SL) were determined for queenfish and white croaker. The total wet weight ($\pm .1$ kg) of the catch of each of these two species of croakers was determined aboard ship.

In cases of rare, very large (> 100 kg) catches of many fish, entire net-hauls were subsampled at shipside using standard live-bait brailers. Evaluation of the precision of subsampling appears in the April 1984 Trimester Report (DeMartini et al. 1984a). The subsampling of seine catches has caused minor (5%) losses of precision in estimating CPUE of queenfish and white croaker; information loss in subsampling for length composition was greater, but acceptable (5% to 20%; DeMartini et al. 1984a). Subsampling accuracy was subsequently evaluated as data became available. For queenfish (the only species for which subsampleable catches occurred once evaluation procedures were established), the effect of subsampling on accurately estimating CPUE was negligible (Appendix A, Table 2).

Data Used in Analyses

CPUE Data. The numerical and biomass catch data provide two types of CPUE (catch-per-unit-of-effort) indices of abundance used in fisheries biology and management estimates. For all species except queenfish, catches were recorded as individuals of all sizes and both sexes pooled. For queenfish, data were evaluated for major maturity and sex categories. The number of immature, adult male, and adult female queenfish present in net-hauls were calculated by applying data on proportions of categories (determined by subsequent examination of subsamples in the laboratory) to the total catch of queenfish. In addition, we evaluated the queenfish catch data for young-of-the-year (YOY), as distinct from "older juvenile and adult" (OJ) age-groupings. The YOY age-grouping was identified from size mode data, assisted by P. Tomlinson's modification of the NORMSEP size-frequency analysis program (Abramson 1971; summarized in Appendix A, part 3).

Only numerical CPUE data were analyzed in our baseline study (DeMartini et al. 1983a). Impact analyses in the present report are also limited to numerical CPUE, because biomass data are generally less precise than numerical data (e.g., DeMartini and Allen 1984).

Size-Composition Data. These data are complementary to CPUE data in that they often allow one to evaluate several meaningful size (age) groupings within catches. The most frequently useful subgroupings are those of YOY (young-of-year, age 0+) and older fish. Abundance of the YOY group is generally used to characterize the recruitment (year-class) success of marine fishes (Pitcher and Hart 1982).

Queenfish and white croaker, queenfish in particular, have been targeted for measurement because of their high levels of entrapment both as juveniles and as adults. Length-frequency as well as abundance data have been divided into size- and sex-categories because ontogenetic changes in behavior (DeMartini, Allen, Fountain, and Roberts 1985) might make different categories differentially susceptible to various sources of SONGS impact. Size-specific entrapment might induce changes in the size- and sex-structure of queenfish near the SONGS intakes. (Immatures may be more vulnerable to entrapment than adults, due to the more onshore nighttime distribution of immatures, as well as the lesser ability of smaller fish to avoid withdrawal.) Queenfish size- and sex-structure was characterized throughout the baseline, interim, and operational monitoring periods. The monitoring of white croaker size- and sex-composition began in March 1982.

For each seine-haul, two samples of approximately 50 fish each of queenfish and white croaker were returned to the laboratory to be measured and sexed. For seine-hauls in which the number of queenfish and white croaker caught was greater than the number measured, the number of fish in each 5-mm length class was multiplied by the number captured divided by the number measured. In this manner, length distributions could be generated for the entire catch.

APPENDIX A -- TABLE 1

LIST OF SAMPLING DATES FOR LAMPARA SEINE CRUISES
(by SONGS Operating Period)

(A) PREOPERATIONAL

Day-Month-Year	Near Impact		Far Impact		Control	
	S	M	S	M	S	M
05 Sep 79	-	X	X	X	X	X
26 Sep 79	-	X	X	X	X	X
10 Oct 79*	-	X	X	X	X	X
02 Nov 79*	-	X	X	X	X	X
05 Nov 79*	-	X	X	X	X	X
15 Nov 79*	-	X	X	X	X	X
26 Nov 79*	-	X	X	X	X	X
11 Dec 79*	-	X	X	X	X	X
19 Dec 79*	-	X	X	X	X	X
19 Mar 80	-	X	X	X	X	X
10 Apr 80	-	X	X	X	X	X
24 Apr 80	-	X	X	X	X	X
08 May 80	-	X	X	X	X	X
20 May 80	-	X	X	X	X	X
05 Jun 80	-	X**	X	X**	X	NQ
19 Jun 80	-	X	X	X	X	X
15 Jul 80	-	X	X	X	X	X
31 Jul 80	-	X**	X	X**	X	NQ
19 Aug 80	-	X	X	X	X	X
28 Aug 80	-	X	X	X	X	X
08 Sep 80	-	X	X	X	X	X
17 Sep 80	-	X	X	X	X	X
23 Sep 80	-	X	X	X	X	X
06 Oct 80*	-	X	X	X	X	X
24 Oct 80*	-	X	X	X	X	X
28 Oct 80*	-	X	X	X	X	X
06 Nov 80*	-	X	X	X	X	X
25 Nov 80*	-	X	X	X	X	X
11 Dec 80*	-	X	X	X	X	X
18 Dec 80*	-	X	X	X	X	X
06 Jan 81	-	X	X	X	X	X
26 Jan 81	-	X	X	X	X	X
02 Feb 81	-	X**	X	X**	X	NQ
11 Feb 81	-	X	X	X	X	X
03 Mar 81	-	X	X	X	X	X
18 Mar 81	-	X	X	X	X	X

* Cruise excluded from baseline/operational-phase comparisons

** Collection excluded because of NQ haul at Control location

APPENDIX A -- TABLE 1(continued)

(A) PREOPERATIONAL

Day-Month-Year	Near Impact		Far Impact		Control	
	S	M	S	M	S	M
01 Apr 81	X	-	X	-	X	-
04 Apr 81	-	X	-	X	-	X
13 Apr 81	X	-	X	-	X	-
14 Apr 81	-	X	-	X	-	X
20 Apr 81	X	-	X	-	X	-
23 Apr 81	-	X	-	X	-	X
28 Apr 81	X	-	X	-	X	-
29 Apr 81	-	X	-	X	-	X
04 May 81	X	-	X	-	X	-
05 May 81	-	X	-	X	-	X
11 May 81	X	-	X	-	X	-
13 May 81	-	X	-	X	-	X
19 May 81	X	-	X	-	X	-
20 May 81	-	X	-	X	-	X
26 May 81	X	-	X	-	X	-
27 May 81	-	X	-	X	-	X
08 Jun 81	X	X	X	X	X	X
18 Jun 81	X	X	X	X	X	X
22 Jun 81	X	X	X	X	X	X
25 Jun 81	X	X	X	X	X	X
08 Jul 81	X	X	X	X	X	X
14 Jul 81	X	X	X	X	X	X
20 Jul 81	X	X	X	X	X	X
30 Jul 81	X	X	X	X	X	X
05 Aug 81	X	X	X	X	X	X
17 Aug 81	X	X	X	X	X	X
24 Aug 81	X	X	X	X	X	X
03 Sep 81	X	X	X	X	X	X
10 Sep 81	X	X	X	X	X	X
24 Sep 81	X	X	X	X	X	X
08 Oct 81*	X	X	X	X	X	X
20 Oct 81*	X	X	X	X	X	X
17 Nov 81*	X	X	X	X	X	X
24 Nov 81*	X	X	X	X	X	X
04 Dec 81*	X	X	X	X	X	X
14 Dec 81*	X	X	X	X	X	X
11 Jan 82	X	X	X	X	X	X
18 Jan 82	X	X	X	X	X	X
22 Jan 82	X	X	X	X	X	X
18 Feb 82	X	X	X	X	X	X
23 Feb 82	X	X	X	X	X	X
26 Feb 82	X	X	X	X	X	X

* Cruise excluded from baseline/operational-phase comparisons

APPENDIX A -- TABLE 1 (continued)

(A) PREOPERATIONAL

<u>Day-Month-Year</u>	<u>Near Impact</u>		<u>Far Impact</u>		<u>Control</u>	
	<u>S</u>	<u>M</u>	<u>S</u>	<u>M</u>	<u>S</u>	<u>M</u>
30 Mar 82	X	X	X	X	X	X
05 Apr 82	X	X	X	X	X	X
19 Apr 82	X	X	X	X	X	X
23 Apr 82	X	X	X	X	X	X
26 Apr 82	X	X	X	X	X	X
29 Apr 82	X	X	X	X	X	X
10 May 82	X	X	X	X	X	X
20 May 82	X	X	X	X	X	X
27 May 82	X	X	X	X	X	X
Total No. Quantitative Cruises	43	76	79	76	79	76
No. Cruises (Fall Dates Deleted)	37	56	59	56	59	56

(B) INTERIM

<u>Day-Month-Year</u>	<u>Near Impact</u>		<u>Far Impact</u>		<u>Control</u>	
	<u>S</u>	<u>M</u>	<u>S</u>	<u>M</u>	<u>S</u>	<u>M</u>
08 Jun 82	X	X	X	X	X	X
30 Jun 82	X	X	X	X	X	X
13 Jul 82	X	X	X	X	X	X
27 Jul 82	X	X	X	X	X	X
24 Aug 82	X	X	X	X	X	X
30 Aug 82	X	X	X	X	X	X
22 Sep 82	X	X	X	X	X	X
30 Sep 82	X	X	X	X	X	X
18 Oct 82*	X	X	X	X	X	X
25 Oct 82*	X	X	X	X	X	X
30 Aug 83	X	X	X	X	X	X
27 Sep 83	X	X	X	X	X	X
11 Oct 83*	X	X	X	X	X	X
08 Feb 84	X	X	X	X	X	X
13 Mar 84	X	X	X	X	X	X
Total No. Quantitative Cruises	15	15	15	15	15	15
No. Cruises (Fall Dates Deleted)	12	12	12	12	12	12

* Cruise excluded from baseline/operational-phase comparisons

APPENDIX A -- TABLE 1 (continued)

(C) OPERATIONAL

Day-Month-Year	Near Impact		Far Impact		Control	
	S	M	S	M	S	M
30 Apr 84	X	X	X	X	X	X
22 May 84	X	X	X	X	X	X
26 Jun 84	X	X	X	X	X	X
07 Aug 84	X	X	X	X	X	X
18 Sep 84	X	X	X	X	X	X
05 Feb 85	X	X	X	X	X	X
10 Apr 85	X	X	X	X	X	X
23 Apr 85	X	X	X	X	X	X
07 May 85	X	X	X	X	X	X
21 May 85	X	X	X	X	X	X
04 Jun 85	X	X	X	X	X	X
01 Jul 85	X*	X*	X*	X*	NQ	- ¹ /
03 Jul 85	X	X	X	X	X	X
10 Jul 85	X	X*	X	X*	X	- ² /
30 Jul 85	X	X	X	X	X	X
15 Aug 85	X	X	X	X	X	X
11 Sep 85	X	X	X	X	X	X
20 Sep 85	X*	X*	X*	X*	NQ	- ¹ /
25 Sep 85	X	X	X	X	X	X
15 Jan 86	X	X	X	X	X	X
28 Jan 86	X	X	X ⁻	X	X	X
12 Feb 86	X	X	X	X	X	X
19 Mar 86	X	X	X	X	X	X
31 Mar 86	X	X	X	X	X	X
22 Apr 86	X	X	X ⁻	X	X	X
29 Apr 86	X	X	X	X	X	X
13 May 86	X	X	X	X	X	X
22 May 86	X	X	X	X	X	X
10 Jun 86	X	X	X	X	X	X
17 Jun 86	X	X	X	X	X	X
23 Jul 86	X	X	X ⁻	X	X	X
13 Aug 86	X	X	X	X	X	X
Total No. Quantitative Cruises	32	32	32	32	30	29
No. Cruises (Fall Dates Deleted)	32	32	32	32	30	29

¹/ Seine haul at Control, mid-depth not taken because of gear malfunction on the preceding Control, shallow haul.

²/ Seine haul at Control, mid-depth mistakenly taken as a second haul in the shallow depth block; this second, shallow set (# 850077) was not analyzed.

*/ Collection deleted from analysis because of inadequate Control data.

-/ Shallow seine-hauls taken at ~11 m.

APPENDIX A -- TABLE 2

PELAGIC FISHES: SUMMARY RESULTS OF KOLMOLGOROV-SMIRNOV (K-S) TESTS OF DIFFERENCES BETWEEN SUBSAMPLES (ALIQUOTS 1 AND 2) AND THE RESPECTIVE TOTAL CATCH OF QUEENFISH FOR EACH OF 3 SUBSAMPLED LAMPARA SEINE COLLECTIONS.

Date	Collection Number	Number of Fish in		Dmax ^a	DCRIT05 ^b	P Value
		Subsample	Sample			
21May85	850044	124	259	.025	.084	>0.2
13May86	860063	104	318	.058	.076	>0.2
22May86	860072	99	162	.094	.107	~0.09

^aDmax = maximum observed deviation between expected and observed cumulative percent frequencies.

^bDCRIT05 = critical value of the K-S statistic for the sample size, using a two-tailed alpha of 0.05.

Appendix A -- Figure 1

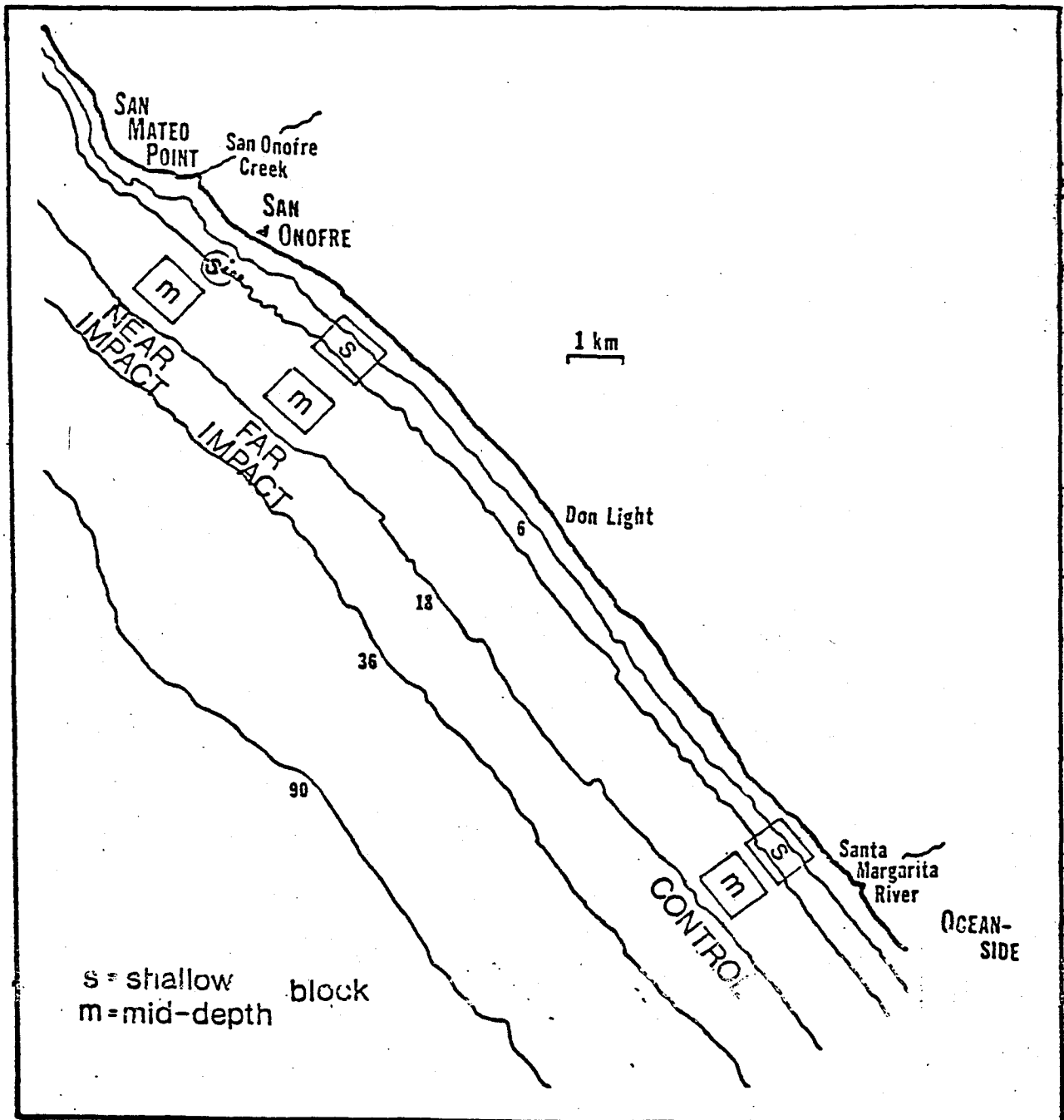


Chart of the general San Onofre area. Noted are the locations of the lampara seine stations. Bottom contours and sampling depth are noted in meters below MLLW.

PART 2. NET GEAR AND SAMPLING PROTOCOLS FOR BENTHIC FISHES

Introduction

An otter trawl task was initiated in January 1980 (quantitative, standard-distance trawling began in May 1980) in order to most accurately sample and determine the relative abundances (CPUE) of select species of fishes that live on or near unconsolidated substrates near San Onofre. Preoperational (Before) sampling of these fishes was completed in June 1982. Interim trawling continued at reduced effort through winter 1984. Operational-phase (After) sampling began in May 1984 and concluded in November 1986.

A single type and size of trawl and associated gear, and the same team of net-deployment personnel were maintained from the beginning of trawl studies, and sampling protocols were checked at intervals to assure consistency of CPUE estimates. The trawl sampling differed from our lampara design in number of locations and level of replication per cruise. On each (approx. monthly) cruise, each of two fixed longshore locations (one Impact, one Control; Appendix A, Fig. 2) were sampled with four replicate, standard-distance trawls along each of two (18-m; 30-m) fixed isobaths. These two isobaths were chosen to represent off-diffuser and off-plume bottom depths, respectively. The single most important aspect of the trawl sample design was that both depths at both locations were sampled with equal (in this case, replicated) effort on each cruise. All trawl cruises made to evaluate numerical impact were completed at night in order to minimize visual net avoidance, capture diurnally unavailable species (e.g., basketweave cusk-eel), and obtain more precise data (DeMartini et al. 1983a; DeMartini and Allen 1984).

Gear Specifications and Protocols

A modified Marinovitch-type otter trawl (bag seine) (manufactured by J. Willis, San Luis Obispo, California) of standard dimensions for coastal trawling in the bight (Mearns and Allen 1978) was used for all trawl operations from their beginning in January 1980. The net used was a 25-ft (7.6-m), single-warp otter trawl with a 50-ft bridle, a 25-ft headrope, a 29-ft footrope, 25 feet of 3/16-in. galvanized chain, body netting of 1-1/2-in. stretch mesh, and 1/2-in. stretch-mesh cod-end liner.

All trawls made throughout baseline and operational sampling were of standard distance, with the start and stop points based on fixed spar buoy stations and/or Motorola Mini-Ranger II positions. The distance travelled by our trawls was an estimated 240 m \pm 10%. Before May 1984, distances were determined from transponder signals sent from an auxiliary craft (4.1-m Boston whaler) temporarily moored ~200 m upcoast or downcoast of the trawling station. Beginning in May 1984, trawl distances were based on transponder signals from shore stations at San Mateo Point and Don Light (Appendix A, Fig. 2). (During January, March, and April 1980, trawls were made on a fixed-time {5-min} rather than a fixed-distance basis; these data have been considered qualitative and not appropriate for inclusion in our baseline abundance estimates.) All baseline and operational-phase catches, whose data were used for Before/After comparisons at Impact and Control locations, were completed at night (1 hr after sunset to 1 hr before sunrise) along 18- and 30-m isobaths (approx. parallel to the coastline). Nets were deployed and retrieved in standard manner (scope: five-to-one at 18 m {90-m tow cable} and at 30 m {152-m cable}; mean drag time 3.3 \pm .6{SE} min and 3.7 \pm .8 min at 18 m and 30 m, respectively; vessel speed an average 2.2 knots using a single vessel {Marine Ecological Consultants' Lo-An} and consistent hauling gear {i.e., A-frame, hydraulic winch}). There were five scientists on the biological sampling crew.

Specifics of Sampling Design

All otter trawling was conducted at two different stations (depths) at each of two longshore locations on repeated cruises (sampling dates). At each station on each cruise a constant four replicate trawls were taken, with two trawls made upcoast and two trawls made downcoast in order to equally sample any possible variation in catch that might result from directional (longshore) currents. (Subsequent analyses have shown that this was an unnecessary precaution {DeMartini and Allen 1984}). Replicate trawls were taken slightly inshore and offshore of the defined isobath to avoid the resampling of trawl tracks.

Preoperational cruises were scheduled, with few exceptions, at monthly intervals from May 1980 to June 1982 (Appendix A, Table 3). One additional cruise was made each month during November-December 1980 (at 18 m and 30 m); two additional cruises were made as part of a pilot "gradient" sampling program (see DeMartini et al. 1981c) during June 1981 (18 m only). Both the additional (November 5-6 and December 3-4) 1980 cruises, and the pilot gradient cruises of

June 8-9 and June 9-10, 1981 were excluded from our baseline-operational comparisons. The June 23-24 and July 16-17, 1980 cruises were not completed until shortly after sunrise. Hence, the data for these two cruises were not used to estimate the abundance of basketweave cusk-eel, a unique species which sequesters itself in burrows (and is thereby unavailable to trawls) after sunrise (Greenfield 1968). Sampling was conducted once every two months during the interim period. Bimonthly sampling was conducted during the first ten months of the operational period. Thereafter, a monthly cruise schedule was followed to complete operational sampling, with the exception of a single cruise in April 1986 for which tows were nonquantitative because pelagic red crabs (Pleuroncodes planipes) continually fouled the trawl.

On each cruise, each of two longshore locations was sampled with the aforementioned four replicate trawls at each of two isobaths (18 m and 30 m), resulting in 16 total trawls per cruise. The two locations, each of ~3-km longshore extent, sampled on each cruise were an Impact (I) area (≤ 1 km upcoast to 2 km downcoast of the SONGS Unit 1 line) and a Control (C) area (17-20 km downcoast of Unit 1; Appendix A, Fig. 2). It is important to reemphasize that all four combinations of depths and locations were sampled on each cruise to minimize the possible effects of date and diel period on the relative distributions and abundances of fishes at the two longshore locations.

Monthly trawling surveys were conducted during the day as well as night from May 1980 through May 1981. These daytime cruises were used to document baseline diel patterns and to evaluate relative catch efficiencies of our otter trawl during day versus night (DeMartini and Allen 1984).

Rationale for Sampling Locations and Depths

The position of the Impact study location was skewed somewhat downcoast of the SONGS outfall lines in order to sample under the average path of the Units 2 and 3 diffuser plume. The average downcoast-setting currents of the area establish an average downcoast-setting plume (Reitzel 1979). The distant Control location was established off Stuart Mesa near Oceanside (Appendix A, Fig. 2) in order to sample a similar environment at a distance from SONGS considered sufficient to preclude influence by Units 2 and 3 operations. This Control location was also used as control station by Marine Ecological Consultants in

their SONGS monitoring studies of mysids, plankton, and ichthyoplankton. The 18- and 30-m isobaths were chosen to represent the off-diffuser and off-plume depths of impact. (At the time that the benthic trawl design was developed, it was thought that the Units 2 and 3 diffuser plume would appreciably alter sediment particle sizes and the relative organic fraction of sediments beneath and offshore of the plume. The plume would thereby affect the kinds and abundances of invertebrate infauna and, indirectly, the abundances of benthic fishes that feed on these invertebrates. At present, several independent types of data on sediment composition and associated benthos strongly suggest that this has been an accurate prediction (Barnett, Watts, and White 1986; Barnett et al. 1986; DeMartini et al. 1986)).

Types of Biological Data

Each trawl catch was brought aboard ship in its entirety, off-loaded into tubs on deck, and wet-sorted by species. The total number of individuals and total wet weight (± 10 g for species < 1 kg catch; $\pm .1$ kg for species ≥ 1 kg catch) was determined for each species and for its aggregate within the trawl. Fish were processed as quickly as possible and returned overboard; valuable species like California halibut were given priority, express treatment. Abundance data were tallied separately for each of the four replicate trawls made at a location and depth (station) on a given cruise.

At the beginning of our monitoring of Units 2 and 3 effects in May 1980, we chose 10 (at 18 m) and 12 (30 m) select target species of fishes for rigorous statistical analyses. The species chosen for this analysis were selected for one or more of the following reasons: (1) abundance and frequency of occurrence in trawls; (2) ecological importance; (3) economic importance; (4) suspected susceptibility to impact by SONGS; and (5) sampling distributions amenable to statistical testing according to the BACI model (Stewart-Oaten 1986; Stewart-Oaten et al. 1986).

The California lizardfish was added to this list in our March 1983 quarterly report (DeMartini et al. 1983c) because it greatly increased in abundance during the early interim period. Data for queenfish and white croaker were subsequently emphasized because of the January-July 1983 hiatus in the lampara effort (DeMartini et al. 1983f). The lampara seine remains our primary method of

characterizing the distribution and abundance of these latter two epibenthic and water-column fishes at intake depths, where both species are primarily at risk to entrapment at the SONGS offshore intake structures. The lampara seine also samples from sea surface to sea bed, whereas the otter trawl samples only the larger individuals (primarily adults) of queenfish and white croaker that occur near the sea bed (Johnson 1980) farther offshore (DeMartini, Allen, Fountain, and Roberts 1985). The queenfish and white croaker data included in our evaluation of soft-bottom fishes therefore characterize the distribution and abundance of the fractions of local stocks of both species that may be impacted by benthos (or near-benthos) alteration.

Size-frequency distributions were determined for certain species among those that were abundant and frequently encountered in pilot baseline samples at the particular isobath (white croaker at 18 and 30 m, California halibut at 18 and 30 m, longfin sanddab at 18 and 30 m, Pacific sanddab at 30 m only, speckled sanddab at 18 m, fantail sole at 30 m, and hornyhead turbot at 18 and 30 m). After the trawl-by-trawl enumeration of total catch, the catches of each of these chosen species were pooled by station and mixed; then a random subsample of a maximum of 50 individuals of each species was measured (± 1 mm SL) but not sexed. Starting in May 1984, subsample size for white croaker was increased from 50 to 100 individuals as a maximum to assure an adequate characterization of croaker of a broad length range on each cruise. Since a maximum of 50 fish of each species (50 or 100 for white croaker) was measured for each aggregate of four trawls, there were instances when the number of fish measured was less than the number captured. On these occasions the number of fish in each length class was adjusted by a scaling factor equal to the number of fish captured, in the respective series of four trawls, divided by the number of fish measured. These length-frequency data provide a station-by-cruise measure of the general length-frequency distributions of a consistent suite of representative species.

Data Used in Analyses

CPUE Data. The numerical and biomass catch data provide two types of CPUE (catch-per-unit-of-effort) indices of abundance used in fisheries biology and management estimates. Numerical CPUE data were analyzed in our baseline study (DeMartini et al. 1983a) and in the present report because biomass data are generally less precise than numerical data (DeMartini and Allen 1984).

Size-Composition Data. These data are complementary to CPUE data in that they often allow one to evaluate several meaningful size (age) groupings within catches. The most frequently useful subgroupings are those of YOY (young-of-year, age 0+) and older fish. Abundance of the YOY group is generally used to characterize the recruitment (year-class) success of marine fishes (Pitcher and Hart 1982).

APPENDIX A -- TABLE 3

LIST OF SAMPLING DATES FOR OTTER TRAWL CRUISES
(by SONGS Operating Period)

(A) PREOPERATIONAL

Day-Month-Year	Impact		Control	
	18 m	30 m	18 m	30 m
30 Apr-01 May 80	X	X	X	X
23-24 Jun 80 **	X	X	X	X
16-17 Jul 80 **	X	X	X	X
13-14 Aug 80	X	X	X	X
12-13 Sep 80	X	X	X	X
21-22 Oct 80	X	X	X	X
05-06 Nov 80*	X	X	X	X
14-15 Nov 80	X	X	X	X
03-04 Dec 80*	X	X	X	X
10-11 Dec 80	X	X	X	X
15-16 Jan 81	X	X	X	X
18-19 Feb 81	X	X	X	X
11-12 Mar 81	X	X	X	X
08-09 Apr 81	X	X	X	X
22-23 May 81	X	X	X	X
04-05 Jun 81	X	X	X	X
08-09 Jun 81*	X	-	X	-
09-10 Jun 81*	X	-	X	-
21-22 Jul 81	X	X	X	X
10-11 Aug 81	X	X	X	X
01-02 Sep 81	X	X	X	X
05-06 Oct 81	X	X	X	X
02-03 Nov 81	X	X	X	X
01-02 Dec 81	X	X	X	X
12-13 Jan 82	X	X	X	X
02-03 Feb 82	X	X	X	X
05-06 Mar 82	X	X	X	X
07-08 Apr 82	X	X	X	X
05-06 May 82	X	X	X	X
03-04 Jun 82	X	X	X	X
Total No. Cruises	30	28	30	28
No. Cruises Used to Construct Baseline	26	26	26	26

* Cruise excluded from baseline/operational-phase comparisons

** Trawls at 30-m depth deleted for BACI tests on cusk-eel

APPENDIX A -- TABLE 3 (continued)

(B) INTERIM

<u>Day-Month-Year</u>	<u>Impact</u>		<u>Control</u>	
	<u>18 m</u>	<u>30 m</u>	<u>18 m</u>	<u>30 m</u>
06-07 Jul 82	X	X	X	X
08-09 Sep 82	X	X	X	X
09-10 Nov 82	X	X	X	X
18-19 Jan 83	X	X	X	X
19-20 Mar 83	X	X	X	X
12-13 May 83	X	X	X	X
14-15 Jul 83	X	X	X	X
06-07 Sep 83	X	X	X	X
08-09 Nov 83	X	X	X	X
10-11 Jan 84	X	X	X	X
09-10 Mar 84	X	X	X	X
Total No. Cruises	11	11	11	11
No. Cruises Used to Characterize Interim	11	11	11	11

APPENDIX A -- TABLE 3 (continued)

(C) OPERATIONAL

Day-Month-Year	Impact		Control	
	18 m	30 m	18 m	30 m
16-17 May 84	X	X	X	X
02-03 Jul 84	X	X	X	X
20-21 Sep 84	X	X	X	X
14-15 Nov 84	X	X	X	X
05 Jan 85	X	X	X	X
03-04 Mar 85	X	X	X	X
12-13 Apr 85	X	X	X	X
11-12 May 85	X	X	X	X
12-13 Jun 85	X	X	X	X
16-17 Jul 85	X	X	X	X
09-10 Aug 85	X	X	X	X
17-18 Sep 85	X	X	X	X
16-17 Oct 85	X	X	X	X
13-14 Nov 85	X	X	X	X
12-13 Dec 85	X	X	X	X
10-11 Jan 86	X	X	X	X
10-11 Feb 86	X	X	X	X
22-23 Mar 86	X	X	X	X
12-13 May 86	X	X	X	X
09-10 Jun 86	X	X	X	X
07-08 Jul 86	X	X	X	X
22-23 Aug 86	X	X	X	X
30 Sep-01 Oct 86	X	X	X	X
26-27 Oct 86	X	X	X	X
23-24 Nov 86	X	X	X	X
No. Cruises Used to Construct Operational	25	25	25	25