MRC DOC
89-2038

TECHNICAL REPORT
TO THE
CALIFORNIA COASTAL COMMISSION

J. Kelp Bed Fish

MARINE REVIEW COMMITTEE, INC.

William W. Murdoch, Chairman
University of California

Byron J. Mechalas
Southern California Edison Company

Rimmon C. Fay
Pacific Bio-Marine Labs, Inc.

Prepared by:
Jon Kastendiek and Keith Parker

Project Principal Investigators:
Edward DeMartini
Ralph Larson
Larry Allen

July 1989

This report analyzes and presents the results of studies of the UCSB Fish Program, which were done on behalf of the MRC over the period 1980-1988, under the direction of Dr. Edward E. DeMartini. The Fish Program's Final Report to the MRC "The Effects of Operations of the San Onofre Nuclear Generating Station on Fish" (December 1987) provided the starting point for the analyses in the present report.

TECHNICAL REPORT
J. KELP BED FISH

CONTRIBUTING STAFF:
Dale Roberts
Bonnie M. Williamson

TABLE OF CONTENTS

APPENDICES

SUMMARY

This report addresses the question: has the operation of the San Onofre Nuclear Generating Station (SONGS) affected the total numbers of fish in nearby the San Onofre kelp forest (SOK, the Impact site) in the After period relative to the numbers in the more distant San Mateo kelp forest (SMK, the Control site)? We estimate these potential changes by combining information on changes in giant kelp (*Macrocystis pyrifera*) populations, the relationship between fish density and kelp density, and changes in the density of fish in areas where kelp density has remained constant.

We present results separately for groups of fish classified by their distribution in the water column. Those fish observed more than 1.5 meters above the bottom are called "water column", and those observed within 1.5 meters of the substrate are called "bottom" fish. While many species were found in both of these strata, generally an individual species was found much more abundantly in either one stratum or the other. For example, California sheephead (*Semicossyphus pulcher*) were characteristically found near the bottom, while kelp perch (*Brachyistius frenatus*) were generally found in the water column.

The relative changes in total numbers and biomass of these groups of fish between Impact and Control locations, indicate different responses on the part of water column and bottom fishes to the operation of SONGS. Fish living near the cobble bottom in SOK showed a 70% relative reduction in numbers and a 73% reduction in biomass, when compared to SMK, during the two Operational years in which samples were taken (1985 and 1986). These numbers translate into a loss of

approximately 191,000 fish weighing 28 metric tons. In contrast, while there are indications that the total numbers and biomass of fish in the water column have also decreased in SOK relative to Control, these decreases are smaller (17% and 33%), and the estimates cannot be held with statistical confidence.

The observed changes in total numbers of fish in SOK appear to arise both from both changes in the kelp populations (particularly the density of kelp and the area of the kelp forest) and from changes in the habitat unrelated to the kelp populations.

Samples from areas with a wide range of kelp densities in 1985 and 1986 indicated that bottom fish, although generally present on hard substrates in the absence of kelp, were more common in areas with kelp. Furthermore, fish densities (and biomass) of bottom fish increased as kelp density increased. These relationships argue that the fish populations are sensitive to the area and density of kelp, and that the smaller area and lower density of kelp in SOK in 1985 and 1986 probably contributed to the smaller numbers of fish in the bottom stratum.

However, decrease in the size of the kelp forest cannot entirely explain the loss of bottom fish. When Before and After densities of these fish were compared in areas where kelp density was constant from Before to After periods, several species of bottom fish exhibited relative decreases. Barred sand bass (*Paralabrax nebulifer*), rainbow seaperch (*Hypsurus caryi*), black seaperch (*Embiotoca jacksoni*) and California sheephead (*Semicossyphus pulcher*) all exhibited relative decreases of 60 to 76% in density throughout SOK compared to SMK. Only one species, the senorita (*Oxyjulis californica*), displayed a relative increase (of over 100%) in density in the bottom stratum. These decreases, observed in areas in which kelp density changed little, argue that SONGS affected fish populations by altering the local habitat in ways other than altering kelp populations (e.g., reducing prey populations).

Unlike the bottom fishes, water column fishes are dependent on the presence of kelp and are virtually absent when kelp is absent. However, they share with bottom fish the characteristic of increasing in density as kelp density increases. While these two observations suggest that water column fish would be sensitive to the area and density of the kelp forest to a greater degree than bottom fish, they have responded to the loss of kelp in SOK by increasing in density in the remaining areas of kelp.

The density of several of these species also changed in those areas chosen to control for changes in the density of kelp. Among water column fish two species, senorita (*Oxyjulis californica*) and halfmoon (*Medialuna californiensis*), increased in density (both over 100%) throughout SOK in the After period relative to the change observed in SMK. Two others, kelp perch (*Brachyistius frenatus*) and giant kelpfish (*Heterostichus rostratus*), exhibited a relative decrease in density in areas of SOK near the diffuser, but increased in areas of SOK further away. These changes in density reflect fish moving into areas of remaining kelp canopy from areas where kelp has been eliminated. As a consequence, the total numbers of water column fish have changed little in SOK in spite of the large reductions in kelp area.

Early MRC studies predicted a loss of fish in the kelp forest because fewer fish were found in areas where kelp was absent and SONGS was predicted to reduce the area of kelp in SOK. This initial prediction has been found to be an oversimplification of the response of fish populations to the operation of SONGS. While, contributing to population changes of some species, the area and density of kelp is unlikely to be the sole determinate of the relative change in fish populations in SOK in the After period.

1. INTRODUCTION

In this report we assess the effects of the operation of the San Onofre Nuclear Generating Station (SONGS) on fish populations living in the San Onofre Kelp Forest (SOK). This forest of giant kelp (*Macrocystis pyrifera*) grows on a cobble seabed located between 0.5 and 2 km downcoast of the Unit 2 and 3 diffusers and between 1.5 and 3 km offshore (Figure 1). Since the diffuser lines of Units 2 and 3 extend to 2.5 km offshore and longshore current flow is directed downcoast approximately 60% of the time, the bed is often exposed to the plant's discharge waters (including water entrained by the discharge). The MRC study of SONGS' effects on these fish began in 1979 and was completed in 1987. The project was conducted under the direction of Dr. Edward DeMartini of the University of California at Santa Barbara.

As natural resources, forests of giant kelp, such as SOK, are of great value to both commercial and sport fishermen. They are structurally complex habitats which provide food and shelter for a diverse assemblage of fishes (Quast 1968a, b; Feder *et al.* 1974; Bray and Ebeling 1975; Hobson and Chess 1976; Bernstein and Jung 1979; Coyer 1979; Hobson *et al.* 1981; Ebeling and Laur 1985; Bodkin 1986). The density of some species of fish are higher in the presence of *Macrocystis* than in its absence (Bray and Ebeling 1975, Larson and DeMartini 1983, Ambrose 1987, Ebeling and Laur 1985, Bodkin 1988, Holbrook *et al.* 1989, Carr 1989, DeMartini and Roberts *in prep.*). In addition, populations of several species of reef fish are replenished at higher rates, via larval recruitment, in the presence of giant kelp (Larson and DeMartini 1983, Carr 1989). Populations of giant kelp are also thought to enhance the productivity of fishes, both by being a source of food for herbivorous fish, and indirectly through invertebrate grazers that are prey of many fish (North 1971, Foster and Schiel 1985, but see MRC Final Technical Report H: Mitigation, for further discussion of this subject).

The basic question addressed in this report is: has the operation of SONGS caused changes in the total numbers or biomass of kelp bed fish in SOK?

In an early MRC study in SOK during the fall of 1979, DeMartini and Larson (1980a, b) first estimated the densities of fish in areas above rocky substrates with and without giant kelp. They found that fish were more abundant in areas with giant kelp than in areas without it. These and subsequent observations became the basis for their prediction that many fishes might exhibit decreases in density of 33% to 67% in areas where dense giant kelp becomes sparse (DeMartini and Larson 1980b; Larson and DeMartini 1983). The predicted effects of the operation of SONGS Units 2 and 3 on kelp bed fish have, therefore, been strongly tied to the predicted effects on kelp in SOK (Dean 1980). Thus, the maximum effect on kelp bed fish was expected in the upcoast and offshore portion of SOK, where giant kelp densities were predicted to decline by as much as 70% (Murdoch *et al.* 1980).

To test these predictions, the densities of fish (numbers per volume of water) and the densities of giant kelp (numbers per area of substrate) were estimated both before and after Units 2 and 3 became operational at various locations in SOK (the Impact site) and in the San Mateo Kelp forest (SMK, the Control site) located off San Mateo Point, 5-6 km upcoast of SONGS (Figure 1).

We use these data to test whether the density of fish changed in SOK from Before to After periods in areas where the kelp densities have remained relatively constant. Such changes might occur if the density of kelp bed fish are being affected by the power plant in ways other than directly through its effects on the density of giant kelp within SOK.

We also use these data to determine the relationship between fish density and giant kelp density. This relationship is then incorporated, with estimates of change in area of the kelp forest and the density of kelp within the forest, to estimate the total change in numbers or biomass of fish in SOK attributable to SONGS.

2. METHODS

2.1 Field sampling of kelp bed fishes

Fish densities within kelp forests are based on underwater surveys conducted by a team of divers. We divide the kelp habitat into two strata (water-column and bottom). We estimate densities separately for these two strata, and combine them in our estimates of total number by taking into account the volumes of the two strata. Fish were counted along transects of known length and estimated volume. The water-column, or "canopy" areas were sampled with diver-held movie cameras (DeMartini *et al.* 1983 a, b; Larson and DeMartini 1983). These "cinetransects" were done at 3.1 m below the surface and were 75 m long (+/- 2 m: Larson and DeMartini 1983), based on a 3-min swim at an average rate of 25 m/min. The average volume sampled by cinetransect was about 1000 m^3, although the width and height of cinetransects varied as a function of underwater visibility (Appendix J in DeMartini *et al.* 1987). All density data were standardized to numbers per 1000 m^3 before analysis. The estimates of density from the water column strata were assumed to apply to the water column extending from the surface to 1.5 m from the bottom. Using the densities from the 3.1 m depth as representative of densities throughout the water column is justified because fish densities at 7.7 m were indistinguishable from those in the standard "water column" depth (DeMartini *et al.* 1987). Because the 7.7 m depth was only sampled during 1985 and 1986 on a subset of surveys and stations we do not incorporate these data into our analyses.

Fishes in the bottom stratum were sampled visually by divers along transects 3 m wide, 1.5 m high, and 75 m long. The area surveyed by bottom transects was

225 m^2; the volume sampled was 337.5 m^3. The volume of this stratum is calculated assuming a 1.5 m depth.

Kelp bed fishes were surveyed only during the fall (October through December) of two Before years (1980 and 1981) and two After years (1985 and 1986). Sampling was restricted to the fall because underwater visibility was generally inadequate for fish observations during other seasons. Because sampling was dependent on sea state and underwater visibility, sampling occurred at irregular intervals throughout the fall periods. Visibility of more than 2.5 m was considered necessary in order to avoid grossly underestimating the numbers of fish. All transects were sampled between the hours of 0800 to 1600. Surveys were done on 20 to 35 days each fall within the control (SMK) and Impact (SOK) kelp beds.

In order to estimate the spatial extent of any potential effects, samples were taken within two large subdivisions of SOK, an upcoast region nearer the diffusers (referred to as SOKU, Figure 2) and a downcoast region further away (SOKD, Figure 2). Originally, a fixed location within SMK, a location in upcoast SOK (SOKU) and a location in downcoast SOK (SOKD) were chosen (locations 1, 3, and 4, respectively, in Figure 2). These were the only stations sampled during the Before period, and they were also sampled in the After period. However, by Fall 1985 kelp densities at the original SOKD site had declined substantially relative to the other sites. Therefore a second SOKD site was sampled (location 6 in Figure 2). In our estimates of density (below) we use data from the original sites in the Before period, and replace site 4 with site 6 at SOKD during the After period. We make this change so that we test for relative changes in fish density in areas that have not showed marked relative changes in giant kelp density.

In addition to the stations described above, several other stations were sampled during the After period to help establish the relationship between fish and giant kelp density. These stations were chosen so that fish were sampled over a wide range of giant kelp densities. All the stations and the dates they were sampled are given in Appendix A.

On each sampling date, a team of four divers (one pair in the water column and one on the bottom) sampled a given location. In the water column stratum fishes were filmed on eight cinetransects per location. On the bottom (which had an average depth of 14.4 m), counts were made on six transects at each site. Fishes were tallied by life stage (juvenile, subadult, and adult), based on length-maturity criteria (Appendix T in DeMartini *et al.* 1987). When cinetransects were viewed in the laboratory, fishes were scored for life stage using visual cues on film -- e.g., lengths of kelp blades, size-specific color patterns and behavior. On the bottom, fishes were counted as the transect line was paid out off a take-up spool. As the line was retrieved on the return swim, the divers counted all *Macrocystis* greater than one meter in height within the three meter width of the transect path. These counts of kelp were used to determine the relationship between fish and kelp densities. Details of these and other sampling protocols are provided in Appendix J in DeMartini *et al.* 1987.

In addition to counts we estimated biomass of the fishes. The biomass of a species was calculated by multiplying the numbers in the various life-stages by the average weights of the life stages and summing over all life-stages. Determining the average weights of the life stages involved (1) determination of length-frequency distributions of the various life-stages in both water column and bottom strata, and

(2) converting the lengths to weights. These conversions were made with the use of directly measured and published relationships between length and weight. The procedures are described in detail in Appendix T of DeMartini *et al.* 1987. The average weights and densities of the various life-stages of the species used in the calculations are presented in Appendices B and C of this report.

As described below, we use estimates of the area of substrate either occupied by kelp populations (densities exceeding 4 plants per hundred m^2) or not so occupied. These areas were estimated from areas enclosed by the 4 plants per 100 m^2 isopleths on maps generated from side-scan SONAR. Down-looking SONAR maps, which are more precise in determining kelp densities (Reitzel *et al.* 1987) were not used because surveys of this type did not begin until 1982. The total area with kelp was subtracted from the total area of hard substrate to give the area of the "kelpless" substrate. The specific maps used were from surveys taken in November 1980; December 1981-January 1982; December 1985; and December 1986-January 1987.

We also use estimates of the bed wide density of giant kelp in areas of hard substrate in SOK in the After period. These are estimated using down-looking SONAR records of kelp density (Reitzel *et al.* 1987), within areas classified as hard substrate based on side-scan SONAR following a procedure described in detail in Technical Report K. The specific down-looking SONAR surveys used were taken in December 1985 and December 1986-January 1987.

2.2 Analytical Methods

Our overall goal is to estimate changes in total numbers (and biomass) that can be attributed to the operation of SONGS. The sampling design used in the Before period was based on two main assumptions: (1) that the principal mechanism of impact would be through changes in kelp density, and not via a change in fish density for a given density of kelp, and (2) that changes in kelp density at the kelp bed fish sampling sites would be representative of changes throughout the bed. However, it became clear early in the After period, that both these assumptions might be violated, and that the change in the total fish population in SOK, relative to the changes in SMK, in the After period could potentially result from a combination of two principal factors. One, is a the relative change in numbers of fish per unit kelp in SOK versus SMK. For example, the amount of kelp could be unchanged from Before to After, but the numbers of fish per kelp plant could change, resulting in a change in total abundance. The second factor is the relative change in the area of kelp found in the two beds. The number of fish per kelp plant could remain the same, but the area of kelp plants could be disproportionately changed between the two beds resulting in a change in fish abundance, particularly if the density of fish is strongly affected by the absence of kelp. It is likely that any change in total fish abundance results from a combination of these two factors. Thus, to estimate the losses throughout SOK we needed information on changes in the density of fish when kelp density was held constant, estimates of changes in the density and areal extent of the kelp forest, and the relationship between fish density and the presence of kelp. As a consequence, the sampling program was expanded during the After period as described above.

Our procedure for estimating total losses (or gains) uses one set of information to estimate the relative change (i.e., percentage loss or gain) between SOK and SMK in numbers or biomass, and a second set of data to estimate the total number or biomass of fish in SOK during the After period. With these two pieces of information in hand it is a simple matter to estimate the number (or biomass) of fish that would be in SOK if SONGS did not exist, and from this the losses or gains.

2.2.1 Estimating Relative Changes in Numbers in SOK

We can estimate the relative change in the number of fish in SOK by using abundance indices that we take to be proportional to the actual abundance of fish in SOK and SMK. (We refer to the estimates used in the calculation of the relative percent change as indices because we believe that the data used result in an overestimation of the actual numbers in a bed at a particular time.) The derivation of these indices is described in Section 2.2.1.1 below. Once we have calculated these abundance indices we can calculate *S*, the multiplying factor representing SONGS' effect. The derivation of *S* is as follows. In the following table, *L* is the effect of location on abundance, *T* is the effect of time, and *S* is the effect of SONGS' operation. If A is the abundance (or some index proportional to the abundance) at SOK in the Before period, then the abundance at SMK in the Before, and at SOK and SMK in the After period can be expressed as multiples of *L*, *T*, and *S*:

	SOK	SMK
Before	A	*L* A
After	*T S* A	*T L* A

We can factor out S,

$$S = [(T\,S\,\mathrm{A})\,(L\,\mathrm{A})]\ /\ [(\mathrm{A})\,(T\,L\,\mathrm{A})].$$

or

$$S = (SOK_{after}\ SMK_{before})\ /\ (SOK_{before}\ SMK_{after}),$$

where SOK_{after}, for example, is the abundance index calculated for SOK in the After period.

S can also be expressed as the percent relative change where,

percent relative change = $(S\text{-}1) \times 100$

The formula for estimating S is derived in more detail in Appendix I.

We now turn to estimating the abundance indices required to estimate S.

2.2.1.1 Estimation of Abundance Indices

The abundance index for a specific kelp bed during a given period, say SOK during the After period, is calculated as:

$SOKU_{after}$= (average fish density in areas of kelp x the area of kelp) + (average fish density in areas without kelp x the area of hard substrate without kelp) found in SOK in the After period.

Note that in the following, abundance indices were calculated for water column and bottom fishes separately and combined to give the index of total numbers.

As described above we obtain the areas of kelp and non-kelp habitat from side-scan SONAR surveys. The average fish density associated with areas of kelp is taken to be the density within the areas used in our tests for changes in density of fish when kelp density is held constant (see Section 2.2.2, Relative changes in density). It is because these fish densities were measured in areas where the giant kelp densities were higher than the bed-wide average, and because there is positive relationship between fish density and kelp density (Section 3.4, Fish-kelp relations), that we believe the abundance indices over-estimate the number of fish (or biomass) in a kelp forest.

The density of fish in areas without kelp are derived by multiplying the fish density in areas with kelp by the estimated ratio of fish density in areas without kelp to fish density in areas with kelp. For the water column strata this was estimated as zero because fish were not seen on portions of cinetransects when kelp was absent (see Results). For bottom fish our ratio was estimated based on transects in SOK done during 1985 and 1986 where giant kelp was or was not present. This information was available because of the expanded sampling during the After period to determine a relationship between fish and kelp densities. The transects without kelp (location 2 for 1985, locations 2 and 9 for 1986) and with kelp (location 3,4, and 6 for both years) are given in Figure 2. We then estimate the ratio by averaging the ratio calculated for each year.

2.2.2. Relative changes in density

In addition to estimating densities in areas with kelp we tested for changes in densities of both water column and bottom fishes within SOKU, SOKD, and SMK that occurred from the Before period (1980 and 1981) to the After period (1985 and 1986). As described above we wished to detect changes in fish density that occurred independent of changes in kelp density, and care was taken to use data collected at locations within the three areas in the After period where kelp densities were similar to those sampled in the Before. The densities of kelp found at locations used in this analysis are presented in Table 1, and densities of kelp from all sampled locations are in Appendix D. The average density of kelp at both the SMK and SOKU sampling locations changed little from Before to After (Table 1). However, the average kelp density at the SOKD locations decreased from the Before to the After period (Appendix D). To reduce the influence of this Before-After change in kelp density on density changes of the associated fish, samples taken in 1981, when kelp density at this location was the highest, were excluded from the analysis. Excluding these samples resulted in a Before kelp density more similar to that found in the After (Table 1).

We take a significant ($p<0.05$) period-by-location interaction from an analysis of variance as evidence for a SONGS effect on density. The model employed was a two-factor fixed model with periods (Before-After) and location (SOKU, SOKD, and SMK) as the factors. The analysis was performed on the log $(x+1)$ transformation of the density estimates (both bottom and water column) from each of the sampling locations. As a check to see if the results of the analysis would change if a different log transformation was used, the analysis was also performed on the log (x+0.1) transformation of the data. The results of the two tests differed only slightly, effects were found in the same suite of species. We report the results only for the log (x+1) transformation.

The taxa tested were selected on the basis of frequency of occurrence. To be tested we required that a taxon occur on more than 20% of the surveys at at least two of the sampling locations in both the Before and After periods.

The test was done on the combined life stages of the species. In general, we did not analyze individual life-stages of a species separately because differences in the habitat preferences among the life stages were not known to be sufficiently different. The one exception, however, is young-of-the-year kelp bass, which are known to inhabit a much more restricted habitat than do other life stages (they are much more closely associated with benthic algae). We therefore analyzed young-of-the-year in addition to all stages combined.

We used the two-factor ANOVA as the primary analytical design rather than the Before-After-Control-Impact-Paired (BACIP) design used by DeMartini *et al.* 1987, for several reasons. (See MRC Interim Technical Report 2: Sampling Design and Analytical Procedures, for a discussion of the rationale and design of the BACIP design.) The BACIP design requires that samples be paired by date. In part, this is to reduce any potential effect of seasonality on the observations. However, seasonality is not expected to strongly influence these data because all samples were taken within the same season of the year. Furthermore, for logistic reasons not all location could be sampled on each sampling date (DeMartini *et al.* 1987). The original SOKD location was sampled on the same days as the original

SMK and SOKU sites in the After period. Unfortunately this new site had to be replaced in the After period in our analyses in order to control for changes in giant kelp density (see above), and this site was not sampled on the same dates as the SOKU and SMK sites were.

As a secondary analysis, we performed a BACIP analysis only using the data from SMK (Control) and SOKU (Impact), where kelp density remained relatively constant and where samples were collected on the same days in both Before and After periods.

In addition to our statistical results we report percent changes (relative to the changes at SMK) at SOKU and SOKD in the After period. These are calculated in the same way as percent relative changes in total numbers, but now we replace the abundance indices with the densities in SMK and either SOKU or SOKD for the two periods in Equation 1 (Section 2.2.1).

2.2.3. Estimates of numbers of fish in SOK during the After Period

The numbers and biomass of fish in each strata (bottom or water column) in SOK in the After period were estimated by multiplying the average bed-wide density (or biomass density) of fish by the volume of each strata. Volumes are simply the vertical distance from the bottom to the top of a strata times the area of hard substrate. Bed wide fish densities were estimated by predicting them, using regression equations, from bed wide giant kelp densities obtained by down-looking SONAR.

Regressions of fish density against kelp density used measures of both as described in Section 2.1. In 1985 data are available from five locations (2, 3, 4, 5, and 6, Figure 2). Two more stations (numbers 7 and 9, Figure 2) were also sampled in 1986. The mean densities of kelp at the various stations are presented in Appendix D.

While bottom fish were counted along transects which had no kelp, water column fish were not. Instead, to estimate the numbers of water column fish in areas without kelp, the cinetransects were analyzed in the following manner. Fish observed on the films were counted and identified to species and classified according to the proximity of fish to kelp. There were two proximity categories: (1) kelp present in the same visual field as the fish, and (2) kelp not present in the visual field. Density estimates were then made by calculating the volume of water searched in the time each category occurred on the film. Thirty-two cinetransects taken during 1986 at location 5, Figure 2, were analyzed in this manner.

Water column and bottom fish densities were analyzed separately. In these regressions, fish densities were not log transformed. All transect counts were scaled to a number per 1000 m^3.

Since the densities of water column fish in areas without kelp were close to zero (see Results), the regression line was fitted through the origin.

2.2.4 Numbers of fish lost or gained due to SONGS operation

As described above we estimate the change in numbers and biomass of fish in SOK that can be attributed to the operation of SONGS by incorporating estimates of the relative change in total abundance between SMK and SOK (from Section 2.3) with an estimate of the absolute numbers of fish in SOK in the After period. The estimated numbers of fish in SOK during the After period uses the kelp-fish relationship described in the previous section. This number is the "observed" abundance in the equation:

No. of fish lost = Expected abundance - Observed abundance

=(Observed abundance) $(1/S)$ - Observed abundance,

where S is, again, the multiplicative effect of SONGS' effect on abundance (see above).

A detailed description of the method used to calculate the numbers of fish lost and of the method used to estimate confidence intervals around these numbers is given in Appendix I.

3. RESULTS

3.1 The Kelp Bed Fish Assemblage

Table 2 ranks, by mean density (per transect), the species observed in the water column and near the bottom at the three sampling locations in both the Before and After periods. These densities are the average of the two Before and two After sampling years. Note that since these are the data used in the test for density changes (the ANOVA described in Section 2.2.2) independent of changes in kelp density, data collected at the SOKD site in 1981, where kelp density was abnormally high, are not included (means for the separate years are presented in Appendix E). Note too, that these are the densities of fish found in areas of the kelp beds where the average density of kelp is 10 or more per 100 m^2 (Table 1) and, therefore, are higher than then the true "bed-wide" averages. A complete list of the mean densities (and standard errors) of the various life-stages of all species observed during the study is presented in Appendix C. The frequency of occurrence for each species and for their various life-stages are presented in Table 3.

Several species found in the water column, which had high densities in the Before period, e.g., kelp perch (*Brachyistius frenatus*) were less dense in the After period at all locations. The occurrence of these changes at all sampling locations may reflect a response to the El Nino that occurred from 1982 to 1984, in the interval between the Before and After periods. However, contrary to the general pattern of decline among species in the water column, several species (e.g., rock wrasse, *Halichoeres semicinctus*) increased in density throughout the study area during the operational period.

While many species were found in both water column and bottom strata, some species were found predominantly in one of the strata. For example, California sheephead (*Semicossyphus pulcher*), rock wrasse (*Halichoeres semicinctus*), barred sand bass (*Paralabrax nebulifer*), and black seaperch (*Embiotoca jacksoni*) appear to be tightly associated with the bottom, while halfmoon (*Medialuna californiensis*) and kelp perch (*Brachyistius frenatus*) were much more likely to be seen in the water column.

Some of the species listed in Table 2 are fish also found in open water areas away from kelp beds. Northern anchovy (*Engraulis mordax*), Pacific barracuda (*Sphyraena argentea*) and silversides spp. (an amalgam of three species of atherinids, primarily topsmelt (*Atherinops affinis*) but with some jacksmelt (*Atherinopsis californiensis*) and California grunion (*Leuresthes tenuis*) are all found in midwater areas away from SOK. It should be noted that these schooling, midwater fish were rarely found, on any given sampling day, at more than one sampling location. In fact, the high density of anchovy in the water column at SMK in the After period (Table 2) is due to observations of schools on only two sampling dates. These species and three others, jack mackerel (*Trachurus symmetricus*), Pacific mackerel (*Scomber japonicus*) and Pacific bonito (*Sarda chiliensis*) are not treated further in the present report (but see MRC Interim Technical Report 3: Midwater and Benthic Fish,), nor are they included in our estimates of "total" numbers or biomass of kelp bed fish.

In contrast to these species, several species appear to be tightly bound to kelp bed habitats in the San Onofre region. Kelp perch, kelp bass (*Paralabrax clathratus*), senorita, halfmoon, rock wrasse, and California sheephead, for example, are all rarely found away from hard substrates, particularly those with kelp, in the study areas. DeMartini *et al.* 1987, present a detailed discussion of the habitats and affinities of this species assemblage.

3.2 Fish Density Changes in Areas of Constant Kelp Density

Changes in fish density in areas of relatively constant giant kelp density play an important part in our calculation of percent change in abundance (Section 2.2.1) and are also of interest in their own right. An ANOVA (described in Section 2.2.2) was performed on the densities of those species which passed our criterion of frequency of occurrence (Appendix E). We report the relative percent change observed from Before to After at SOKU and SOKD for those species which displayed a significant ($p<0.05$) period-by-location interaction in Table 4. The direction of the indicated change in density is presented for the species which did not have a significant interaction. Fish densities are summarized in Table 2 (yearly densities are presented in Appendix F). Complete ANOVA tables for those species with significant period-by-location interactions are presented in Appendix G.

In the water column stratum, two species showed statistically significant ($p<0.05$) increases in density at both locations in SOK relative to the change in density observed in SMK. Senorita decreased in mean density from 21.5 (all densities are per 1000 m^3 of water) to 18 in SMK, but increased at SOKU and SOKD from approximately 14 to over 35. These changes result in relative increases of 224% and 185%, respectively, at the two SOK stations. Halfmoon changed in a similar manner. While densities decreased in SMK, they increased at both locations in SOK. These changes resulted in relative increases of 548% at SOKU and 529% at SOKD.

Two other species in the water column displayed significant period-by-location interactions in which the densities showed a relative decline in upcoast SOK and a relative increase in downcoast SOK. Kelp perch decreased in density throughout the study area. However, relative to SMK, they decreased by 25% at SOKU but increased by 86% at SOKD. Giant kelpfish (*Heterostichius rostratus*) increased throughout the study area, but relative to SMK, it declined 42% at the location in SOKU and increased 85% at SOKD. The results of a second ANOVA on the densities of these fish in which samples from SOKU and SOKD were combined and tested for a period-by-location interaction against the densities at SMK indicate that the density of giant kelpfish increased 67% in SOK overall ($p<0.01$, Appendix H). An overall change in kelp perch density in SOK, however, was not detected in this analysis.

In the bottom stratum, four species decreased significantly in density throughout SOK relative to SMK in the After period. Sheephead declined throughout the study area but density declined more in SOK so that relative to SMK they declined by 46% at SOKU and by 70% at SOKD. Rainbow seaperch (*Hypsurus caryi*) densities changed very little at SMK from Before to After. However, they declined in SOK so that relative to SMK they declined by 68% (SOKU) and 59% (SOKD). Barred sand bass (*Paralabrax nebulifer*) increased in density at SOKD and decreased slightly at SOKU in the After period. However, when compared to the large increase in density observed at SMK in the After period, these changes result in relative decreases of 74% near the diffusers and 43% at the SOKD location. The mean densities of black perch (*Embiotoca jacksoni*) increased at SMK, but declined within SOK resulting in relative decreases of 85% at SOKU and 74% at SOKD.

Only one species, senorita, increased in density in the bottom stratum in SOK relative to SMK. The mean densities declined in SMK but increased in SOK resulting in relative increases of 580% at SOKU and 330% at SOKD.

As a secondary analysis, a BACIP analysis was performed on paired samples taken at the SMK and SOKU locations. (Recall that these stations were sampled on the same day but the SOKD station used in our analysis of density was not (see Methods).) The results (Appendix J) corroborate the results of the ANOVA, particularly those of the SMK-SOKU comparison.

3.3 Relative Change in Total Fish Abundance

We calculate the relative percent change in fish abundance so that we can estimate the numbers and biomass of the fish lost due to the operation of SONGS (Section 3.5, below). These changes in SOK relative to SMK are reported in Table 5. Estimates of relative percent change in numbers and biomass are presented for three categories of fish in both the bottom and water column strata: total kelp-bed fish, senorita only, and all non-senorita fish. Senorita were considered separately because they were the most abundant kelp bed fish and we wished to know if the results regarding total kelp bed fish were being dominated by the change in this one species. (Estimates of relative changes in other individual species are presented in Appendix K.)

As described in Section 2.2.1 the estimate of relative change between SOK and SMK in total abundance or biomass uses the products of fish density within a habitat type (substrate with kelp or substrate without kelp) times the area of that habitat type (i.e., the abundance index). These abundance indices were derived for both SMK and SOK in both sampling periods. The relative changes in the area of the substrate types, the relative changes in the densities of bottom fish, water column fish and biomass are presented in Table 6.

The fish densities, areas of habitat, volumes of strata and their products, the abundance indices, are presented in Appendix L. Recall that these indices are not unbiased estimates of the abundance. A more accurate estimate of the total number of fish is derived below for SOK in the After period (Section 3.5).

The densities of fish in areas without kelp are determined using a ratio based on the observed densities in area with and without kelp in the After period in SOK. The ratios are presented in Table 7.

3.3.1. Areas of kelp

Changes in areas of giant kelp are an important factor in helping determine the relative changes in fish abundance between the two kelp beds. The relative decrease in area of kelp in SOK in the After period at those times when kelp bed fish were sampled is approximately 76% (Table 6). At the Control site kelp was present on an average of 49% of available substrate during the Before period (Appendix L). During the After there was little change in this percentage as kelp was found on an average of 55% of the available substrate. In contrast, the percentage of hard substrate with kelp decreased at the Impact site from 60% to 26% from Before to After.

3.3.2. Bottom fish

There has been a disproportionate decrease in the total number of bottom fish in SOK, compared to SMK, during the After period (Table 6). Relative to Control (SMK), the total number of bottom fish in SOK displayed a relative decrease of 70%. When sorted into senorita and non-senorita a further pattern becomes apparent. Non-senorita fish decreased in abundance in SOK 82% relative to SMK. The abundance of senorita, on the other hand, increased in SOK 168% relative to SMK. (Estimates of the changes in other individual species are presented in Appendix K.)

The pattern of change in the biomass of bottom fish corresponds to the change seen in total numbers (Table 5). The biomass of all bottom fish combined displayed a relative decrease of 73% in SOK. The change observed in the biomass of non-senorita fish amounted to a relative decrease of 76% in SOK and corresponded to the decrease seen in numbers. Likewise, senoritas, which showed a relative increase in numbers in SOK, also displayed a relative increase in biomass (226%).

3.3.3. Water column fish

The relative changes in abundance of fish in the water column were not as great as seen among the fish in the bottom stratum (Table 5). The total abundance of all fish species in the water column in SOK declined relative to SMK, but the decline was small (17%). When divided into senoritas and non-senoritas, the same pattern of relative changes occurred. In contrast to the relative increase in abundance seen in the bottom stratum, senorita exhibited a relative decrease of 27% in SOK. Non-senorita fish exhibited a small relative decline of 6%. (Estimates of the relative changes in other individual species are presented in Appendix K.)

The changes in kelp area and water column fish density (in areas with kelp) were in opposite directions (Table 6). While the area of kelp in SOK exhibited a relative decrease of 76%, the density of fish in the kelp areas of SOK increased by over 200% relative to the change observed in SMK (Again this estimate of change is based on areas where kelp density remained relatively constant). Thus while the area of kelp in SOK experienced a three-fold decrease relative to the change in SMK, the density of the water column fish in this area approximately tripled relative to that in SMK.

Although the numbers of water-column fish did not show large relative changes between Impact and Control, total biomass declined by 33% in SOK relative to SMK. Among non-senorita fish, the relative decrease in biomass in SOK was 36%, which is considerably larger than the 6% relative decline in numbers. Senorita biomass declined by 27% in SOK relative to SMK just as did its abundance.

3.4 Fish-Kelp Relationships

3.4.1 Water Column fish

The importance of the presence of kelp to water column fish is apparent (Table 8). Fish found in the water column in kelp forests are rarely found in the water column away from kelp.

The relationship between total water column fish density and kelp density was evaluated in SOK in both 1985 and 1986 (Figure 3). Significant positive relationships between water column fish density and kelp density were obtained in both years (1985: $p=0.02$, $r^2=0.16$; 1986: $p=0.03$, $r^2=0.17$), although the variance explained by the relation is rather small. Note that the regression lines fit to these data pass through the origin because examination of the cinetransects indicated that water column fish were very rare away from kelp (Table 8). However, the significance of the regression is not dependent on the line passing through the origin. The slopes for the two years were not found to be significantly different from one another although there were differences in the kelp densities and overall fish abundances between the two years.

The regression of water column fish biomass against kelp density (Figure 4) also had a positive slope and was significant ($p=0.02$; $r^2=0.18$) in 1985. The relationship was not as strong in 1986 ($p=0.097$; $r^2=0.09$). The slopes of the regression lines from the two years did not differ significantly. As can be seen in Figure 4, the biomass regression for water-column fish was fitted through the origin.

3.4.2. Bottom fish

Significant positive relationships were also obtained between kelp density and bottom fish density in SOK during 1985 ($p<0.01$; $r^2=0.27$) and 1986 ($p<0.01$; $r^2=0.45$; Figure 3). Note that for fish in the bottom stratum we do not fit the regression line through the origin. Unlike fish in the water column, fish in the bottom stratum are present in areas of hard substrate where kelp is absent (Table 7). As was the case with the water column fish regression, the slopes of the regression for bottom fish were not found to differ significantly between years although there were differences in the kelp densities and overall fish abundances between the two years.

Significant positive relationships between biomass of bottom fish and kelp density were obtained in both 1985 ($p<0.01$; $r^2=0.18$) and 1986 ($p<<0.01$; $r^2=0.52$; Figure 4). The slopes of the two regression lines did not differ significantly.

3.5 Estimate of numbers of fish lost in SOK

We use the kelp-fish relationships (Section 3.4) to estimate numbers and biomass of fish in SOK in the After period (See Methods). These estimates are the "observed" values in Table 9. The "expected" values are the values we would expect if SONGS had no effect (see Section 2.2.1). The difference between observed and predicted values is our estimate of the losses (or gains) due to the operation of SONGS.

The estimated number of bottom fish in SOK in the After period is approximately 84,000 and their aggregate biomass is 9.3 metric tons. The expected values, however, are 275,000 fish weighing 34.4 metric tons. The loss in numbers (191,000) and biomass (25 metric tons) in SOK has been quite marked.

The estimates for water column fish indicate that 133,000 fish totaling 10.6 metric tons were present in SOK in the After period. The expected values were 160,000 and 15.6 metric tons. The differences between the estimated and expected values are not as great as among bottom fish although there has been an appreciable loss in biomass.

To assess the strength of our estimates of the SONGS effect, ninety-five percent confidence intervals were calculated on the differences between expected and observed abundances (See Appendix I for their derivation). The difference and the confidence intervals are presented in Table 11. The confidence interval around the estimate of losses among bottom fish does not overlap zero and therefore we are confident that losses have indeed occurred. Although the confidence interval around the indicated difference among water column fish overlaps zero and therefore should be viewed cautiously, the indicated change is our best estimate of SONGS' effect.

In estimating the density of fishes (and subsequently abundance) we used the average bed-wide densities of kelp in SOK as determined by down-looking SONAR In 1985 the estimated density was 3.23 plants/100 m^2 and in 1986 it was 1.40 plants/100 m^2. The fish densities and biomass predicted from the regression equations are tabulated in Table 10. These values were multiplied by the area of small but abundant fish, did not account for much of the biomass of the kelp bed fish assemblage.

The reduction in water column fishes was less, a 17% decline in numbers in SOK. However, the decline in SOK was more pronounced in terms of total biomass (33%). Again this pattern was more pronounced among non-senorita fish. In numbers, they expressed a slight (6%) relative decrease in SOK, but a 36% decrease in biomass. This suggests that, while approximately the same number of fish were present in SOK in the After period, there were fewer large fish. This suggests, further, that while SOK may be still be an adequate habitat for recruitment and survival of younger, smaller fish, it may not as suitable as it once was for larger individuals. However, while the loss of total water column fish is estimated to translate into approximately 27,000 fish weighing 5 metric tons, this estimate, unlike that of the bottom fishes, cannot be held with statistical confidence. The relative changes in abundance of water column and bottom fish are somewhat surprising in light of the relationships between the density of each of the groups and the area and density of kelp.

4.1 Changes in abundance of water column fishes

Many fish found in the water column within the kelp bed are closely associated with the kelp plants themselves and are rarely found in the midwater even a short distance away from the kelp plant. Thus the absence of kelp in an area results in the absence of these fish in the water column. Furthermore, the density of these fish increases as the density of kelp increases. Both of these relationships suggest that the abundance of these fish would be very sensitive to kelp loss.

However, it appears that even in light of the large reduction in kelp observed at SOK during the sampling period (1985 and 1986), the total numbers of fish in the water column were not reduced to the same extent. This suggests that some fish species increased density in the smaller areas of remaining kelp habitat in the After period (although not all species behaved in this fashion).

Evidence of such "crowding" comes from the changes in densities, per unit kelp, of several species of fish which changed differentially among the sampling locations selected for constant kelp density from the Before to the After period. A number of species of water column fish which displayed these "location-by-period" interactions increased in relative density (numbers per unit kelp) in SOK. The most striking was the senorita. While its densities declined slightly at SMK, its densities in SOK increased dramatically, more than doubling its Before density. Several mechanisms may have resulted in this increase. Resident populations of senorita may be confined to smaller areas of available habitat (kelp) and the increased densities result from this "concentrating" of the population into relatively small areas. While the area of kelp in SOK decreased approximately 70% in relation to the change in SMK (this amounts to an approximate three-fold decrease), the relative increase in senorita density per kelp plant (in the water-column) was 180-220%, approximately a three-fold increase in SOK. These figures suggest the that change in fish density can be accounted for by the "concentrating" of population into a smaller area of habitat. Another process that may act to increase the number of fish per kelp plant in a kelp bed that has decreased in size is the fact that as patches of kelp within the bed become smaller, the amount of "edge" of the kelp bed increases. Some kelp bed fish have been observed to be more abundant near these edges (R. Bray, CSULB, *pers. comm.*)

However, we cannot discount other processes which may have increased senorita densities. Perhaps additional food, either material discharged by the generating station or material in bottom waters redistributed throughout the water column as a result of entrainment by the discharge water, is made available to the senorita. Although larger individuals primarily pick invertebrates off kelp blades and other objects, they and smaller individuals are known to pick plankton from the water column (Bray and Ebeling 1975; Hobson and Chess 1976; Bernstein and Jung 1979; Hobson *et al.* 1981) Since increased fouling on kelp blades was not found in SOK in the After period (Dixon *et al.* 1987), it is likely that a greater availability of waterborne prey in the diffuser plume has enhanced the attractiveness of this area for such an opportunistic forager (Hobson and Chess 1976; Bray and Ebeling 1975; Bernstein and Jung 1979).

Relative increases in density in another species, the halfmoon, were observed in the water column throughout SOK. While it declined in density in SMK, it increased at both locations in SOK. Again, this species may be "crowding" into smaller areas of dense kelp. However, the relative increase in density (approximately six-fold) is much greater than the three-fold decrease in kelp habitat. This suggests that other factors, such as food made available by the operation of SONGS, may be important in causing the increase in density in SOK.

Two species of fish, the giant kelpfish and the kelp perch, exhibited a relative decline in density at the Impact station nearest the diffusers and an increase at the more distant Impact site. The density of giant kelpfish increased at all locations sampled but increased the least in the upcoast portion of SOK. The relative decline in SOK near the diffusers is where the kelp population has been most reduced in the

After period (Technical Report K: Giant Kelp). The same pattern of density changes was observed in the kelp perch. Although this species declined throughout the study area, their density decreased, relative to SMK, near the diffusers and increased at the distant Impact site. These patterns cannot be explained simply by "concentrating" numbers of this species in smaller patches of habitat. Perhaps increased turbidity has made the areas nearer the diffusers a less attractive habitat to these species. The increases in density at the further Impact station suggests that the fishes may have redistributed themselves within the kelp bed and, in general, have moved from near the generating station, to areas further away. This pattern is suggested further by the observation that all of the indicated decreases in density (when considered regardless of statistical significance) among the water column fishes occurred at the nearer Impact location (SOKU) only.

It is important to keep in mind, in terms of predicting the future response of this group of fish, that we do not know if the higher densities resulting from the fish concentrating into smaller areas of habitat are sustainable.

4.2. Changes in relative abundance among bottom fishes

Unlike water column fish, which are essentially absent when kelp is absent, bottom fish do occur in areas without kelp, although they are less abundant there. Therefore, these fish were not expected to be affected by the loss of kelp as much as the water column fishes. However, large relative reductions did occur among these fishes, suggesting several possible effects of SONGS.

The loss of kelp habitat almost certainly accounted for some of the reduction in these fish. However, several observations indicate that kelp loss cannot account for all of the losses observed. Again, some of the strongest evidence for this comes from the relative changes in fish densities per unit kelp in the areas of SOK selected for constant kelp density.

In the bottom stratum the general patten of changes in density was a relative decline in density per kelp plant in SOK. Barred sand bass, black perch, rainbow seaperch, and California sheephead all declined significantly at both of the SOK locations relative to SMK. All of these species, which feed on benthic invertebrates, are capable of a great degree of habitat selection and may be responding to some alteration of habitat in SOK such as altered prey abundances.

The one species which demonstrated a relative increase in the bottom stratum in SOK was the senorita. Its density increased at both SOK sites while decreasing in SMK. This pattern corroborates that seen among the water column portion of the kelp beds and, again, may be due to the concentrating of the population in smaller areas of habitat or to additional food material made available in the water column.

Since the relative reduction of these fish (with the exception of the senorita) is greater than the relative reduction in the area of kelp, and as discussed above, the density of these fish have decreased in areas where the kelp density has remained constant, other mechanisms accounting for these reductions are suggested. There is evidence from MRC studies that other aspects of the benthic environment near the diffusers have changed during the After period. There have been changes in the substrate types, some areas of cobble substrate have become covered with soft sediments (Final Technical Report B: Anomalous Sediments in the San Onofre Kelp Forest). There have been changes in populations of benthic invertebrates (e.g., several species of snails) which may indicate that other benthic prey items of the fish may also be reduced (Final Technical Report F). There have been changes, too, in the growth and survival of young kelp plants near the diffusers (Final Technical Report K). All of these patterns suggest that the benthic environment has been altered and it is likely that the fish found in this habitat would be affected as well.

4.3 Predicted long-term effects of SONGS

It is important to keep in mind that the estimates of SONGS' effects are in terms of *relative changes* in SOK compared to changes observed in SMK. The important variables used to estimate this relative change were the relative changes in area of kelp habitat and fish densities within the habitat in both SOK and SMK. To determine if the effect of SONGS changes in time, data on these variables must be gathered. For example, it will not be sufficient to determine any change in SONGS effects by monitoring the size of SOK only. A doubling of the extent of SOK does not necessarily mean that fish populations will double in size. Nor, if such an increase in fish does occur, that it is still not less than a corresponding increase in SMK.

On the other hand, while the relative effect of SONGS may remain constant, the estimated numbers of fish affected (and their biomass) over any one period are very much a function of the fish densities present in the study area during that period. Fish abundances in the study area during a particular year are a function of a great many factors, many of which are exogenous to the study area. For example, our assessment of the effect of SONGS on the abundance of kelp bed fishes was set against several patterns of wide-scale changes in the abundances of fish observed throughout the study area. Perhaps the most striking pattern was the decrease in the densities of many species from Before to After at both Impact and Control. DeMartini *et al.* (1987) point out that many of the species that declined are primarily cold-temperate in terms of distribution, and their reductions may have been caused by the warm waters associated with the El Nino that occurred between the Before and After sampling periods. Conversely, several species increased in density throughout the general study area. These species, particularly senorita and rock wrasse, are considered warm-temperate species with respect to their distributions. Other studies (Patton 1985) observed similar increases in senorita and rock wrasse on a bightwide scale during 1983-84. It is expected that subsequent to 1986 (the end of the MRC sampling period), many fish populations adversely affected by El Nino, will grow again. Therefore, while the SONGS' effect in terms of percent change may stay the same, the numbers of fish affected are expected to change from year to year.

5. REFERENCES

Ambrose, R.F. 1987. Comparison of communities on artificial reefs in Southern California, with emphasis on fish assemblages. Final Report to the Marine Review Committee.

Bernstein, B.B. and N. Jung. 1979. Selective pressures and coevolution in a kelp canopy community in southern California. *Ecol. Monogr.* 49: 335-355.

Bodkin, J.L. 1986. Fish assemblages in *Macrocystis* and *Nereocystis* forests off central California. *U.S. Fish. Bull.* 84: 799-808.

Bodkin, J.L. 1988. Effects of kelp removal on associated fish assemblages in central California. *J. Exp. Mar. Biol. Ecol.* 117: 227-238.

Bray, R.N. and A.W. Ebeling. 1975. Food, activity, and habitat of three "picker-type" microcarnivorous fishes in the kelp forests off Santa Barbara, California. *U.S. Fish. Bull.* 73: 815-829.

Carr, M.H. 1989. Effects of macroalgal assemblages on the recruitment of temperate zone reef fishes. Jour. Exp. Mar. Bio. Ecol. *in press*

Coyer, J.A. 1979. The invertebrate assemblage associated with *Macrocystis pyrifera* and its utilization as a food source by kelp forest fishes. Ph. D. thesis, University of Southern California, Los Angeles. 364 p.

Dean, T.A. 1980. The effects of the San Onofre Nuclear Generating Station on the giant kelp, *Macrocystis pyrifera*. Annual report of the Kelp Ecology Project: January 1979 through January 1980. Report to the MRC. 280 pp.

DeMartini, E.E. and R.J. Larson. 1980a. Predicted effects of the operations of SONGS Units 1, 2, and 3 on the fish fauna of the San Onofre region. Report submitted to the Marine Review Committee, Inc., May 1980.

DeMartini, E.E. and R J. Larson. 1980b. Appendix I, summary of SONGS' predicted impact on fishes, with emphasis on the loss of egg/larval-adult equivalents. Report submitted to the Marine Review Committee, Inc. in support of the "Report of the Marine Review Committee to the California Coastal Commission: predictions of the effects of San Onofre Nuclear Generating Station and recommendations. Part I: recommendations, predictions, and rationale," November 1980. MRC Doc. No. 80-04 (I).

DeMartini, E.E., L.G. Allen, and UCSB Staff. 1983a. Patterns of distribution and abundance of coastal, pelagic; benthic, soft-bottom; and kelp bed fishes near San Onofre Nuclear Generating Station (SONGS): evaluation of the BACI model. Final preoperational monitoring report of the UCSB Fish Project on SONGS Units 2 and 3. Vol. I, general summary of findings. Report submitted to the Marine Review Committee, Inc., March 1983. MRC File No. 967(I).

DeMartini, E.E., L.G. Allen, and UCSB Staff. 1983b. Patterns of distribution and abundance of coastal, pelagic; benthic, soft-bottom; and kelp bed fishes near San Onofre Nuclear Generating Station (SONGS): evaluation of the BACI model. Final preoperational monitoring report of the UCSB Fish Project on SONGS Units 2 and 3. Vol. II, appendices. Report submitted to the Marine Review Committee, Inc., March 1983. MRC File No. 967(I).

DeMartini, E.E. and UCSB Staff. 1987. The effects of operations of the San Onofre Nuclear Generating Station. Final Report submitted to the Marine Review Committee, Inc., December 1987. MRC No. D86-386.

Dixon, J.D., S.C. Schroeter, T.A. Dean. 1987. Studies of fouling organisms on giant kelp, 1980-1986. Draft Final Report submitted to the MRC October 1987.

Ebeling, A.W. and D.R. Laur. 1985. The influence of plant cover on surfperch abundance at an offshore temperate reef. *Environ. Biol. Fish.* 12: 169-179.

Feder, H.M., C.L. Turner and C. Limbaugh. 1974. Observations on fishes associated with kelp beds in southern California. Calif. Dept. Fish Game, *Fish Bull.* 160: 1-144.

Foster, M.S. and D.R. Schiel. 1985. The ecology of giant kelp forests in California: a community profile. U. S. Fish Wildl. Serv., *Biol. Rep.* 85 (7.2). May 1985.

Hobson, E.S. and J.R. Chess. 1976. Trophic interactions among fishes and zooplankters near shore at Santa Catalina Island, California. *U.S. Fish. Bull.* 74: 567-598.

Hobson, E.S., W.N. McFarland, and J.R. Chess. 1981. Crepuscular and nocturnal activities of Californian nearshore fishes, with consideration of the scotopic visual pigments and the photic environment. *U.S. Fish. Bull.* 79: 1-30.

Holbrook, S.J., M.H. Carr, R.J. Schmitt, and J.A. Coyer. 1989. The effect of giant kelp on local abundance of demersal fishes: The importance of ontogenetic resource requirements. *Bull. Mar. Sci., in press.*

Larson, R.J. and E.E. DeMartini. 1983. Abundance and vertical distribution of fishes in a cobble-bottom kelp forest off San Onofre, California. *U.S. Fish. Bull.* 82: 37-53.

Murdoch, W.W., B.J. Mechalas, and R.C. Fay. 1980. Predictions of the effects of San Onofre Nuclear Generating Station and recommendations, Part I: recommendations, predictions, and rationale. Report of the Marine Review Committee to the California Coastal Commission. MRC Doc No. 80-04(I).

North, W.J. 1971. The biology of giant kelp beds in California. Nova Hedwigia Beihefte 32: 1-600.

Patton, M.L. 1985. Changes in fish abundance in the Southern California Bight during a warm-water episode. Chapter 8 *in* Report on 1984 data: marine environmental analysis and interpretation, San Onofre Nuclear Generating Station. So. Calif. Edison Co., SCE Res. Dev. Rep. 85-RD-37. MRC File No. 1097.

Quast, J.C. 1968a. Fish fauna of the rocky inshore zone. Pp 35-55 *in* (W. J. North and C. L. Hubbs, eds.), Utilization of kelp-bed resources in southern California. Calif. Dept. Fish Game, *Fish Bull.* 139: 1-264.

Quast, J.C. 1968b. Observations on the food of the kelp-bed fishes. Pp 109-142 *in* (W. J. North and C. L. Hubbs, eds.), Utilization of kelp-bed resources in southern California. Calif. Dept. Fish Game, *Fish Bull.* 139: 1-264.

Reitzel, J., H. Elwany, and K. Zabloudil. 1987. Kelp density estimates from down-looking SONAR surveys. Final Report, Vol. IV-1. Submitted to the Marine Review Committee, Inc., July 1987.

Seber, G.A.F. 1983. *The Estimation of Animal Abundance*. Griffin, London. 506 pp.

This page intentionally left blank.

6. TABLES

Table 1

AVERAGE KELP DENSITIES (per 100 m²) AT SITES USED IN ANOVA ON FISH DENSITY.

Means (and standard errors) are presented. N = number of transects on which kelp was counted.

PERIOD	SMK	SOKU	SOKD
Before	40.3 (2.5) n=212	12.8 (0.4) n=204	11.4 (0.4) n=126
After	44.8 (3.0) n=90	16.3 (0.8) n=90	16.2 (0.8) n=96

Table 2

AVERAGE KELP BED FISH (IN WATER COLUMN AND BOTTOM STRATA) RANKED BY DENSITY AT SMK, SOKU, AND SOKD IN BOTH SAMPLING PERIODS.

Densities in water column are per 1000 m^3, bottom densities are per 337 m^3. All life stages of each species are combined.

Table 2 (Continued)

KELP BED
MEAN FISH DENSITIES
ALL LIFE STAGES COMBINED
BEFORE PERIOD

STRATUM=CANOPY

SAN MATEO		SAN ONOFRE UPCOAST		SAN ONOFRE DOWNCOAST	
SPECIES	DENSITY	SPECIES	DENSITY	SPECIES	DENSITY
KELP PERCH	32.31	SENORITA	14.25	SENORITA	14.51
SENORITA	21.53	JACK MACKEREL	11.68	KELP PERCH	8.17
JACK MACKEREL	8.37	KELP PERCH	10.69	KELP BASS	7.42
SILVERSIDES SPP.	7.93	KELP BASS	6.94	JACK MACKEREL	3.36
KELP BASS	4.38	SILVERSIDES SPP.	3.44	SILVERSIDES SPP.	2.18
HALFMOON	4.24	HALFMOON	2.91	HALFMOON	1.75
WHITE SEAPERCH	2.24	WHITE SEAPERCH	2.73	WHITE SEAPERCH	0.34
OPALEYE	1.86	PACIFIC MACKEREL	0.38	PACIFIC BARRACUDA	0.10
PACIFIC BARRACUDA	1.07	PACIFIC BARRACUDA	0.31	GIANT KELPFISH	0.03
SALEMA	0.37	OPALEYE	0.09	PILE PERCH	0.02
GIANT KELPFISH	0.10	PILE PERCH	0.07	OPALEYE	0.01
PILE PERCH	0.06	BLACKSMITH	0.06	BARRED SAND BASS	0.00
BARRED SAND BASS	0.00	GIANT KELPFISH	0.05	BLACK PERCH	0.00
PACIFIC ELECTRIC RAY	0.00	BLACK PERCH	0.01	BLACKSMITH	0.00
PACIFIC MACKEREL	0.00	CA SHEEPHEAD	0.00	CA SHEEPHEAD	0.00
BLACK PERCH	0.00	SARGO	0.00	KELP ROCKFISH	0.00
BLACKSMITH	0.00	WHITE SEABASS	0.00	NORTHERN ANCHOVY	0.00

Table 2 (Continued)

KELP BED
MEAN FISH DENSITIES
ALL LIFE STAGES COMBINED
AFTER PERIOD

STRATUM=CANOPY

SAN MATEO		SAN ONOFRE UPCOAST		SAN ONOFRE DOWNCOAST	
SPECIES	DENSITY	SPECIES	DENSITY	SPECIES	DENSITY
NORTHERN ANCHOVY	29.76	SENORITA	39.27	SENORITA	35.27
SENORITA	18.34	SALEMA	9.99	KELP BASS	5.77
KELP PERCH	3.69	HALFMOON	5.29	SALEMA	5.26
KELP BASS	3.32	KELP BASS	2.75	HALFMOON	3.09
SILVERSIDES SPP.	3.19	JACK MACKEREL	2.04	KELP PERCH	1.74
HALFMOON	1.19	PACIFIC BARRACUDA	1.48	JACK MACKEREL	1.12
BLACKSMITH	0.84	SILVERSIDES SPP.	0.94	PACIFIC BARRACUDA	0.83
GIANT KELPFISH	0.45	KELP PERCH	0.91	PACIFIC BONITO	0.37
JACK MACKEREL	0.10	PACIFIC BONITO	0.81	GIANT KELPFISH	0.25
PACIFIC BARRACUDA	0.09	WHITE SEAPERCH	0.33	WHITE SEAPERCH	0.23
WHITE SEAPERCH	0.05	GIANT KELPFISH	0.13	SILVERSIDES SPP.	0.08
PILE PERCH	0.05	BLACKSMITH	0.03	BLACKSMITH	0.08
OPALEYE	0.04	ROCK WRASSE	0.02	PILE PERCH	0.06
ROCK WRASSE	0.04	OPALEYE	0.01	BARRED SAND BASS	0.03
PIPEFISH	0.04	PACIFIC ELECTRIC RAY	0.01	ROCK WRASSE	0.03
BLACK PERCH	0.03	PILE PERCH	0.01	OPALEYE	0.01
BARRED SAND BASS	0.00	BARRED SAND BASS	0.00	KELP ROCKFISH	0.01

Table 2 (Continued)

KELP BED
MEAN FISH DENSITIES
ALL LIFE STAGES COMBINED
BEFORE PERIOD

STRATUM=BOTTOM

SAN MATEO		SAN ONOFRE UPCOAST		SAN ONOFRE DOWNCOAST	
SPECIES	DENSITY	SPECIES	DENSITY	SPECIES	DENSITY
SENORITA	11.50	WHITE SEAPERCH	14.97	KELP BASS	13.25
KELP BASS	4.92	KELP BASS	8.72	BLACK PERCH	11.42
CA SHEEPHEAD	2.61	CA SHEEPHEAD	7.35	CA SHEEPHEAD	7.90
JACK MACKEREL	2.05	BLACK PERCH	3.90	JACK MACKEREL	4.76
WHITE SEAPERCH	1.82	SENORITA	3.36	BLACK CROAKER	3.49
BLACK PERCH	1.38	BARRED SAND BASS	2.21	SENORITA	2.97
ROCK WRASSE	1.37	BLACK CROAKER	1.96	BARRED SAND BASS	1.80
PILE PERCH	1.09	JACK MACKEREL	1.32	PILE PERCH	1.80
BLACKSMITH	1.09	PILE PERCH	0.96	RAINBOW SEAPERCH	1.56
BLACK CROAKER	0.95	ROCK WRASSE	0.36	RUBBERLIP SEAPERCH	0.90
SALEMA	0.81	RAINBOW SEAPERCH	0.27	ROCK WRASSE	0.86
BARRED SAND BASS	0.40	SALEMA	0.25	WHITE SEAPERCH	0.63
RAINBOW SEAPERCH	0.29	RUBBERLIP SEAPERCH	0.24	OPALEYE	0.13
RUBBERLIP SEAPERCH	0.25	BLACKSMITH	0.23	GARIBALDI	0.13
KELP PERCH	0.24	SARGO	0.06	HALFMOON	0.10
HALFMOON	0.12	OPALEYE	0.04	BLACKSMITH	0.05
OPALEYE	0.11	HALFMOON	0.03	BAT RAY	0.02
GARIBALDI	0.07	KELP ROCKFISH	0.03	LEOPARD SHARK	0.02
SARGO	0.06	GARIBALDI	0.01	ROUND STINGRAY	0.02
LEOPARD SHARK	0.03	KELP PERCH	0.01	TURBOT SPP.	0.02
PACIFIC ELECTRIC RAY	0.02	LEOPARD SHARK	0.01	HORNYHEAD TURBOT	0.01
GIANT KELPFISH	0.02	CA SCORPIONFISH	0.01	SMOOTHHOUND SPP.	0.01
BAT RAY	0.01	BAT RAY	0.00	CA HALIBUT	0.00
CA HALIBUT	0.00	GIANT KELPFISH	0.00	CA SCORPIONFISH	0.00
CA SCORPIONFISH	0.00	HORNYHEAD TURBOT	0.00	CABEZON	0.00
CABEZON	0.00	PACIFIC ELECTRIC RAY	0.00	GIANT KELPFISH	0.00
GIBBONSIA SPP.	0.00	THORNBACK	0.00	GIBBONSIA SPP.	0.00

Table 2 (Continued)

KELP BED
MEAN FISH DENSITIES
ALL LIFE STAGES COMBINED
AFTER PERIOD

STRATUM=BOTTOM

SAN MATEO

SPECIES	DENSITY
ROCK WRASSE	12.19
SENORITA	5.38
KELP BASS	3.01
BLACK PERCH	1.91
BARRED SAND BASS	1.44
BLACKSMITH	1.08
JACK MACKEREL	0.90
CA SHEEPHEAD	0.86
PILE PERCH	0.51
WHITE SEAPERCH	0.31
RUBBERLIP SEAPERCH	0.21
RAINBOW SEAPERCH	0.20
HALFMOON	0.07
GIANT KELPFISH	0.01
SARGO	0.01
THORNBACK	0.01
BAT RAY	0.00
BLACK CROAKER	0.00
CA HALIBUT	0.00
CA SCORPIONFISH	0.00
CABEZON	0.00
GARIBALDI	0.00

SAN ONOFRE UPCOAST

SPECIES	DENSITY
SENORITA	10.69
ROCK WRASSE	7.54
KELP BASS	3.66
BARRED SAND BASS	2.03
WHITE SEAPERCH	1.64
CA SHEEPHEAD	1.30
BLACK PERCH	0.81
JACK MACKEREL	0.78
BLACKSMITH	0.59
SALEMA	0.42
RUBBERLIP SEAPERCH	0.26
PILE PERCH	0.22
RAINBOW SEAPERCH	0.06
BAT RAY	0.01
CA SCORPIONFISH	0.01
HALFMOON	0.01
LEOPARD SHARK	0.01
ROUND STINGRAY	0.01
SARGO	0.01
BLACK CROAKER	0.00
CA HALIBUT	0.00
CABEZON	0.00

SAN ONOFRE DOWNCOAST

SPECIES	DENSITY
ROCK WRASSE	10.59
KELP BASS	7.36
SENORITA	5.98
BLACK PERCH	4.18
BARRED SAND BASS	3.69
PILE PERCH	2.43
RUBBERLIP SEAPERCH	1.26
JACK MACKEREL	1.12
WHITE SEAPERCH	0.78
CA SHEEPHEAD	0.77
RAINBOW SEAPERCH	0.44
PACIFIC BARRACUDA	0.21
HALFMOON	0.14
GIANT KELPFISH	0.03
LEOPARD SHARK	0.03
BLACKSMITH	0.02
HORN SHARK	0.02
CA HALIBUT	0.01
PIPEFISH	0.01
ROUND STINGRAY	0.01
SALEMA	0.01
SHOVELNOSE GUITARFISH	0.01

Table 3

PERCENT FREQUENCY OF OCCURRENCE OF EACH SPECIES AND LIFE STAGE AT SMK, SOKU, AND SOKD IN BOTH SAMPLING PERIODS.

Number of dates sampled are indicated in parentheses. Data are from samples used in the test for changes in density (ANOVA).

Table 3 (Continued)

KELP BED
PERCENT FREQUENCY OF OCCURRENCE

STRATUM=CANOPY

SPECIES	MATURITY	BEFORE SMK (42)	BEFORE SOKU (48)	BEFORE SOKD (24)	AFTER SMK (18)	AFTER SOKU (18)	AFTER SOKD (19)
PACIFIC ELECTRIC RAY	AD	0.00	0.00	0.00	0.00	5.56	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	2.38	0.00	0.00	0.00	0.00	0.00
	TOTAL	2.38	0.00	0.00	0.00	5.56	0.00
NORTHERN ANCHOVY	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	11.11	0.00	0.00
	TOTAL	0.00	0.00	0.00	11.11	0.00	0.00
KELP BASS	AD	14.29	25.00	20.83	22.22	27.78	31.58
	JUV	69.05	72.92	50.00	94.44	83.33	84.21
	OJ	59.52	70.83	45.83	88.89	83.33	84.21
	SAD	97.62	100.00	100.00	94.44	88.89	94.74
	TOTAL	97.62	100.00	100.00	94.44	88.89	94.74
	YOY	26.19	39.58	20.83	33.33	27.78	42.11
BARRED SAND BASS	AD	0.00	0.00	4.17	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	2.38	0.00	0.00	0.00	0.00	10.53
	TOTAL	2.38	0.00	4.17	0.00	0.00	10.53
SILVERSIDES SPP.	AD	52.38	52.08	37.50	50.00	16.67	10.53
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	52.38	52.08	37.50	50.00	16.67	10.53
PACIFIC BARRACUDA	AD	0.00	0.00	4.17	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	11.90	10.42	0.00	5.56	44.44	21.05
	TOTAL	11.90	10.42	4.17	5.56	44.44	21.05
JACK MACKEREL	AD	0.00	0.00	0.00	5.56	5.56	0.00
	JUV	0.00	2.08	0.00	0.00	0.00	5.26
	SAD	26.19	18.75	12.50	5.56	33.33	15.79
	TOTAL	26.19	20.83	12.50	11.11	33.33	15.79
PACIFIC BONITO	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	11.11	5.26
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	11.11	5.26
PACIFIC MACKEREL	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	2.38	6.25	0.00	0.00	0.00	0.00
	TOTAL	2.38	6.25	0.00	0.00	0.00	0.00
SARGO	AD	0.00	2.08	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	2.08	0.00	0.00	0.00	0.00
SALEMA	AD	7.14	0.00	0.00	0.00	0.00	5.26
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	27.78	26.32
	TOTAL	7.14	0.00	0.00	0.00	27.78	26.32
WHITE SEABASS	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	2.08	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	2.08	0.00	0.00	0.00	0.00

Table 3 (Continued)

KELP BED
PERCENT FREQUENCY OF OCCURRENCE

STRATUM=CANOPY

SPECIES	MATURITY	BEFORE SMK (42)	BEFORE SOKU (48)	BEFORE SOKD (24)	AFTER SMK (18)	AFTER SOKU (18)	AFTER SOKD (19)
KELP PERCH	AD	97.62	97.92	66.67	100.00	66.67	42.11
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	97.62	97.92	66.67	100.00	66.67	42.11
BLACK PERCH	AD	0.00	4.17	0.00	5.56	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	4.17	0.00	5.56	0.00	0.00
WALLEYE SURFPERCH	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00
WHITE SEAPERCH	AD	52.38	79.17	29.17	5.56	44.44	31.58
	JUV	0.00	2.08	0.00	0.00	0.00	0.00
	SAD	14.29	27.08	16.67	27.78	50.00	36.84
	TOTAL	52.38	85.42	37.50	27.78	55.56	47.37
RUBBERLIP SEAPERCH	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00
PILE PERCH	AD	30.95	20.83	8.33	5.56	0.00	5.26
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	2.38	0.00	0.00	16.67	5.56	26.32
	TOTAL	33.33	20.83	8.33	22.22	5.56	31.58
BLACKSMITH	AD	0.00	0.00	0.00	0.00	0.00	5.26
	JUV	0.00	4.17	0.00	11.11	5.56	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	4.17	0.00	11.11	5.56	5.26
ROCK WRASSE	AD	0.00	0.00	0.00	5.56	5.56	10.53
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	16.67	5.56	10.53
	TOTAL	0.00	0.00	0.00	16.67	11.11	21.05
SENORITA	AD	100.00	97.92	95.83	100.00	100.00	100.00
	JUV	33.33	10.42	4.17	50.00	38.89	31.58
	SAD	9.52	2.08	4.17	50.00	38.89	36.84
	TOTAL	100.00	97.92	95.83	100.00	100.00	100.00
CA SHEEPHEAD	AD	0.00	2.08	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	2.08	0.00	0.00	0.00	0.00
OPALEYE	AD	59.52	20.83	8.33	16.67	5.56	5.26
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	2.38	0.00	0.00	0.00	0.00	0.00
	TOTAL	61.90	20.83	8.33	16.67	5.56	5.26
HALFMOON	AD	97.62	70.83	41.67	55.56	38.89	47.37
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	11.90	10.42	8.33	16.67	27.78	15.79
	TOTAL	97.62	72.92	50.00	66.67	66.67	52.63
ROCKFISH SPP.	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00

Table 3 (Continued)

KELP BED
PERCENT FREQUENCY OF OCCURRENCE

STRATUM=CANOPY

SPECIES	MATURITY	BEFORE SMK (42)	BEFORE SOKU (48)	BEFORE SOKD (24)	AFTER SMK (18)	AFTER SOKU (18)	AFTER SOKD (19)
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00
KELP ROCKFISH	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	5.26
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	5.26
OLIVE ROCKFISH	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00
PIPEFISH	AD	0.00	0.00	0.00	16.67	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	16.67	0.00	0.00
GIANT KELPFISH	AD	9.52	8.33	16.67	0.00	0.00	5.26
	JUV	19.05	18.75	0.00	33.33	27.78	47.37
	SAD	16.67	4.17	0.00	66.67	38.89	52.63
	TOTAL	38.10	29.17	16.67	77.78	44.44	63.16
TOTAL KELP SPECIES	AD	100.00	100.00	100.00	100.00	100.00	100.00
	JUV	78.57	72.92	50.00	100.00	94.44	84.21
	SAD	97.62	100.00	100.00	100.00	100.00	94.74
	TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
TOTAL INDIVIDUALS	AD	100.00	100.00	100.00	100.00	100.00	100.00
	JUV	78.57	72.92	50.00	100.00	94.44	84.21
	SAD	97.62	100.00	100.00	100.00	100.00	94.74
	TOTAL	100.00	100.00	100.00	100.00	100.00	100.00

Table 3 (Continued)

KELP BED
PERCENT FREQUENCY OF OCCURRENCE

STRATUM=BOTTOM

		BEFORE			AFTER		
SPECIES	MATURITY	SMK (34)	SOKU (34)	SOKD (21)	SMK (15)	SOKU (15)	SOKD (16)
HORN SHARK	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	12.50
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	12.50
SMOOTHHOUND SPP.	AD	0.00	0.00	4.76	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	4.76	0.00	0.00	0.00
LEOPARD SHARK	AD	8.57	5.88	14.29	0.00	6.67	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	12.50
	SAD	2.86	2.94	0.00	0.00	0.00	6.25
	TOTAL	11.43	8.82	14.29	0.00	6.67	18.75
THORNBACK	AD	0.00	2.94	0.00	6.67	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	2.94	0.00	6.67	0.00	0.00
SHOVELNOSE GUITARFISH	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	6.25
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	6.25
PACIFIC ELECTRIC RAY	AD	8.57	2.94	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	8.57	2.94	0.00	0.00	0.00	0.00
ROUND STINGRAY	AD	0.00	0.00	14.29	0.00	6.67	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	6.25
	TOTAL	0.00	0.00	14.29	0.00	6.67	6.25
BAT RAY	AD	5.71	2.94	14.29	0.00	6.67	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	5.71	2.94	14.29	0.00	6.67	0.00
CA HALIBUT	AD	0.00	0.00	0.00	0.00	0.00	6.25
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	6.25
TURBOT SPP.	AD	0.00	0.00	9.52	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	9.52	0.00	0.00	0.00
HORNYHEAD TURBOT	AD	0.00	0.00	4.76	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	2.94	0.00	0.00	0.00	0.00
	TOTAL	0.00	2.94	4.76	0.00	0.00	0.00
KELP BASS	AD	34.29	58.82	85.71	26.67	53.33	43.75
	JUV	97.14	100.00	85.71	100.00	100.00	100.00
	OJ	71.43	100.00	.	100.00	100.00	100.00
	SAD	91.43	97.06	100.00	93.33	73.33	100.00
	TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
	YOY	71.43	78.57	.	71.43	60.00	50.00

Table 3 (Continued)

KELP BED
PERCENT FREQUENCY OF OCCURRENCE

STRATUM=BOTTOM

SPECIES	MATURITY	BEFORE SMK (34)	BEFORE SOKU (34)	BEFORE SOKD (21)	AFTER SMK (15)	AFTER SOKU (15)	AFTER SOKD (16)
BARRED SAND BASS	AD	17.14	88.24	90.48	53.33	33.33	62.50
	JUV	20.00	61.76	42.86	73.33	66.67	87.50
	SAD	57.14	94.12	100.00	93.33	100.00	100.00
	TOTAL	65.71	100.00	100.00	100.00	100.00	100.00
PACIFIC BARRACUDA	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	6.25
	TOTAL	0.00	0.00	0.00	0.00	0.00	6.25
JACK MACKEREL	AD	0.00	8.82	0.00	0.00	0.00	0.00
	JUV	0.00	2.94	0.00	26.67	13.33	12.50
	SAD	14.29	17.65	4.76	13.33	13.33	12.50
	TOTAL	14.29	26.47	4.76	33.33	20.00	25.00
PACIFIC MACKEREL	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00
SARGO	AD	8.57	8.82	0.00	6.67	6.67	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	5.71	5.88	0.00	0.00	0.00	0.00
	TOTAL	14.29	11.76	0.00	6.67	6.67	0.00
SALEMA	AD	5.71	2.94	0.00	0.00	0.00	6.25
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	6.67	0.00
	TOTAL	5.71	2.94	0.00	0.00	6.67	6.25
BLACK CROAKER	AD	0.00	5.88	14.29	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	2.86	0.00	0.00	0.00	0.00	0.00
	TOTAL	2.86	5.88	14.29	0.00	0.00	0.00
WHITE SEABASS	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00
QUEENFISH	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00
KELP PERCH	AD	28.57	5.88	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	8.57	0.00	0.00	0.00	0.00	0.00
	TOTAL	31.43	5.88	0.00	0.00	0.00	0.00
BLACK PERCH	AD	48.57	58.82	95.24	80.00	60.00	75.00
	JUV	0.00	2.94	9.52	26.67	0.00	18.75
	SAD	34.29	35.29	66.67	100.00	33.33	87.50
	TOTAL	54.29	70.59	100.00	100.00	66.67	93.75
RAINBOW SEAPERCH	AD	11.43	32.35	80.95	6.67	13.33	31.25
	JUV	2.86	0.00	4.76	6.67	0.00	0.00
	SAD	22.86	23.53	47.62	20.00	13.33	31.25
	TOTAL	25.71	47.06	85.71	20.00	26.67	56.25
WHITE SEAPERCH	AD	45.71	55.88	9.52	6.67	60.00	18.75
	JUV	5.71	17.65	0.00	0.00	6.67	0.00

Table 3 (Continued)

KELP BED
PERCENT FREQUENCY OF OCCURRENCE

STRATUM=BOTTOM

SPECIES	MATURITY	BEFORE SMK (34)	BEFORE SOKU (34)	BEFORE SOKD (21)	AFTER SMK (15)	AFTER SOKU (15)	AFTER SOKD (16)
	SAD	34.29	52.94	9.52	20.00	53.33	25.00
	TOTAL	57.14	61.76	14.29	20.00	66.67	31.25
RUBBERLIP SEAPERCH	AD	31.43	32.35	38.10	0.00	20.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	5.71	8.82	9.52	13.33	6.67	18.75
	TOTAL	31.43	32.35	38.10	13.33	20.00	18.75
PILE PERCH	AD	62.86	55.88	57.14	26.67	46.67	50.00
	JUV	5.71	2.94	0.00	20.00	0.00	6.25
	SAD	48.57	35.29	42.86	40.00	6.67	75.00
	TOTAL	82.86	61.76	66.67	66.67	46.67	81.25
BLACKSMITH	AD	0.00	0.00	9.52	0.00	0.00	6.25
	JUV	25.71	11.76	0.00	26.67	46.67	0.00
	SAD	0.00	0.00	9.52	6.67	0.00	0.00
	TOTAL	25.71	11.76	19.05	26.67	46.67	6.25
GARIBALDI	AD	25.71	5.88	42.86	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	5.71	0.00	19.05	0.00	0.00	0.00
	TOTAL	25.71	5.88	57.14	0.00	0.00	0.00
ROCK WRASSE	AD	88.57	64.71	85.71	100.00	100.00	100.00
	JUV	2.86	2.94	0.00	60.00	46.67	62.50
	SAD	48.57	11.76	33.33	100.00	100.00	100.00
	TOTAL	94.29	67.65	95.24	100.00	100.00	100.00
SENORITA	AD	97.14	85.29	80.95	66.67	93.33	93.75
	JUV	80.00	29.41	23.81	53.33	53.33	56.25
	SAD	82.86	61.76	42.86	73.33	86.67	87.50
	TOTAL	100.00	91.18	85.71	80.00	100.00	100.00
CA SHEEPHEAD	AD	51.43	76.47	100.00	20.00	20.00	6.25
	JUV	82.86	94.12	90.48	73.33	93.33	87.50
	SAD	91.43	100.00	100.00	53.33	60.00	62.50
	TOTAL	97.14	100.00	100.00	93.33	100.00	93.75
OPALEYE	AD	14.29	20.59	47.62	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	2.86	0.00	0.00	0.00	0.00	0.00
	TOTAL	14.29	20.59	47.62	0.00	0.00	0.00
HALFMOON	AD	22.86	5.88	23.81	6.67	0.00	12.50
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	25.71	5.88	9.52	20.00	6.67	12.50
	TOTAL	37.14	8.82	33.33	20.00	6.67	12.50
CA SCORPIONFISH	AD	0.00	2.94	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	2.94	0.00	0.00	6.67	0.00
	TOTAL	0.00	5.88	0.00	0.00	6.67	0.00
KELP ROCKFISH	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	8.82	0.00	0.00	0.00	0.00
	SAD	0.00	8.82	0.00	0.00	0.00	0.00
	TOTAL	0.00	8.82	0.00	0.00	0.00	0.00
GRASS ROCKFISH	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00

Table 3 (Continued)

KELP BED
PERCENT FREQUENCY OF OCCURRENCE

STRATUM=BOTTOM

SPECIES	MATURITY	BEFORE SMK (34)	BEFORE SOKU (34)	BEFORE SOKD (21)	AFTER SMK (15)	AFTER SOKU (15)	AFTER SOKD (16)
OLIVE ROCKFISH	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00
PAINTED GREENLING	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00
CABEZON	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00
PIPEFISH	AD	0.00	0.00	0.00	0.00	0.00	6.25
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	6.25
GIBBONSIA SPP.	AD	0.00	0.00	0.00	0.00	0.00	0.00
	JUV	0.00	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.00	0.00	0.00	0.00	0.00	0.00
GIANT KELPFISH	AD	5.71	2.94	0.00	6.67	0.00	0.00
	JUV	5.71	0.00	0.00	0.00	0.00	0.00
	SAD	0.00	0.00	0.00	0.00	0.00	18.75
	TOTAL	11.43	2.94	0.00	6.67	0.00	18.75
TOTAL KELP SPECIES	AD	100.00	100.00	100.00	100.00	100.00	100.00
	JUV	100.00	100.00	100.00	100.00	100.00	100.00
	SAD	100.00	100.00	100.00	100.00	100.00	100.00
	TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
TOTAL INDIVIDUALS	AD	100.00	100.00	100.00	100.00	100.00	100.00
	JUV	100.00	100.00	100.00	100.00	100.00	100.00
	SAD	100.00	100.00	100.00	100.00	100.00	100.00
	TOTAL	100.00	100.00	100.00	100.00	100.00	100.00

Table 4

SUMMARY OF THE ANOVA ON DENSITIES OF KELP BED FISHES.

The alpha level (P) of the period-by-location interaction from the two-factor ANOVA is given. The relative percent change in mean densities from Before period to After at each location relative to the San Mateo kelp forest (SMK) are given for those taxa which displayed a significant ($p < 0.05$) location-by-period interaction. Indicated directions of the change (d = decrease; i = increase) are given for the other species. Locations are: SOKU = upcoast portion of San Onofre kelp forest; SOKD = downcoast portion of San Onofre kelp forest.

TAXA	P	RELATIVE % CHANGE SOKU	SOKD
WATER COLUMN STRATUM			
Kelp Perch	0.03	-25	86
Senorita	<0.01	224	185
Halfmoon	0.01	548	529
Giant kelpfish	0.00	-42	85
Kelp bass	-	d	i
Kelp bass YOY	-	i	i
White perch	-	d	i
Pile perch	-	i	i
BOTTOM STRATUM			
Barred sand bass	<0.01	-74	-43
Black perch	0.04	-85	-74
Rainbow perch	0.04	-68	-59
Senorita	<0.01	580	330
California sheephead	<0.01	-46	-70
White seaperch	-	d	i
Kelp bass	-	d	d
Kelp bass YOY	-	d	i
Pile perch	-	d	i
Rock wrasse	-	i	i

Table 5

ESTIMATED PERCENT RELATIVE CHANGE AT SOK IN NUMBERS AND BIOMASS.

Percent change in SOK relative to SMK based on abundance indices presented in Appendix H.

	NUMBERS % CHANGE	BIOMASS % CHANGE
WATER COLUMN STRATUM		
Total	-17.2	-32.7
Senorita	-27.3	-26.8
Non-Senorita	-6.0	-35.8
BOTTOM STRATUM		
Total	-69.6	-72.9
Senorita	167.5	225.8
Non-Senorita	-82.3	-76.4

Table 6

RELATIVE PERCENT CHANGE OF BOTTOM SUBSTRATES, AND FISH DENSITIES AND BIOMASS IN THE WATER COLUMN AND BOTTOM STRATA SOK.

"Cobble" substrate has < 4 kelp plants/100 m^2. Percent change relative to SMK based on values presented in Appendix L.

	Relative % Change
BOTTOM SUBSTRATES	
Cobble	46
Kelp	-75.7

	Relative % Change	
	Numbers	Biomass
FISH DENSITIES IN WATER COLUMN		
Total	272	254
Senorita	214	218
Non-senorita	309	270

	Relative % Change			
	Cobble		Kelp	
	Numbers	Biomass	Numbers	Biomass
FISH DENSITIES IN BOTTOM STRATUM				
Total	-39	-53	-21	-32
Senorita	447	847	501	522
Non-senorita	-65	-59	-65	-40

Table 7

RATIOS OF BOTTOM FISH DENSITY IN AREAS WITHOUT KELP TO DENSITY IN AREAS WITH KELP.

Densities are per 1000 m^3.

YEAR	MEAN DENSITY WITH KELP	MEAN DENSITY WITHOUT KELP	RATIO
1985	62.6	38.2	0.61
1986	119.4	28.6	0.24

Table 8

MEAN DENSITIES OF FISH NEAR (KELP PLANT IN VISUAL FIELD ON CINETRANSECT) AND AWAY (KELP NOT IN VISUAL FIELD) FROM KELP.

Standard error of the mean is in parentheses. 32 cinetransects examined. Counts scaled to number per 1000 m^3 searched.

	NEAR KELP		AWAY FROM KELP	
	MEAN	SE	MEAN	SE
KELP FOREST FISH				
Kelp bass	2.57	(0.67)	0.01	(0.01)
Rock wrasse	0.03	(0.03)	0.00	(0.00)
Senorita	6.95	(1.96)	0.00	(0.00)
Halfmoon	12.80	(4.85)	0.00	(0.00)
Giant kelpfish	0.05	(0.05)	0.00	(0.00)
PELAGIC FISH				
Silversides spp.	1.73	(1.32)	5.86	(4.88)
Pacific barracuda	8.03	(5.65)	9.16	(6.25)
Jack mackerel	0.00	(0.00)	0.01	(0.01)
Pacific bonito	0.00	(0.00)	3.60	(2.83)

Table 9

THE EFFECT OF SONGS ON ABUNDANCES AND BIOMASS (IN KGS) IN SOK IN THE AFTER PERIOD.

	TOTAL FISH	BIOMASS
FISH IN WATER COLUMN		
Observed	132,600	10,600
Expected	160,000	15,600
Difference	-27,400	-5,000
FISH IN BOTTOM STRATUM		
Observed	83,500	9,300
Expected	275,200	34,400
Difference	-191,700	-25,100

Table 10

ESTIMATED 95% CONFIDENCE INTERVALS AROUND THE EFFECT OF SONGS ON ABUNDANCES AND BIOMASS (IN KGS).

	Estimated change due to songs	Confidence interval
FISH IN WATER COLUMN		
Numbers	-27,400	± 142,000
Biomass	-5,000	25,900
FISH IN BOTTOM STRATUM		
Numbers	-191,700	± 157,000
Biomass	-28,100	± 23,000

Table 11

REGRESSION COEFFICIENTS AND PREDICTED DENSITIES.

Densities (numbers/1000 m^3) ; Biomass (gms/1000 m^3)

	WATER COLUMN		BOTTOM	
	1985	1986	1985	1986
Predicted Densities				
All fish	5.1	11.2	34.2	53.4
senorita	3.2	8.2	14.3	15.5
non-senorita	1.91	3.04	19.88	37.9
biomass	301.2	1021.2	4096.8	5671.1
Regression coefficients				
All fish	1.58	7.91	2.49	7.75
senorita	0.99	5.78	0.75	0.73
non-senorita	0.59	2.14	1.75	7.63
biomass	92	719	220	966

This page intentionally left blank.

7. FIGURES

Figure 1: **Map of the San Onofre area.**

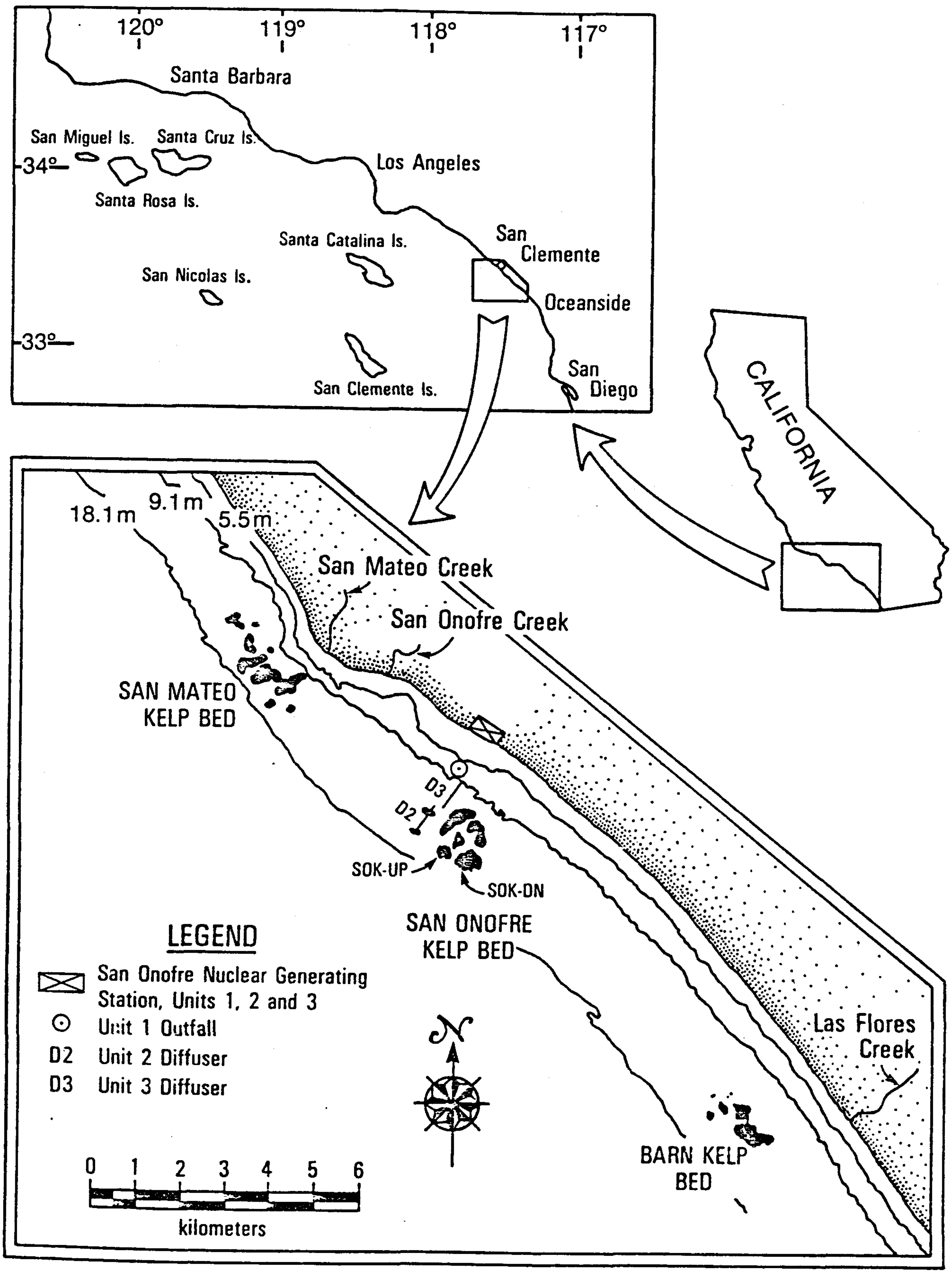

120°
119°
118°
117°
Santa Barbara
San Miguel Is.
Santa Cruz Is.
34°
Santa Rosa Is.
Los Angeles
Santa Catalina Is.
San Clemente
San Nicolas Is.
Oceanside
33°
San Clemente Is.
San Diego
CALIFORNIA
18.1 m
9.1 m
5.5 m
San Mateo Creek
San Onofre Creek
SAN MATEO KELP BED
D3
D2
SOK-UP
SOK-DN
SAN ONOFRE KELP BED
LEGEND
San Onofre Nuclear Generating Station, Units 1, 2 and 3
Unit 1 Outfall
D2 Unit 2 Diffuser
D3 Unit 3 Diffuser
Las Flores Creek
BARN KELP BED
0 1 2 3 4 5 6
kilometers

Figure 2: LOCATIONS OF SAMPLING SITES. Areas of hard substrate in SMK and SOK are outlined. Upper map is of San Onofre kelp forest, lower map is San Mateo kelp forest. Subregions sampled are indicated by boxes. SMK=San Mateo Kelp, SOKU=Upcoast portion of San Onofre Kelp Bed; SOKD=Downcoast portion of San Onofre Kelp Bed. Numbers indicate locations where kelp bed fish densities were sampled (referred to throughout the report). Location 1 is in SMK; locations 2, 3, and 5 are in SOKU; locations 4, 6 and 9 are in SOKD. Note that the axes of the maps are marked in meters from a common reference point (the outfall of Unit 1). Locations of the diffuser lines of Units 2 and 3 are shown on the upper map.

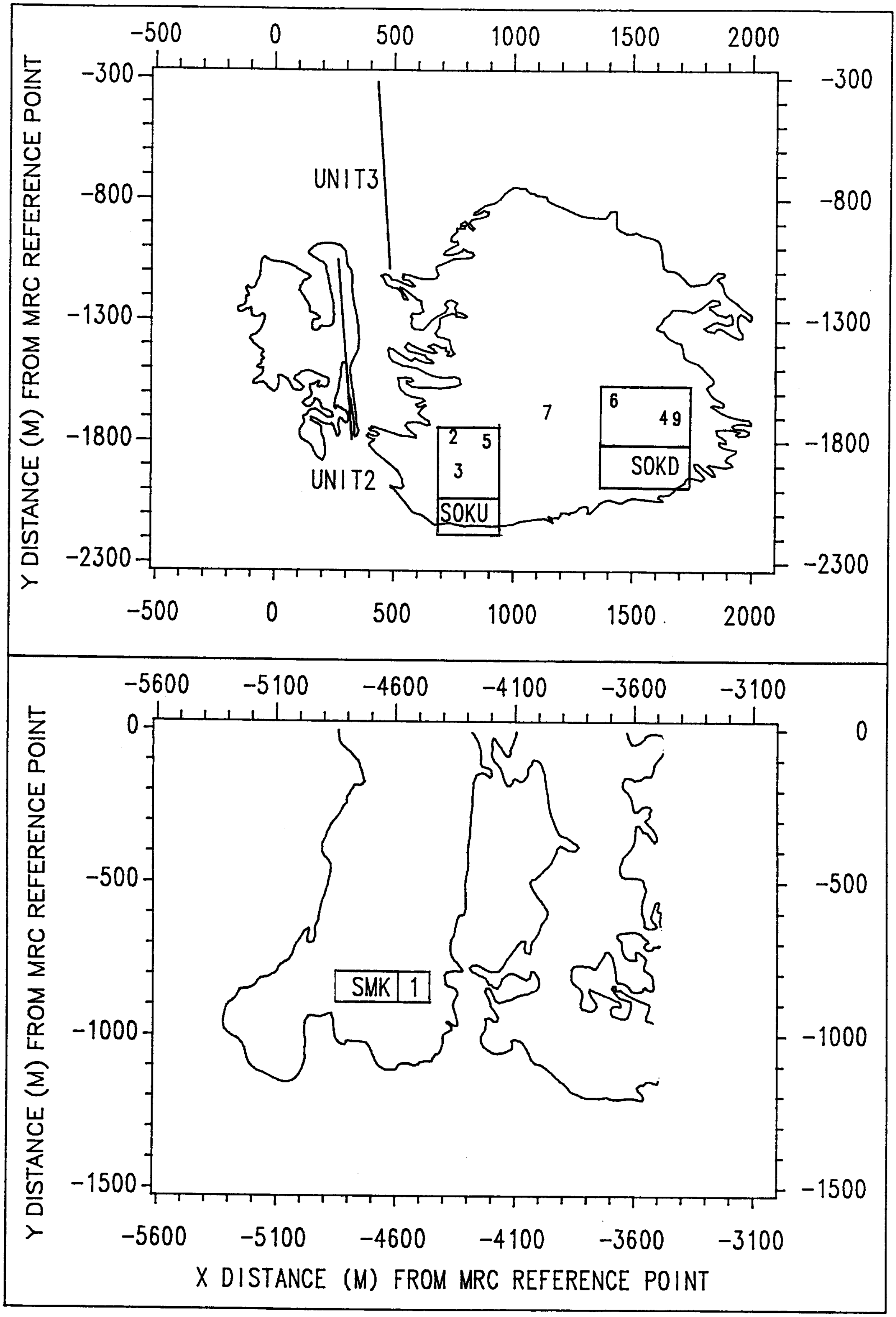

UNIT3
UNIT2
2
5
3
7
6
4 9
SOKU
SOKD
SMK
1
Y DISTANCE (M) FROM MRC REFERENCE POINT
X DISTANCE (M) FROM MRC REFERENCE POINT
-500
0
500
1000
1500
2000
-300
-800
-1300
-1800
-2300
-5600
-5100
-4600
-4100
-3600
-3100
0
-500
-1000
-1500

Figure 3: The regression of kelp bed fish density (per 1000 m^3) against kelp density (per 100 m^2).

Separate regressions for water column and bottom strata for both 1985 and 1986 are presented. Numbers in plot represent locations (see Figure 2) where data were gathered.

KELP BED FISHES

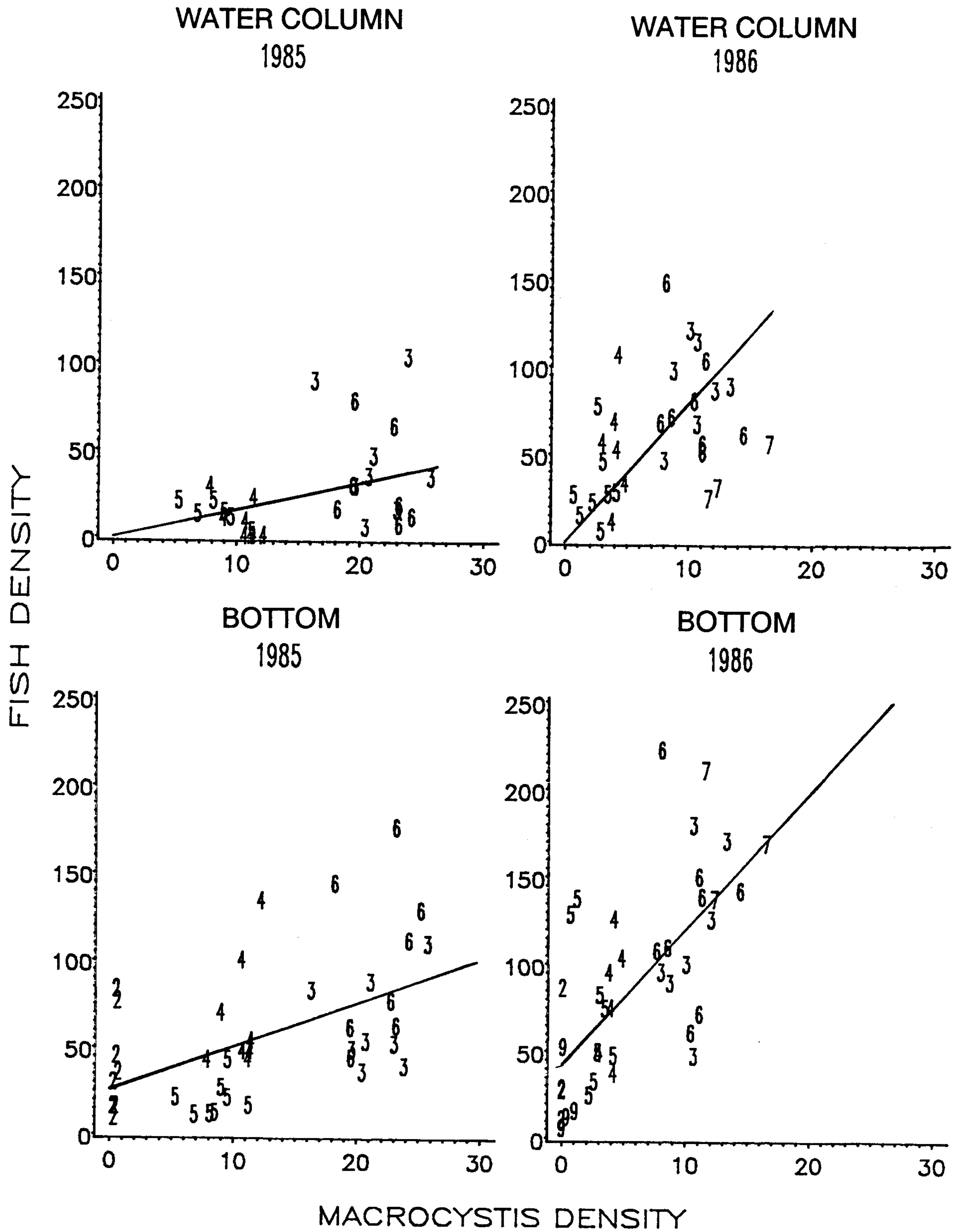
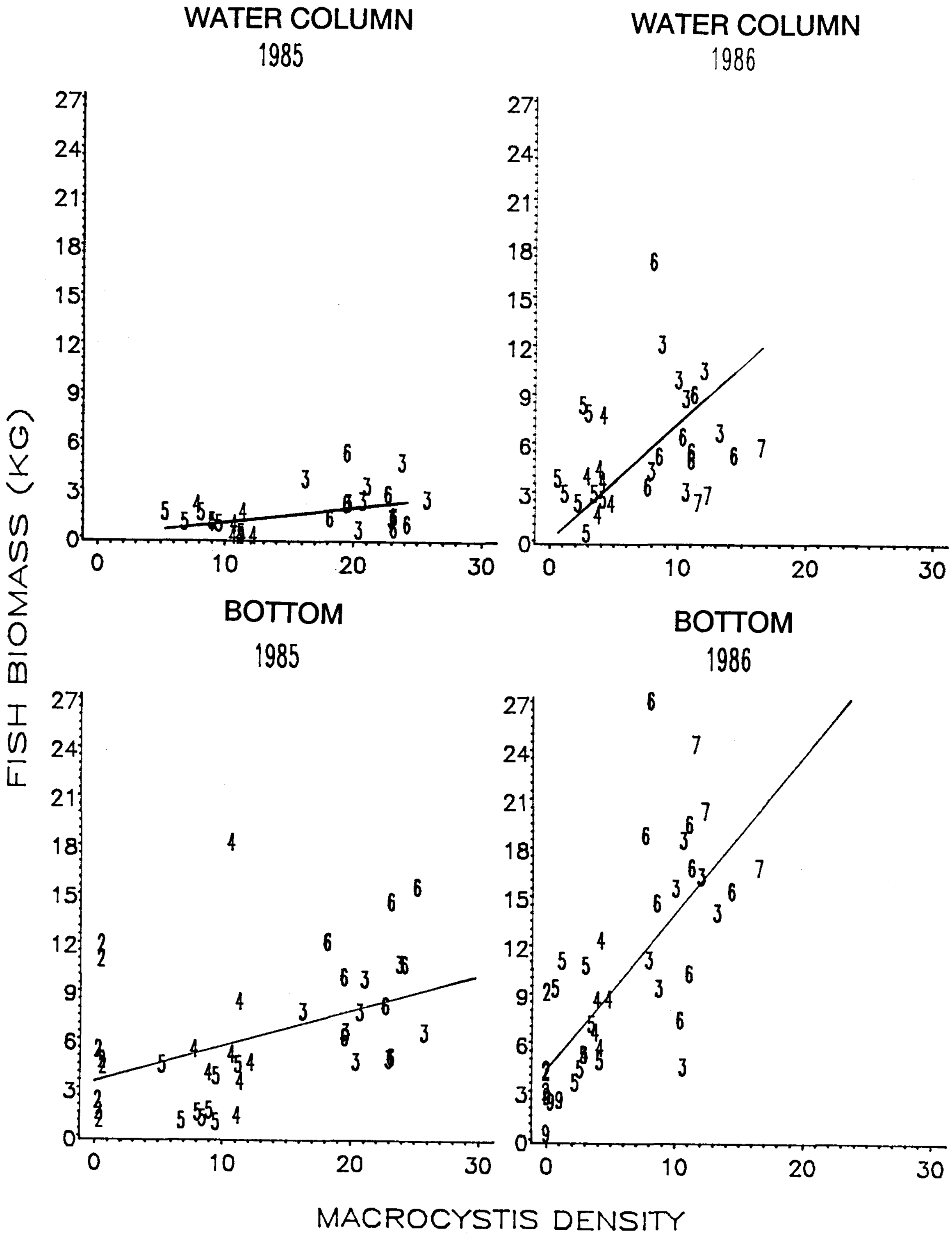


Figure 4: The regression of kelp bed fish biomass (kg per 1000 m^3) against kelp density (per 100 m^2).

Separate regressions for water column and bottom strata for both 1985 and 1986 are presented. Numbers in plot represent locations (see Figure 2) where data were gathered.

KELP BED FISHES



This page intentionally left blank.

APPENDICES

This page intentionally left blank.

APPENDIX A

KELP BED FISH SAMPLING DATES.

The dates the various locations (designated by number, see Figure 2) and strata were sampled are listed.

APPENDIX A. KELP BED SAMPLING DATES

KELP BED
SAMPLING DATES
1980

DATE	STRATUM	SMK 1	SOK-U 3	SOK-D 4
07OCT80	CANOPY		X	X
10OCT80	CANOPY	X	X	X
20OCT80	CANOPY	X	X	X
20OCT80	BOTTOM	X		
22OCT80	CANOPY	X	X	X
24OCT80	CANOPY	X	X	X
24OCT80	BOTTOM	X	X	X
27OCT80	CANOPY		X	X
27OCT80	BOTTOM		X	X
29OCT80	BOTTOM	X	X	X
31OCT80	CANOPY	X	X	X
31OCT80	BOTTOM	X	X	X
03NOV80	CANOPY	X	X	X
10NOV80	CANOPY	X	X	X
12NOV80	CANOPY	X		X
14NOV80	BOTTOM		X	X
17NOV80	BOTTOM	X	X	X
19NOV80	CANOPY	X	X	X
19NOV80	BOTTOM	X		X
20NOV80	CANOPY	X	X	X
20NOV80	BOTTOM	X	X	X
21NOV80	CANOPY	X	X	X
21NOV80	BOTTOM	X	X	X
24NOV80	CANOPY	X	X	X
24NOV80	BOTTOM	X	X	X
25NOV80	CANOPY	X	X	X
25NOV80	BOTTOM	X	X	X
26NOV80	CANOPY	X	X	
26NOV80	BOTTOM	X	X	X
02DEC80	CANOPY	X	X	X
02DEC80	BOTTOM	X	X	X
03DEC80	CANOPY	X	X	X
03DEC80	BOTTOM	X	X	X
08DEC80	CANOPY		X	X
08DEC80	BOTTOM		X	X
10DEC80	CANOPY	X	X	X
10DEC80	BOTTOM	X	X	X
11DEC80	CANOPY	X	X	X
11DEC80	BOTTOM	X	X	X
12DEC80	CANOPY	X	X	X
12DEC80	BOTTOM	X	X	X
15DEC80	CANOPY	X	X	X
15DEC80	BOTTOM	X	X	X
17DEC80	CANOPY	X	X	X
17DEC80	BOTTOM	X	X	X
18DEC80	CANOPY	X	X	X
18DEC80	BOTTOM	X	X	X

APPENDIX A. (Continued)

KELP BED
SAMPLING DATES
1981

DATE	STRATUM	SMK 1	SOK-U 3	SOK-D 4
07OCT81	CANOPY	X	X	X
07OCT81	BOTTOM	X	X	X
09OCT81	CANOPY	X	X	X
09OCT81	BOTTOM	X	X	X
12OCT81	CANOPY	X	X	X
12OCT81	BOTTOM	X		
14OCT81	CANOPY	X	X	X
16OCT81	CANOPY		X	X
19OCT81	CANOPY	X	X	X
19OCT81	BOTTOM	X	X	X
21OCT81	CANOPY	X	X	X
21OCT81	BOTTOM	X	X	X
23OCT81	CANOPY	X	X	X
23OCT81	BOTTOM	X	X	X
28OCT81	CANOPY		X	X
02NOV81	BOTTOM	X	X	X
04NOV81	CANOPY	X	X	X
04NOV81	BOTTOM	X		
06NOV81	CANOPY	X	X	X
09NOV81	CANOPY	X	X	X
09NOV81	BOTTOM	X	X	X
11NOV81	BOTTOM	X	X	X
13NOV81	CANOPY	X		X
23NOV81	CANOPY	X	X	X
30NOV81	CANOPY		X	X
30NOV81	BOTTOM		X	X
01DEC81	CANOPY		X	X
02DEC81	CANOPY	X	X	X
04DEC81	CANOPY	X		
07DEC81	CANOPY	X	X	X
09DEC81	CANOPY		X	X
11DEC81	CANOPY	X	X	X
14DEC81	CANOPY	X	X	X
14DEC81	BOTTOM	X	X	X
15DEC81	CANOPY	X	X	X
15DEC81	BOTTOM	X	X	X
16DEC81	CANOPY		X	X
16DEC81	BOTTOM	X	X	X
17DEC81	CANOPY	X	X	X
17DEC81	BOTTOM	X	X	X
18DEC81	CANOPY	X	X	X
18DEC81	BOTTOM	X	X	X

KELP BED
SAMPLING DATES
1985

		SMK	SOK-U			SOK-D	
DATE	STRATUM	1	2	3	5	4	6
09OCT85	CANOPY	X		X			
11OCT85	CANOPY	X		X		X	
11OCT85	BOTTOM	X		X		X	
17OCT85	CANOPY	X		X		X	
17OCT85	BOTTOM	X		X		X	
18OCT85	CANOPY				X		X
18OCT85	BOTTOM		X		X		X
22OCT85	CANOPY				X		X
25OCT85	CANOPY	X		X		X	
25OCT85	BOTTOM	X		X		X	
28OCT85	CANOPY				X	X	X
04NOV85	CANOPY	X		X		X	
06NOV85	CANOPY				X		X
14NOV85	CANOPY						X
14NOV85	BOTTOM		X		X		X
19NOV85	CANOPY	X		X		X	
19NOV85	BOTTOM	X		X		X	
20NOV85	CANOPY				X		X
20NOV85	BOTTOM		X		X		X
22NOV85	CANOPY	X		X		X	
22NOV85	BOTTOM	X		X		X	
27NOV85	CANOPY				X		X
27NOV85	BOTTOM		X		X		X
02DEC85	BOTTOM		X		X		X
06DEC85	CANOPY					X	X
12DEC85	CANOPY				X		X
12DEC85	BOTTOM		X		X		X
16DEC85	CANOPY	X		X		X	
16DEC85	BOTTOM	X		X		X	
17DEC85	CANOPY				X		X
17DEC85	BOTTOM		X		X		X
18DEC85	CANOPY	X		X		X	
18DEC85	BOTTOM	X		X		X	
19DEC85	CANOPY				X		X
19DEC85	BOTTOM		X		X		X
20DEC85	CANOPY	X		X		X	
20DEC85	BOTTOM	X		X		X	

APPENDIX A. (Continued)

KELP BED
SAMPLING DATES
1986

		SMK	SOK-U			SOK-D			
DATE	STRATUM	1	2	3	5	4	6	7	9
03OCT86	CANOPY	X		X					
03OCT86	BOTTOM	X		X					
14OCT86	CANOPY	X		X		X			
16OCT86	BOTTOM								X
07NOV86	CANOPY				X		X		
07NOV86	BOTTOM		X		X		X		
11NOV86	CANOPY	X		X		X			
11NOV86	BOTTOM	X		X		X			
12NOV86	CANOPY				X		X	X	
12NOV86	BOTTOM				X		X	X	
13NOV86	CANOPY	X		X					
13NOV86	BOTTOM	X		X					
14NOV86	CANOPY				X		X		
14NOV86	BOTTOM				X		X		X
19NOV86	CANOPY				X		X		
19NOV86	BOTTOM		X		X		X		
26NOV86	CANOPY	X		X		X			
26NOV86	BOTTOM	X		X		X			
02DEC86	CANOPY				X		X	X	
02DEC86	BOTTOM				X		X	X	
03DEC86	CANOPY	X		X		X			
03DEC86	BOTTOM	X		X		X			
04DEC86	CANOPY				X		X		
04DEC86	BOTTOM				X		X		X
05DEC86	CANOPY	X		X		X			
05DEC86	BOTTOM	X		X		X			
09DEC86	CANOPY				X		X		
09DEC86	BOTTOM		X		X		X		
10DEC86	CANOPY	X		X		X			
10DEC86	BOTTOM	X		X		X			
11DEC86	CANOPY							X	
11DEC86	BOTTOM		X					X	X
12DEC86	CANOPY				X	X	X		
12DEC86	BOTTOM				X	X	X		

This page intentionally left blank.

APPENDIX B

MEAN WEIGHTS (IN GRAMS) OF THE LIFE STAGES OF FISH USED IN BIOMASS CALCULATIONS.

(from Appendix T in DeMartini et al. 1987)

KELP BED
FISH WEIGHTS (GRAMS)

SPECIES	JUVENILE	SUBADULT	ADULT
HORN SHARK	235.426	783.24	.
LEOPARD SHARK	444.987	2200.90	12732.1
THORNBACK	.	230.15	2416.6
SHOVELNOSE GUITARFISH	324.846	.	.
PACIFIC ELECTRIC RAY	.	8962.14	.
ROUND STINGRAY	.	271.61	587.2
BAT RAY	.	2721.03	11613.5
NORTHERN ANCHOVY	.	3.96	.
CA HALIBUT	.	364.18	6619.3
KELP BASS	47.967	202.09	670.3
BARRED SAND BASS	79.431	219.88	644.9
SILVERSIDES SPP.	.	.	37.3
PACIFIC BARRACUDA	56.611	245.86	.
JACK MACKEREL	15.312	30.55	.
PACIFIC BONITO	244.523	.	465.7
PACIFIC MACKEREL	28.673	.	.
SARGO	.	.	419.7
SALEMA	.	36.98	73.1
WHITE SEABASS	.	.	936.8
KELP PERCH	1.439	11.62	24.3
BLACK PERCH	.	85.60	189.0
WALLEYE SURFPERCH	.	.	.
RAINBOW SEAPERCH	.	82.47	177.6
WHITE SEAPERCH	.	48.93	110.0
RUBBERLIP SEAPERCH	29.348	163.24	512.3
PILE PERCH	.	110.11	322.6
BLACKSMITH	1.502	35.45	.
GARIBALDI	27.744	76.46	.
ROCK WRASSE	10.377	65.12	176.0
SENORITA	1.397	26.57	67.3
CA SHEEPHEAD	107.675	452.00	1290.5
OPALEYE	.	300.37	764.6
HALFMOON	.	127.61	227.2
CA SCORPIONFISH	.	518.51	745.7
KELP ROCKFISH	5.862	133.69	222.5
OLIVE ROCKFISH	42.274	126.75	.
PAINTED GREENLING	29.006	.	.
PIPEFISH	.	.	29.5
GIBBONSIA SPP.	.	9.08	122.6
GIANT KELPFISH	4.359	56.44	207.2

This page intentionally left blank.

APPENDIX C

MEAN DENSITIES (per 1000 m^3 for fish in water column fish, per 337 m^3 for fish in bottom stratum) OF ALL LIFE STAGES OF FISH AT SAMPLING LOCATIONS USED IN THE ANOVA.

Maturity stages are ad=adult, juv=juvenile, sad=subadult and total=all life stages combined. Standard errors of the mean are also presented. Sampling locations: SMK = location 1, figure 2 in both Before and After periods, SOKU = location 3, figure 2 in both Before and After periods, SOKD = location 4, figure 2 in the Before period, location 6, figure 2, in the After period.

KELP BED
MEAN FISH DENSITIES

STRATUM=CANOPY

SPECIES	MATURITY	BEFORE SMK DENS	BEFORE SMK SE	BEFORE SOKU DENS	BEFORE SOKU SE	BEFORE SOKD DENS	BEFORE SOKD SE	AFTER SMK DENS	AFTER SMK SE	AFTER SOKU DENS	AFTER SOKU SE	AFTER SOKD DENS	AFTER SOKD SE
ROCKFISH SPP.	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	--	--
KELP ROCKFISH	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	0.01	0.01
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	0.01	0.01
OLIVE ROCKFISH	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	--	--
PIPEFISH	AD	--	--	--	--	--	--	0.04	0.02	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	0.04	0.02	--	--	--	--
GIANT KELPFISH	AD	0.02	0.01	0.01	0.01	0.03	0.01	--	--	--	--	0.01	0.01
	JUV	0.03	0.01	0.03	0.01	--	--	0.17	0.07	0.06	0.03	0.07	0.02
	SAD	0.05	0.02	0.01	0.01	--	--	0.28	0.07	0.07	0.02	0.17	0.06
	TOTAL	0.10	0.03	0.05	0.01	0.03	0.01	0.45	0.09	0.13	0.04	0.25	0.08
TOTAL KELP SPECIES	AD	60.15	3.80	30.19	2.68	24.56	4.46	20.86	3.85	42.64	7.93	38.76	6.73
	JUV	2.77	0.87	1.28	0.33	0.37	0.13	3.57	0.94	3.77	1.63	3.73	1.10
	SAD	4.17	0.84	6.31	0.95	7.31	1.19	3.64	1.04	12.35	6.12	9.35	3.01
	TOTAL	67.09	4.15	37.78	2.94	32.25	5.00	28.06	4.61	58.76	8.81	51.84	8.02
TOTAL INDIVIDUALS	AD	68.08	5.33	33.62	2.56	26.84	4.80	24.11	4.18	43.68	7.88	38.84	6.73
	JUV	2.77	0.87	1.31	0.33	0.37	0.13	3.57	0.94	4.59	1.75	4.42	1.16
	SAD	13.61	3.57	18.65	4.98	10.68	3.08	33.52	29.39	15.78	7.27	10.98	3.11
	TOTAL	84.46	6.69	53.59	6.66	37.89	6.91	61.20	29.17	64.05	9.83	54.24	8.14

KELP BED
MEAN FISH DENSITIES

STRATUM=BOTTOM

SPECIES	MATURITY	BEFORE SMK DENS	BEFORE SMK SE	BEFORE SOKU DENS	BEFORE SOKU SE	BEFORE SOKD DENS	BEFORE SOKD SE	AFTER SMK DENS	AFTER SMK SE	AFTER SOKU DENS	AFTER SOKU SE	AFTER SOKD DENS	AFTER SOKD SE
HORN SHARK	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	0.02	0.01
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	0.02	0.01
SMOOTHHOUND SPP.	AD	--	--	--	--	0.01	0.01	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	0.01	0.01	--	--	--	--	--	--
LEOPARD SHARK	AD	0.03	0.02	0.01	0.01	0.02	0.01	--	--	0.01	0.01	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	0.02	0.01
	SAD	--	--	--	--	--	--	--	--	--	--	0.01	0.01
	TOTAL	0.03	0.02	0.01	0.01	0.02	0.01	--	--	0.01	0.01	0.03	0.02
THORNBACK	AD	--	--	--	--	--	--	0.01	0.01	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	0.01	0.01	--	--	--	--
SHOVELNOSE GUITARFISH	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	0.01	0.01
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	0.01	0.01
PACIFIC ELECTRIC RAY	AD	0.02	0.01	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	0.02	0.01	--	--	--	--	--	--	--	--	--	--
ROUND STINGRAY	AD	--	--	--	--	0.02	0.01	--	--	0.01	0.01	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	0.01	0.01
	TOTAL	--	--	--	--	0.02	0.01	--	--	0.01	0.01	0.01	0.01
BAT RAY	AD	0.01	0.01	--	--	0.02	0.01	--	--	0.01	0.01	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	0.01	0.01	--	--	0.02	0.01	--	--	0.01	0.01	--	--
CA HALIBUT	AD	--	--	--	--	--	--	--	--	--	--	0.01	0.01
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	0.01	0.01
TURBOT SPP.	AD	--	--	--	--	0.02	0.01	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	0.02	0.01	--	--	--	--	--	--
HORNYHEAD TURBOT	AD	--	--	--	--	0.01	0.01	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	0.01	0.01	--	--	--	--	--	--
KELP BASS	AD	0.17	0.06	0.24	0.07	0.71	0.19	0.06	0.03	0.21	0.08	0.24	0.14
	JUV	2.67	0.42	4.18	1.01	2.95	0.95	2.14	0.36	1.84	0.35	4.19	0.91
	OJ	2.71	1.93	5.82	2.16	.	.	1.48	0.32	1.62	0.36	4.83	1.11
	SAD	2.08	0.51	4.31	1.30	9.58	2.15	0.81	0.21	1.60	0.41	2.94	0.87
	TOTAL	4.92	0.83	8.72	1.80	13.25	2.88	3.01	0.45	3.66	0.69	7.36	1.70

KELP BED
MEAN FISH DENSITIES

STRATUM=BOTTOM

SPECIES	MATURITY	BEFORE SMK DENS	BEFORE SMK SE	BEFORE SOKU DENS	BEFORE SOKU SE	BEFORE SOKD DENS	BEFORE SOKD SE	AFTER SMK DENS	AFTER SMK SE	AFTER SOKU DENS	AFTER SOKU SE	AFTER SOKD DENS	AFTER SOKD SE
	YOY	0.71	0.27	0.37	0.08	.	.	0.52	0.19	0.22	0.07	0.11	0.04
BARRED SAND BASS	AD	0.03	0.01	0.62	0.08	0.44	0.08	0.32	0.12	0.14	0.07	0.40	0.09
	JUV	0.04	0.02	0.25	0.07	0.16	0.06	0.36	0.11	0.38	0.09	1.69	0.49
	SAD	0.33	0.07	1.34	0.21	1.21	0.21	0.77	0.20	1.51	0.67	1.60	0.32
	TOTAL	0.40	0.08	2.21	0.28	1.80	0.28	1.44	0.33	2.03	0.69	3.69	0.74
PACIFIC BARRACUDA	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	0.21	0.21
	TOTAL	--	--	--	--	--	--	--	--	--	--	0.21	0.21
JACK MACKEREL	AD	--	--	0.19	0.12	--	--	--	--	--	--	--	--
	JUV	--	--	0.25	0.25	--	--	0.58	0.35	0.34	0.29	0.19	0.13
	SAD	2.05	1.18	0.88	0.45	4.76	4.76	0.32	0.24	0.43	0.34	0.94	0.79
	TOTAL	2.05	1.18	1.32	0.51	4.76	4.76	0.90	0.43	0.78	0.47	1.12	0.78
PACIFIC MACKEREL	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	--	--
SARGO	AD	0.05	0.03	0.01	0.01	--	--	0.01	0.01	0.01	0.01	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	0.01	0.01	0.04	0.04	--	--	--	--	--	--	--	--
	TOTAL	0.06	0.03	0.06	0.04	--	--	0.01	0.01	0.01	0.01	--	--
SALEMA	AD	0.81	0.64	0.25	0.25	--	--	--	--	--	--	0.01	0.01
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	0.42	0.42	--	--
	TOTAL	0.81	0.64	0.25	0.25	--	--	--	--	0.42	0.42	0.01	0.01
BLACK CROAKER	AD	--	--	1.96	1.54	3.49	2.13	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	0.95	0.95	--	--	--	--	--	--	--	--	--	--
	TOTAL	0.95	0.95	1.96	1.54	3.49	2.13	--	--	--	--	--	--
WHITE SEABASS	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	--	--
QUEENFISH	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	--	--
KELP PERCH	AD	0.21	0.08	0.01	0.01	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	0.03	0.02	--	--	--	--	--	--	--	--	--	--
	TOTAL	0.24	0.09	0.01	0.01	--	--	--	--	--	--	--	--
BLACK PERCH	AD	0.95	0.32	3.57	1.48	8.79	2.25	0.38	0.09	0.66	0.21	1.44	0.49
	JUV	--	--	--	--	0.09	0.08	0.14	0.08	--	--	0.06	0.04
	SAD	0.43	0.14	0.33	0.13	2.54	1.19	1.39	0.20	0.16	0.07	2.68	0.53
	TOTAL	1.38	0.36	3.90	1.49	11.42	3.19	1.91	0.24	0.81	0.25	4.18	0.84
RAINBOW SEAPERCH	AD	0.08	0.04	0.21	0.11	1.17	0.35	0.03	0.03	0.02	0.02	0.15	0.06
	JUV	--	--	--	--	0.02	0.02	0.01	0.01	--	--	--	--
	SAD	0.20	0.12	0.07	0.03	0.37	0.20	0.16	0.11	0.03	0.02	0.29	0.17
	TOTAL	0.29	0.13	0.27	0.11	1.56	0.47	0.20	0.13	0.06	0.03	0.44	0.18

KELP BED
MEAN FISH DENSITIES

STRATUM=BOTTOM

SPECIES	MATURITY	BEFORE SMK DENS	BEFORE SMK SE	BEFORE SOKU DENS	BEFORE SOKU SE	BEFORE SOKD DENS	BEFORE SOKD SE	AFTER SMK DENS	AFTER SMK SE	AFTER SOKU DENS	AFTER SOKU SE	AFTER SOKD DENS	AFTER SOKD SE
WHITE SEAPERCH	AD	0.73	0.26	6.81	1.80	0.41	0.40	0.11	0.11	0.94	0.36	0.55	0.39
	JUV	0.07	0.06	0.10	0.04	--	--	--	--	0.01	0.01	--	--
	SAD	1.02	0.44	8.06	2.85	0.22	0.20	0.20	0.17	0.69	0.44	0.23	0.14
	TOTAL	1.82	0.59	14.97	4.00	0.63	0.59	0.31	0.28	1.64	0.78	0.78	0.51
RUBBERLIP SEAPERCH	AD	0.20	0.08	0.21	0.10	0.82	0.39	--	--	0.09	0.06	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	0.05	0.05	0.03	0.02	0.09	0.07	0.21	0.20	0.17	0.17	1.26	0.87
	TOTAL	0.25	0.10	0.24	0.11	0.90	0.41	0.21	0.20	0.26	0.22	1.26	0.87
PILE PERCH	AD	0.57	0.22	0.45	0.14	1.20	0.46	0.07	0.04	0.20	0.10	0.35	0.18
	JUV	0.01	0.01	--	--	--	--	0.07	0.04	--	--	0.06	0.06
	SAD	0.51	0.19	0.51	0.24	0.60	0.30	0.38	0.19	0.02	0.02	2.01	0.88
	TOTAL	1.09	0.31	0.96	0.28	1.80	0.75	0.51	0.21	0.22	0.10	2.43	0.91
BLACKSMITH	AD	--	--	--	--	0.02	0.01	--	--	--	--	0.02	0.02
	JUV	1.09	0.89	0.23	0.16	--	--	1.07	0.58	0.59	0.31	--	--
	SAD	--	--	--	--	0.03	0.02	0.01	0.01	--	--	--	--
	TOTAL	1.09	0.89	0.23	0.16	0.05	0.03	1.08	0.58	0.59	0.31	0.02	0.02
GARIBALDI	AD	0.06	0.02	0.01	0.01	0.10	0.03	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	0.01	0.01	--	--	0.03	0.01	--	--	--	--	--	--
	TOTAL	0.07	0.02	0.01	0.01	0.13	0.03	--	--	--	--	--	--
ROCK WRASSE	AD	1.21	0.17	0.33	0.06	0.69	0.13	4.18	0.54	3.22	0.61	3.76	0.43
	JUV	--	--	0.01	0.01	--	--	0.38	0.13	0.17	0.08	0.68	0.25
	SAD	0.16	0.04	0.02	0.01	0.17	0.08	7.63	0.66	4.16	0.91	6.16	0.57
	TOTAL	1.37	0.17	0.36	0.06	0.86	0.13	12.19	0.81	7.54	1.41	10.59	0.84
SENORITA	AD	5.90	1.10	2.51	0.74	2.67	0.84	0.84	0.41	4.71	1.56	1.84	0.73
	JUV	3.90	0.92	0.35	0.18	0.10	0.05	1.29	0.70	0.38	0.17	1.65	0.64
	SAD	1.70	0.41	0.50	0.25	0.19	0.08	3.24	1.78	5.60	1.56	2.49	0.85
	TOTAL	11.50	1.91	3.36	0.78	2.97	0.88	5.38	2.31	10.69	2.29	5.98	1.79
CA SHEEPHEAD	AD	0.17	0.03	0.91	0.17	0.78	0.14	0.04	0.03	0.03	0.02	0.02	0.02
	JUV	0.85	0.15	2.08	0.44	2.06	0.42	0.57	0.13	1.11	0.28	0.62	0.16
	SAD	1.60	0.31	4.36	0.60	5.06	0.64	0.24	0.09	0.16	0.04	0.12	0.03
	TOTAL	2.61	0.33	7.35	0.85	7.90	0.68	0.86	0.12	1.30	0.27	0.77	0.16
OPALEYE	AD	0.11	0.07	0.04	0.02	0.13	0.03	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	0.11	0.07	0.04	0.02	0.13	0.03	--	--	--	--	--	--
HALFMOON	AD	0.06	0.02	0.01	0.01	0.07	0.04	0.01	0.01	--	--	0.09	0.07
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	0.06	0.02	0.01	0.01	0.03	0.02	0.06	0.03	0.01	0.01	0.04	0.03
	TOTAL	0.12	0.03	0.03	0.02	0.10	0.04	0.07	0.04	0.01	0.01	0.14	0.10
CA SCORPIONFISH	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	0.01	0.01	--	--
	TOTAL	--	--	0.01	0.01	--	--	--	--	0.01	0.01	--	--
KELP ROCKFISH	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	0.01	0.01	--	--	--	--	--	--	--	--
	SAD	--	--	0.01	0.01	--	--	--	--	--	--	--	--
	TOTAL	--	--	0.03	0.02	--	--	--	--	--	--	--	--
GRASS ROCKFISH	AD	--	--	--	--	--	--	--	--	--	--	--	--

KELP BED
MEAN FISH DENSITIES

STRATUM=BOTTOM

SPECIES	MATURITY	BEFORE SMK DENS	BEFORE SMK SE	BEFORE SOKU DENS	BEFORE SOKU SE	BEFORE SOKD DENS	BEFORE SOKD SE	AFTER SMK DENS	AFTER SMK SE	AFTER SOKU DENS	AFTER SOKU SE	AFTER SOKD DENS	AFTER SOKD SE
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	--	--
OLIVE ROCKFISH	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	--	--
PAINTED GREENLING	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	--	--
CABEZON	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	--	--
PIPEFISH	AD	--	--	--	--	--	--	--	--	--	--	0.01	0.01
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	0.01	0.01
GIBBONSIA SPP.	AD	--	--	--	--	--	--	--	--	--	--	--	--
	JUV	--	--	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	--	--
	TOTAL	--	--	--	--	--	--	--	--	--	--	--	--
GIANT KELPFISH	AD	0.01	0.01	--	--	--	--	0.01	0.01	--	--	--	--
	JUV	0.01	0.01	--	--	--	--	--	--	--	--	--	--
	SAD	--	--	--	--	--	--	--	--	--	--	0.03	0.02
	TOTAL	0.02	0.01	--	--	--	--	0.01	0.01	--	--	0.03	0.02
TOTAL KELP SPECIES	AD	11.37	1.35	18.19	3.50	21.60	4.55	6.08	0.66	10.28	2.17	8.90	1.39
	JUV	8.64	1.56	7.22	1.33	5.37	1.11	6.02	0.95	4.48	0.66	9.00	1.11
	SAD	9.16	1.50	19.61	3.47	20.13	3.47	15.10	2.22	14.53	2.14	19.87	2.42
	TOTAL	29.17	3.25	45.01	5.83	47.10	7.75	27.20	2.77	29.29	3.89	37.77	4.12
TOTAL INDIVIDUALS	AD	11.37	1.35	18.38	3.52	21.60	4.55	6.08	0.66	10.28	2.17	8.90	1.39
	JUV	8.64	1.56	7.46	1.34	5.37	1.11	6.60	0.88	4.82	0.77	9.19	1.15
	SAD	11.21	2.30	20.50	3.74	24.89	6.40	15.42	2.16	14.97	2.26	21.02	2.43
	TOTAL	31.22	3.77	46.33	5.95	51.86	10.72	28.10	2.81	30.07	4.09	39.10	4.20

APPENDIX D

KELP DENSITIES (per 100 m²) AT SAMPLING LOCATIONS.

Means (and standard errors) are presented. N = number of transects on which kelp was counted. Locations are designated by number. Number 1 is in SMK; numbers 2, 3 and 5 are in SOKU; numbers 4, 6, and 9 are in SOKD (see Figure 2).

KELP BED FISHES
MEAN DENSITY OF MACROCYSTIS PER 100 SQUARE METERS

LOCATION	TYPE	1980	1981	1985	1986
1	MEAN	18.27	70.05	33.12	58.07
	N	125.00	90.00	48.00	42.00
	SE	0.55	4.02	1.05	5.60
2	MEAN	.	.	0.46	0.00
	N	.	.	48.00	24.00
	SE	.	.	0.10	0.00
3	MEAN	13.35	12.13	21.36	10.51
	N	120.00	84.00	48.00	42.00
	SE	0.48	0.54	0.99	0.56
4	MEAN	11.12	42.03	10.55	3.98
	N	132.00	84.00	48.00	36.00
	SE	0.42	2.67	0.53	0.38
5	MEAN	.	.	8.54	2.53
	N	.	.	48.00	48.00
	SE	.	.	0.64	0.35
6	MEAN	.	.	21.97	10.35
	N	.	.	48.00	48.00
	SE	.	.	1.01	0.56
7	MEAN	.	.	.	13.53
	N	.	.	.	18.00
	SE	.	.	.	1.37
9	MEAN	.	.	.	0.37
	N	.	.	.	24.00
	SE	.	.	.	0.24

This page intentionally left blank.

APPENDIX E

TAXA TESTED FOR DENSITY CHANGES WITH AN ANALYSIS OF VARIANCE.

Tests were performed on all life stages combined.

WATER COLUMN

Kelp bass (*Paralabrax clathratus*) (plus young-of-the-year)
Kelp perch (*Brachyistius frenatus*)
White seaperch (*Phanerodon furcatus*)
Senorita (*Oxyjulis californica*)
Halfmoon (*Medialuna californiensis*)
Giant kelpfish (*Heterostichus rostratus*)
Pile perch (*Rhacochilus vacca*)

BOTTOM

Kelp bass (*Paralabrax clathratus*) (plus young-of-the-year)
Barred sand bass (*Paralabrax nebulifer*)
Black perch (*Embiotoca jacksoni*)
Rainbow perch (*Hypsurus caryi*)
White seaperch (*Phanerodon furcatus*)
Pile perch (*Rhacochilus vacca*)
Rock wrasse (*Halichoeres semicinctus*)
Senorita (*Oxyjulis californica*)
California sheephead (*Semicossyphus pulcher*)

This page intentionally left blank.

APPENDIX F

MEAN DENSITIES (per 1000 m^3) FOR FISH IN WATER COLUMN AND IN BOTTOM STRATUM AT THE SITES USED IN ANALYSIS OF DENSITY CHANGES IN AREAS OF CONSTANT KELP DENSITY.

Dates are presented by year at each site. Sites are designated by number. Location 1 = SMK; location 3 = SOKU; locations 4 and 6 = SOKD (see Figure 2).

KELP BED FISHES -- 1980
MEAN DENSITY OF FISHES PER 1000 CUBIC METERS
STRATUM = BOTTOM

SPECIES	LOC 1	LOC 3	LOC 4
KELP BASS	11.7	21.5	39.2
CA SHEEPHEAD	6.9	26.4	23.4
BLACK PERCH	2.4	17.5	33.8
SENORITA	30.1	11.1	8.8
BLACK CROAKER	<.1	9.9	10.3
WHITE SEAPERCH	1.3	16.7	1.9
JACK MACKEREL	<.1	<.1	14.1
BARRED SAND BASS	1.2	7.3	5.3
PILE PERCH	2.2	0.9	5.3
RAINBOW SEAPERCH	0.8	0.9	4.6
ROCK WRASSE	2.4	1.0	2.5
SALEMA	3.2	1.2	<.1
RUBBERLIP SEAPERCH	0.4	0.6	2.7
OPALEYE	<.1	0.2	0.4
HALFMOON	0.2	<.1	0.3
GARIBALDI	<.1	<.1	0.4
LEOPARD SHARK	0.1	<.1	<.1
BLACKSMITH	<.1	<.1	0.1
SARGO	<.1	0.2	<.1
BAT RAY	<.1	<.1	<.1
GIANT KELPFISH	<.1	<.1	<.1
PACIFIC ELECTRIC RAY	<.1	<.1	<.1
ROUND STINGRAY	<.1	<.1	<.1
KELP PERCH	<.1	<.1	<.1
CA SCORPIONFISH	<.1	<.1	<.1
TURBOT SPP.	<.1	<.1	<.1
THORNBACK	<.1	<.1	<.1
SMOOTHHOUND SPP.	<.1	<.1	<.1
HORNYHEAD TURBOT	<.1	<.1	<.1
	====	=====	=====
	63.3	115.7	153.6

KELP BED FISHES -- 1980
MEAN DENSITY OF FISHES PER 1000 CUBIC METERS
STRATUM = CANOPY

SPECIES	LOC 1	LOC 3	LOC 4
SENORITA	26.4	10.6	13.2
KELP PERCH	31.3	8.7	7.5
KELP BASS	4.5	7.1	6.3
JACK MACKEREL	1.0	8.1	4.0
SILVERSIDES SPP.	3.2	5.0	2.2
HALFMOON	3.3	1.2	1.5
WHITE SEAPERCH	5.0	0.5	0.1
OPALEYE	0.4	<.1	<.1
GIANT KELPFISH	0.1	<.1	<.1
PILE PERCH	<.1	<.1	<.1
PACIFIC BARRACUDA	<.1	<.1	<.1
CA SHEEPHEAD	<.1	<.1	<.1
BARRED SAND BASS	<.1	<.1	<.1
	====	====	====
	75.3	41.2	34.9

KELP BED FISHES -- 1981
MEAN DENSITY OF FISHES PER 1000 CUBIC METERS
STRATUM = BOTTOM

SPECIES	LOC 1	LOC 3	LOC 4
WHITE SEAPERCH	10.8	83.8	57.9
SENORITA	39.4	8.3	16.8
KELP BASS	18.5	32.1	8.0
JACK MACKEREL	14.2	9.5	33.8
CA SHEEPHEAD	8.8	15.1	9.1
BLACK PERCH	6.3	3.0	7.1
PILE PERCH	4.6	5.6	2.0
SALEMA	1.3	<.1	8.2
BLACKSMITH	7.4	1.6	<.1
ROCK WRASSE	6.3	1.2	1.4
RUBBERLIP SEAPERCH	1.3	0.8	6.5
BARRED SAND BASS	1.2	5.4	1.3
BLACK CROAKER	6.6	<.1	<.1
RAINBOW SEAPERCH	1.0	0.6	4.5
PACIFIC BARRACUDA	<.1	<.1	2.7
KELP PERCH	1.6	0.1	0.7
HALFMOON	0.6	0.2	0.8
OPALEYE	0.7	<.1	<.1
SARGO	0.4	0.1	0.1
GARIBALDI	0.4	0.1	<.1
KELP ROCKFISH	<.1	0.2	0.1
LEOPARD SHARK	<.1	<.1	0.2
PACIFIC ELECTRIC RAY	<.1	<.1	<.1
GIANT KELPFISH	<.1	<.1	<.1
SMOOTHHOUND SPP.	<.1	<.1	<.1
ROUND STINGRAY	<.1	<.1	<.1
HORNYHEAD TURBOT	<.1	<.1	<.1
WHITE SEABASS	<.1	<.1	<.1
	=====	=====	=====
	131.4	168.1	161.4

KELP BED FISHES -- 1981
MEAN DENSITY OF FISHES PER 1000 CUBIC METERS
STRATUM = CANOPY

SPECIES	LOC 1	LOC 3	LOC 4
KELP PERCH	37.4	14.6	7.8
SENORITA	17.5	15.4	9.7
JACK MACKEREL	19.3	4.5	10.8
SILVERSIDES SPP.	20.1	4.2	9.5
KELP BASS	4.9	9.4	6.2
HALFMOON	5.6	3.0	4.9
PACIFIC BARRACUDA	3.5	0.3	6.4
WHITE SEAPERCH	<.1	4.8	1.1
OPALEYE	3.7	<.1	<.1
SALEMA	1.3	<.1	1.3
BLACKSMITH	<.1	<.1	0.4
GIANT KELPFISH	<.1	0.1	<.1
PILE PERCH	<.1	0.1	<.1
PACIFIC ELECTRIC RAY	<.1	<.1	<.1
BLACK PERCH	<.1	<.1	<.1
WHITE SEABASS	<.1	<.1	<.1
PACIFIC MACKEREL	<.1	<.1	<.1
	=====	====	====
	113.5	56.6	58.0

KELP BED FISHES -- 1985
MEAN DENSITY OF FISHES PER 1000 CUBIC METERS
STRATUM = BOTTOM

SPECIES	LOC 1	LOC 3	LOC 6
SENORITA	21.4	25.4	24.8
ROCK WRASSE	34.6	14.2	30.4
KELP BASS	12.2	6.9	9.7
BARRED SAND BASS	4.3	7.3	4.6
BLACK PERCH	5.6	1.4	8.2
PILE PERCH	1.5	0.3	10.6
WHITE SEAPERCH	0.2	3.0	1.0
BLACKSMITH	6.0	2.3	0.1
CA SHEEPHEAD	2.0	2.0	1.3
RUBBERLIP SEAPERCH	<.1	<.1	7.5
RAINBOW SEAPERCH	0.5	<.1	1.0
PACIFIC BARRACUDA	<.1	<.1	1.2
LEOPARD SHARK	<.1	<.1	0.2
HORN SHARK	<.1	<.1	0.1
BAT RAY	<.1	<.1	<.1
GIANT KELPFISH	<.1	<.1	<.1
THORNBACK	<.1	<.1	<.1
ROUND STINGRAY	<.1	<.1	<.1
CA HALIBUT	<.1	<.1	<.1
CA SCORPIONFISH	<.1	<.1	<.1
GIBBONSIA SPP.	<.1	<.1	<.1
SHOVELNOSE GUITARFISH	<.1	<.1	<.1
SALEMA	<.1	<.1	<.1
PAINTED GREENLING	<.1	<.1	<.1
PIPEFISH	<.1	<.1	<.1
	====	====	=====
	88.3	62.9	101.1

KELP BED FISHES -- 1985
MEAN DENSITY OF FISHES PER 1000 CUBIC METERS
STRATUM = CANOPY

SPECIES	LOC 1	LOC 3	LOC 6
SENORITA	23.2	21.0	20.5
KELP BASS	4.4	1.0	1.1
KELP PERCH	3.0	0.1	0.1
SALEMA	0.0	21.5	9.3
WHITE SEAPERCH	0.02	0.3	0.2
GIANT KELPFISH	0.6	0.1	0.06
BLACKSMITH	0.3	0.0	0.2
HALFMOON	0.04	0.2	0.0
ROCK WRASSE	0.03	0.02	0.00
PILE PERCH	0.02	0.0	<0.01
	31.61	44.22	31.47

KELP BED FISHES -- 1986
MEAN DENSITY OF FISHES PER 1000 CUBIC METERS
STRATUM = BOTTOM

SPECIES	LOC 1	LOC 3	LOC 6
ROCK WRASSE	37.8	31.7	32.3
SENORITA	9.7	38.9	10.6
KELP BASS	5.1	15.4	33.9
BLACK PERCH	5.8	3.5	16.5
WHITE SEAPERCH	1.8	7.1	3.6
BARRED SAND BASS	4.3	4.6	17.3
JACK MACKEREL	5.7	4.9	6.7
PACIFIC BARRACUDA	<.1	<.1	<.1
PILE PERCH	1.6	1.1	3.8
CA SHEEPHEAD	3.1	6.0	3.3
RAINBOW SEAPERCH	0.7	0.3	1.5
HALFMOON	0.4	<.1	0.8
RUBBERLIP SEAPERCH	1.3	1.6	<.1
SALEMA	<.1	2.7	<.1
BLACKSMITH	<.1	1.1	<.1
GIANT KELPFISH	<.1	<.1	0.2
OLIVE ROCKFISH	<.1	<.1	<.1
ROUND STINGRAY	<.1	<.1	<.1
PACIFIC MACKEREL	<.1	<.1	<.1
LEOPARD SHARK	<.1	<.1	<.1
SARGO	<.1	<.1	<.1
GIBBONSIA SPP.	<.1	<.1	<.1
CA SCORPIONFISH	<.1	<.1	<.1
THORNBACK	<.1	<.1	<.1
SHOVELNOSE GUITARFISH	<.1	<.1	<.1
	====	=====	=====
	77.5	119.0	130.6

KELP BED FISHES -- 1986
MEAN DENSITY OF FISHES PER 1000 CUBIC METERS
STRATUM = CANOPY

SPECIES	LOC 1	LOC 3	LOC 6
SENORITA	17.8	66.9	54.4
KELP BASS	2.6	5.0	11.5
KELP PERCH	5.6	2.0	4.1
SALEMA	0.0	0.0	0.0
WHITE SEAPERCH	0.06	0.4	0.4
GIANT KELPFISH	0.29	0.22	0.50
BLACKSMITH	0.0	0.08	0.0
HALFMOON	2.4	12.7	7.3
ROCK WRASSE	0.0	0.02	0.05
PILE PERCH	0.1	0.03	0.14
OPALEYE	0.1	0.03	0.03
BARRED SAND BASS	0.0	0.0	0.06
BLACK PERCH	0.07	0.0	0.0
PIPEFISH	0.08	0.0	0.0
	29.10	87.38	78.48

This page intentionally left blank.

APPENDIX G

ANOVA TABLES FOR THOSE SPECIES WHICH DISPLAYED A SIGNIFICANT ($p < 0.05$) PERIOD-BY-LOCATION INTERACTION.

KELP BED
TWO FACTOR FIXED EFFECTS ANOVA
PERFORMED ON LOG10(X + 1) FISH DENSITIES
1981 DATA TAKEN AT SOKD EXCLUDED FROM ANALYSIS

CANOPY STRATUM
TOT SENORITA

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	5	4.47581231	0.89516246	5.18	0.0002	0.137156	35.5593
ERROR	163	28.15712356	0.17274309		ROOT MSE		LOGDENS MEAN
CORRECTED TOTAL	168	32.63293587			0.41562374		1.16881861

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
LOC	2	0.15351954	0.44	0.6420	2	0.10000208	0.29	0.7491
PERIOD	1	1.86937081	10.82	0.0012	1	2.02280808	11.71	0.0008
LOC*PERIOD	2	2.45292196	7.10	0.0011	2	2.45292196	7.10	0.0011

APPENDIX G. (Continued)

KELP BED
TWO FACTOR FIXED EFFECTS ANOVA
PERFORMED ON LOG10(X + 1) FISH DENSITIES
1981 DATA TAKEN AT SOKD EXCLUDED FROM ANALYSIS

CANOPY STRATUM
TOT HALFMOON

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	5	2.71697989	0.54339598	3.73	0.0032	0.102655	91.4313
ERROR	163	23.75022997	0.14570693		ROOT MSE		LOGDENS MEAN
CORRECTED TOTAL	168	26.46720986			0.38171577		0.41748910

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
LOC	2	1.05011134	3.60	0.0294	2	0.44174615	1.52	0.2227
PERIOD	1	0.38635512	2.65	0.1054	1	0.32421562	2.23	0.1377
LOC*PERIOD	2	1.28051343	4.39	0.0138	2	1.28051343	4.39	0.0138

APPENDIX G. (Continued)

KELP BED
TWO FACTOR FIXED EFFECTS ANOVA
PERFORMED ON LOG10(X + 1) FISH DENSITIES
1981 DATA TAKEN AT SOKD EXCLUDED FROM ANALYSIS

CANOPY STRATUM
TOT KELP PERCH

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	5	29.34166097	5.86833219	39.45	0.0001	0.547544	46.5003
ERROR	163	24.24609592	0.14874905		ROOT MSE		LOGDENS MEAN
CORRECTED TOTAL	168	53.58775688			0.38567999		0.82941370

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
LOC	2	12.60354303	42.37	0.0001	2	8.01012683	26.92	0.0001
PERIOD	1	15.62378798	105.03	0.0001	1	14.79136609	99.44	0.0001
LOC*PERIOD	2	1.11432995	3.75	0.0257	2	1.11432995	3.75	0.0257

APPENDIX G. (Continued)

KELP BED
TWO FACTOR FIXED EFFECTS ANOVA
PERFORMED ON LOG10(X + 1) FISH DENSITIES
1981 DATA TAKEN AT SOKD EXCLUDED FROM ANALYSIS

CANOPY STRATUM
TOT GIANT KELPFISH

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	5	0.28220973	0.05644195	12.87	0.0001	0.283032	141.3625
ERROR	163	0.71488372	0.00438579		ROOT MSE		LOGDENS MEAN
CORRECTED TOTAL	168	0.99709345			0.06622529		0.04684785

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
LOC	2	0.06114766	6.97	0.0012	2	0.09531020	10.87	0.0001
PERIOD	1	0.18033964	41.12	0.0001	1	0.18281409	41.68	0.0001
LOC*PERIOD	2	0.04072243	4.64	0.0109	2	0.04072243	4.64	0.0109

APPENDIX G. (Continued)

KELP BED
TWO FACTOR FIXED EFFECTS ANOVA
PERFORMED ON LOG10(X + 1) FISH DENSITIES
1981 DATA TAKEN AT SOKD EXCLUDED FROM ANALYSIS

CANOPY STRATUM
TOT TOTAL INDIVIDUALS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	5	3.92668497	0.78533699	6.60	0.0001	0.168294	20.9028
ERROR	163	19.40561692	0.11905286		ROOT MSE		LOGDENS MEAN
CORRECTED TOTAL	168	23.33230189			0.34504038		1.65069361

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
LOC	2	1.56377096	6.57	0.0018	2	0.65431402	2.75	0.0670
PERIOD	1	0.07319813	0.61	0.4341	1	0.03683803	0.31	0.5788
LOC*PERIOD	2	2.28971588	9.62	0.0001	2	2.28971588	9.62	0.0001

APPENDIX G. (Continued)

KELP BED
TWO FACTOR FIXED EFFECTS ANOVA
PERFORMED ON LOG10(X + 1) FISH DENSITIES
1981 DATA TAKEN AT SOKD EXCLUDED FROM ANALYSIS

BOTTOM STRATUM
TOT BARRED SAND BASS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	5	3.19617648	0.63923530	16.37	0.0001	0.386371	54.6458
ERROR	130	5.07612132	0.03904709		ROOT MSE		LOGDENS MEAN
CORRECTED TOTAL	135	8.27229780			0.19760336		0.36160760

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
LOC	2	2.35791889	30.19	0.0001	2	1.52578127	19.54	0.0001
PERIOD	1	0.35952669	9.21	0.0029	1	0.37700105	9.66	0.0023
LOC*PERIOD	2	0.47873090	6.13	0.0029	2	0.47873090	6.13	0.0029

APPENDIX G. (Continued)

KELP BED
TWO FACTOR FIXED EFFECTS ANOVA
PERFORMED ON LOG10(X + 1) FISH DENSITIES
1981 DATA TAKEN AT SOKD EXCLUDED FROM ANALYSIS

BOTTOM STRATUM
TOT RAINBOW SEAPERCH

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	5	1.15482806	0.23096561	8.64	0.0001	0.249376	148.6828
ERROR	130	3.47604719	0.02673882		ROOT MSE		LOGDENS MEAN
CORRECTED TOTAL	135	4.63087526			0.16352010		0.10997915

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
LOC	2	0.77438985	14.48	0.0001	2	0.67868238	12.69	0.0001
PERIOD	1	0.21004087	7.86	0.0058	1	0.23452297	8.77	0.0036
LOC*PERIOD	2	0.17039734	3.19	0.0446	2	0.17039734	3.19	0.0446

APPENDIX G. (Continued)

KELP BED
TWO FACTOR FIXED EFFECTS ANOVA
PERFORMED ON LOG10(X + 1) FISH DENSITIES
1981 DATA TAKEN AT SOKD EXCLUDED FROM ANALYSIS

BOTTOM STRATUM
TOT BLACK PERCH

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	5	5.91064616	1.18212923	8.79	0.0001	0.252686	86.2135
ERROR	130	17.48064555	0.13446650		ROOT MSE		LOGDENS MEAN
CORRECTED TOTAL	135	23.39129171			0.36669675		0.42533543

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
LOC	2	4.94087777	18.37	0.0001	2	4.33021319	16.10	0.0001
PERIOD	1	0.05665892	0.42	0.5174	1	0.07784586	0.58	0.4481
LOC*PERIOD	2	0.91310948	3.40	0.0365	2	0.91310948	3.40	0.0365

APPENDIX G. (Continued)

KELP BED
TWO FACTOR FIXED EFFECTS ANOVA
PERFORMED ON LOG10(X + 1) FISH DENSITIES
1981 DATA TAKEN AT SOKD EXCLUDED FROM ANALYSIS

BOTTOM STRATUM
TOT SENORITA

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	5	6.81664362	1.36332872	8.99	0.0001	0.256862	58.4691
ERROR	130	19.72149135	0.15170378		ROOT MSE		LOGDENS MEAN
CORRECTED TOTAL	135	26.53813497			0.38949169		0.66615009

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
LOC	2	1.95564408	6.45	0.0021	2	0.77471148	2.55	0.0817
PERIOD	1	0.13722499	0.90	0.3433	1	0.17331460	1.14	0.2871
LOC*PERIOD	2	4.72377455	15.57	0.0001	2	4.72377455	15.57	0.0001

APPENDIX G. (Continued)

KELP BED
TWO FACTOR FIXED EFFECTS ANOVA
PERFORMED ON LOG10(X + 1) FISH DENSITIES
1981 DATA TAKEN AT SOKD EXCLUDED FROM ANALYSIS

BOTTOM STRATUM
TOT CA SHEEPHEAD

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	5	9.83881961	1.96776392	47.18	0.0001	0.644720	35.5885
ERROR	130	5.42178548	0.04170604		ROOT MSE		LOGDENS MEAN
CORRECTED TOTAL	135	15.26060508			0.20422057		0.57383789

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
LOC	2	1.81068863	21.71	0.0001	2	1.12339277	13.47	0.0001
PERIOD	1	6.98643024	167.52	0.0001	1	7.24479050	173.71	0.0001
LOC*PERIOD	2	1.04170074	12.49	0.0001	2	1.04170074	12.49	0.0001

This page intentionally left blank.

APPENDIX H

CHANGES IN DENSITY OF KELP BED FISHES IN SOK RELATIVE TO SMK.

Alpha levels (P) of the period-by-location interactions from the two-factor ANOVA are presented. In this analysis samples from both the SOKU and SOKD locations in SOK are combined. Relative percent change is presented for those species with a significant ($P < 0.05$) period-by-location interaction and the indicated direction of change (d = decrease, i = increase) is presented for the others. YOY = young-of-the-year.

TAXA	P	RELATIVE % CHANGE SOK
WATER COLUMN FISH		
Senorita	<0.01	204
Halfmoon	0.01	541
Giant kelpfish	0.01	67
Kelp Perch	0.14	i
Kelp bass	0.19	d
Kelp bass YOY	0.22	i
White seaperch	0.82	i
Pile perch	0.93	i
BOTTOM FISH		
Barred sand bass	0.04	-60
Black perch	0.05	-76
Senorita	<0.01	462
California sheephead	<0.01	-59
Rainbow seaperch	0.24	d
White seaperch	0.82	d
Pile perch	0.43	i
Rock wrasse	0.89	i
Kelp bass	0.40	d
Kelp bass YOY	0.75	d

This page intentionally left blank.

APPENDIX I

ESTIMATING THE CONFIDENCE INTERVAL FOR CHANGES IN ABUNDANCE DUE TO SONGS

We estimate confidence intervals for Changes in Abundance to help determine if the estimated Changes in Abundance (presented in Section 3.4.4) are significantly different than zero.

In Section 2.2.4 we present a formula for computing the Change in Abundance due to SONGS:

(1) Change in Abundance

= Expected Abundance - Observed Abundance

= (Observed Abundance) $(1/S)$ - Observed Abundance,

where S is the multiplicative effect of SONGS' operation, discussed in the following.

The Observed Abundance is the product of a regression estimate of density (y) and the volume of water. Volume is the product of surface area and depth :

(2) Observed Abundance = y (surface area) (depth).

The estimate (y) is the predicted density from the regression of fish density on kelp density. We use the regression coefficients given in Table X and the average kelp density to estimate y. As discussed in the report, we did not use the average density of fish from the transects used in the BACIP analysis because kelp densities on these transects were higher than average, and there was a positive relationship between fish density and kelp density.

For surface area and density we use the following subscripts to indicate time and location:

	Subscript
SOK, before	1
SMK, before	2
SOK, after	3
SMK, after	4

We use the symbol "a" to denote the surface area within the canopy and "c" for the surface area over cobble, outside the canopy. Thus $(a_3 + c_3)$ is the total surface area at SOK in the After period. Using "d" for depth, equation (2) becomes

(3) Observed Abundance $= y\,(a_3 + c_3)\,d$,

and then from equation (1),

(4) Change in Abundance =

$y\,(a_3 + c_3)\,d\,(1/S) - y\,(a_3 + c_3)\,d$, or

$= y\,(a_3 + c_3)\,d\,[(1/S) - 1]$

We use a multiplicative model, shown in the following table, to estimate *S*. *L* is the location effect, *T* is the time effect, and *S* is the effect of SONGS' operation. If A is the abundance at SOK in the Before period, then the abundance at SMK in the Before, and at SOK and SMK in the After period can be expressed as multiples of *L*, *T*, and *S*:

	SOK	SMK
Before	A	*L* A
After	*T S* A	*T L* A

Thus our model assumes that SMK abundance remains the same multiple (*L*) of SOK abundance for Before and After periods. The multiple of change in abundance from Before to After (T) is the same for SOK and SMK. Again, S is the multiplicative effect of SONGS' operation.

We can factor out S,

(5) $S = [(T\,S\,\mathrm{A})\,(L\,\mathrm{A})] \,/\, [(\mathrm{A})\,(T\,L\,\mathrm{A})]$.

or

(6) $S = (\mathrm{SOK}_{after}\ \mathrm{SMK}_{before}) \,/\, (\mathrm{SOK}_{before}\ \mathrm{SMK}_{after})$,

where SOK_{after} is the abundance at SOK in the After period, etc.

Using x_i to denote density at location and time, indexed the same as a_i and c_i, we estimate abundances in terms of density (x_i), area (a_i and c_i) and a proportion (p), where (p) is the estimated proportion of the density of fish over cobble (no canopy) to the density of canopy fish on the bottom.

$$\mathrm{SOK}_{before} = x_1\,a_1 + x_1\,p\,c_1 = x_1\,(a_1 + p\,c_1)$$

$$\mathrm{SMK}_{before} = x_2\,a_2 + x_2\,p\,c_2 = x_2\,(a_2 + p\,c_2)$$

$$\mathrm{SOK}_{after} = x_3\,a_3 + x_3\,p\,c_3 = x_3\,(a_3 + p\,c_3)$$

$$\mathrm{SMK}_{after} = x_4\,a_4 + x_4\,p\,c_4 = x_4\,(a_4 + p\,c_4)$$

Note, the x_i are averages of fish density from transects used in the BACIP analysis and therefore are from areas of higher than average kelp and fish densities. Even though from higher than average kelp and fish densities the x_i are appropriate for estimating S since the relative densities of kelp were held constant for BACIP between SOK and SMK for Before and After.

S (equation 6) now can be written in terms of estimable parameters,

(7) $S = [x_3\,(a_3 + p\,c_3)\ \ x_2\,(a_2 + p\,c_2)] \,/$
$[(x_1\,(a_1 + p\,c_1)\ \ x_4\,(a_4 + p\,c_4)]$

And now the Change in Abundance (equation 4) can be written,

Change in Abundance =

(8) $$y\,(a_3 + c_3)\,d\,[(x_1\,(a_1 + p\,c_1)\;x_4\,(a_4 + p\,c_4))\,/\,(x_2\,(a_2 + p\,c_2)\,x_3\,(a_3 + p\,c_3)) - 1].$$

We use the delta method (Seber 1973), a commonly used procedure for estimating the variance of products and quotients, to estimate the variance of Change in Abundance:

(9) $$\mathrm{Var}\,(\text{Change in Abundance}) = \Sigma\,(\partial/\partial z_i)^2\,\mathrm{Var}\,(z_i),$$

where $z_i = y, x_1..x_4, a_1..a_4, c_1..c_4$ and p.

We show partial derivatives in Table I-1.

Note that the equations for computing Change in Abundance and its variance, equation (8) and (9), work for both canopy and bottom fish: for canopy fish set p equal to zero.

In Tables I-2 through I-7 we present estimated confidence intervals and the parameter estimates needed to compute them. Surface area for canopy (a_i) and cobble (c_i) were estimated without replication. Rather than treat them as constants we gave them estimates of variance of 10% of their estimated densities. Thus for a surface area of 100 HA, we believe that nearly all estimates of mean area would fall between 105 and 95 HA, essentially two standard errors. We treated depth (d) as a constant.

Covariances were not estimable. Covariance between surface area and fish density may exist. Covariance between a_i and c_i also likely exist since the total area of the kelp bed remains relatively constant. These covariances would reduce the estimated variance and tighten estimates of confidence intervals.

Table I-1

Partial derivatives for computing the variance of Change in Abundance, equation (8).

$\partial/\partial y = (a_3 + c_3)\ d\ [x_1 x_4 (a_1 + p c_1)(a_4 + p c_4) / (x_2 x_3 (a_2 + p c_2)(a_3 + p c_3)) - 1]$

$\partial/\partial x_1 = y (a_3 + c_3)\ d\ x_4 (a_1 + p c_1)(a_4 + p c_4) / (x_2 x_3 (a_2 + p c_2)(a_3 + p c_3))$

$\partial/\partial x_4 = y (a_3 + c_3)\ d\ x_1 (a_1 + p c_1)(a_4 + p c_4) / (x_2 x_3 (a_2 + p c_2)(a_3 + p c_3))$

$\partial/\partial x_2 = - y (a_3 + c_3)\ d\ x_1 x_4 (a_1 + p c_1)(a_4 + p c_4) / (x_2^2 x_3 (a_2 + p c_2)(a_3 + p c_3))$

$\partial/\partial x_3 = - y (a_3 + c_3)\ d\ x_1 x_4 (a_1 + p c_1)(a_4 + p c_4) / (x_2 x_3^2 (a_2 + p c_2)(a_3 + p c_3))$

$\partial/\partial a_1 = y (a_3 + c_3)\ d\ x_1 x_4 (a_4 + p c_4) / (x_2 x_3 (a_2 + p c_2)(a_3 + p c_3))$

$\partial/\partial a_4 = y (a_3 + c_3)\ d\ x_1 x_4 (a_1 + p c_1) / (x_2 x_3 (a_2 + p c_2)(a_3 + p c_3))$

$\partial/\partial a_2 = - y (a_3 + c_3)\ d\ x_1 x_4 (a_1 + p c_1)(a_4 + p c_4) / (x_2 x_3 (a_2 + p c_2)^2 (a_3 + p c_3))$

$\partial/\partial a_3 = y\ d\ [x_1 x_4 (a_1 + p c_1)(a_4 + p c_4) / (x_2 x_3 (a_2 + p c_2)(a_3 + p c_3)) - 1] - y (a_3 + c_3)\ d\ x_1 x_4 (a_1 + p c_1)(a_4 + p c_4) / (x_2 x_3 (a_2 + p c_2)(a_3 + p c_3)^2)$

$\partial/\partial c_1 = p y (a_3 + c_3)\ d\ x_1 x_4 (a_4 + p c_4) / (x_2 x_3 (a_2 + p c_2)(a_3 + p c_3))$

$\partial/\partial c_4 = p y (a_3 + c_3)\ d\ x_1 x_4 (a_1 + p c_1) / (x_2 x_3 (a_2 + p c_2)(a_3 + p c_3))$

$\partial/\partial c_2 = p (-y (a_3 + c_3)\ d\ [x_1 x_4 (a_1 + p c_1)(a_4 + p c_4) / (x_2 x_3 (a_2 + p c_2)^2 (a_3 + p c_3)))$

$\partial/\partial c_3 = y\ d\ [x_1 x_4 (a_1 + p c_1)(a_4 + p c_4) / (x_2 x_3 (a_2 + p c_2)(a_3 + p c_3)) - 1] - p y (a_3 + c_3)\ d\ x_1 x_4 (a_1 + p c_1)(a_4 + p c_4) / (x_2 x_3 (a_2 + p c_2)(a_3 + p c_3)^2)$

to differentiate with respect to p, let

$A = y (a_3 + c_3)\ d$

$B = (x_1 x_4) / (x_2 x_3)$

$C = c_1 c_4$

$E = a_1 a_4$

$F = c_2 c_3$

$G = a_2 c_3 + a_3 c_2$

$H = a_2 a_3$

$J = a_1 c_4 + a_4 c_1$

$\partial/\partial p = A B (((J - G C / F) / (F p^2 + G p + H)) - ((J - G C / F) p + E - H C / F)(2 F p + G) / ((F p^2 + G p + H))^2)$

Table I-2

All canopy fish: computation of standard deviation and confidence intervals. Densities are in numbers per 1000 m^3, areas in hectare, depth in meters.

Parameter estimates used in estimating partial derivatives and variance:

Expected Values

	SOK before	SMK before	SOK after	SMK after
Reg. estimate (y)	n/a	n/a	8.2	n/a
Proportion (p)	0	0	0	0
Density (x_i)	38	71	60	30
Area of canopy (a_i)	88	50	32	74
Area of cobble (c_i)	0	0	0	0
Depth	12.9	12.9	12.9	12.9

Variances

	SOK before	SMK before	SOK after	SMK after
Reg. estimate (y)	n/a	n/a	32	n/a
Proportion (p)	0	0	0	0
Density (x_i)	14	48	59	57
Area of canopy (a_i)	9	5	3	7
Area of cobble (c_i)	0	0	0	0
Depth	0	0	0	0

Percent Change = (S - 1)100% = -17.2%

Expected Abundance = 160×10^3

Observed Abundance = 132.6×10^3

Change in Abundance = 27.4×10^3

Std (Change in Abundance) ≈ 71.1×10^3

95 % C.I. (Change in Abundance) ≈ $27.4 \times 10^3 +/- 142.2 \times 10^3$

Table I-3

All bottom fish: computation of standard deviation and confidence intervals. Densities are in numbers per 1000 m^3, areas in hectare, depth in meters.

Parameter estimates used in estimating partial derivatives and variance:

Expected Values

	SOK before	SMK before	SOK after	SMK afer
Reg. estimate (y)	n/a	n/a	44	n/a
Proportion (p)	0.43	0.43	0.33	0.43
Density (x_i)	143	90	100	80
Area of canopy (a_i)	88	50	32	74
Area of cobble (c_i)	58	52	93	60
Depth	1.5	1.5	1.5	1.5

Variances

	SOK before	SMK before	SOK after	SMK after
Reg. estimate (y)	n/a	n/a	43	n/a
Proportion (p)	0.01	0.01	0.01	0.01
Density (x_i)	467	172	129	133
Area of canopy (a_i)	9	5	3	7
Area of cobble (c_i)	6	5	9	6
Depth	0	0	0	0

Percent Change = (S - 1)100% = -69.6%

Expected Abundance = 275.2×10^3

Observed Abundance = 83.5×10^3

Change in Abundance = 191.7×10^3

Std (Change in Abundance) ≈ 78.6×10^3

95 % C.I. (Change in Abundance) ≈ 191.4×10^3 +/- 157.2×10^3

Table I-4

Senorita canopy: computation of standard deviation and confidence intervals. Densities are in numbers per 1000 m^3, areas in hectare, depth in meters.

Parameter estimates used in estimating partial derivatives and variance:

Expected Values

	SOK before	SMK before	SOK after	SMK after
Reg. estimate (y)	n/a	n/a	5.2	n/a
Proportion (p)	0	0	0	0
Density (x_i)	14	22	40	21
Area of canopy (a_i)	88	50	32	74
Area of cobble (c_i)	0	0	0	0
Depth	12.9	12.9	12.9	12.9

Variances

	SOK before	SMK before	SOK after	SMK after
Reg. estimate (y)	n/a	n/a	17	n/a
Proportion (p)	0	0	0	0
Density (x_i)	10	13	26	44
Area of canopy (a_i)	9	5	3	7
Area of cobble (c_i)	0	0	0	0
Depth	0	0	0	0

Percent Change = (S - 1)100% = -27.3%

Expected Abundance = 126.8×10^3

Observed Abundance = 92.3×10^3

Change in Abundance = 34.5×10^3

Std (Change in Abundance) ≈ 73.0×10^3

95 % C.I. (Change in Abundance) ≈ $34.5 \times 10^3 +/- 146.0 \times 10^3$

Table I-5

Senorita bottom: computation of standard deviation and confidence intervals. Densities are in numbers per 1000 m^3, areas in hectare, depth in meters.

Parameter estimates used in estimating partial derivatives and variance:

Expected Values

	SOK before	SMK before	SOK after	SMK afer
Reg. estimate (y)	n/a	n/a	15	n/a
Proportion (p)	0.43	0.43	0.39	0.43
Density (x_i)	9	15	24	35
Area of canopy (a_i)	88	50	32	74
Area of cobble (c_i)	58	52	93	60
Depth	1.5	1.5	1.5	1.5

Variances

	SOK before	SMK before	SOK after	SMK after
Reg. estimate (y)	n/a	n/a	15	n/a
Proportion (p)	0.01	0.01	0.01	0.01
Density (x_i)	4	70	40	87
Area of canopy (a_i)	9	5	3	7
Area of cobble (c_i)	6	5	9	6
Depth	0	0	0	0

Percent Change = (S - 1)100% = 167.6%

Expected Abundance = 10.7×10^3

Observed Abundance = 28.7×10^3

Change in Abundance = 18.0×10^3

Std (Change in Abundance) ≈ 9.2×10^3

95 % C.I. (Change in Abundance) ≈ 18.0×10^3 +/- 18.4×10^3

Table I-6

Non-Senorita canopy: computation of standard deviation and confidence intervals. Densities are in numbers per 1000 m^3, areas in hectare, depth in meters.

Parameter estimates used in estimating partial derivatives and variance:

Expected Values

	SOK before	SMK before	SOK after	SMK after
Reg. estimate (y)	n/a	n/a	2.5	n/a
Proportion (p)	0	0	0	0
Density (x_i)	24	49	20	19
Area of canopy (a_i)	88	50	32	74
Area of cobble (c_i)	0	0	0	0
Depth	12.9	12.9	12.9	12.9

Variances

	SOK before	SMK before	SOK after	SMK after
Reg. estimate (y)	n/a	n/a	12	n/a
Proportion (p)	0	0	0	0
Density (x_i)	10	34	20	19
Area of canopy (a_i)	9	5	3	7
Area of cobble (c_i)	0	0	0	0
Depth	0	0	0	0

Percent Change = (S - 1)100% = -6.01%

Expected Abundance = 43.1×10^3

Observed Abundance = 40.5×10^3

Change in Abundance = 2.6×10^3

Std (Change in Abundance) ≈ 26.3×10^3

95 % C.I. (Change in Abundance) ≈ 2.6×10^3 +/- 52.6×10^3

Table I-7

Non-Senorita bottom: computation of standard deviation and confidence intervals. Densities are in numbers per 1000 m^3, areas in hectare, depth in meters.

Parameter estimates used in estimating partial derivatives and variance:

Expected Values

	SOK before	SMK before	SOK after	SMK afer
Reg. estimate (y)	n/a	n/a	29	n/a
Proportion (p)	0.43	0.43	0.36	0.43
Density (x_i)	134	55	76	64
Area of canopy (a_i)	88	50	32	74
Area of cobble (c_i)	58	52	93	60
Depth	1.5	1.5	1.5	1.5

Variances

	SOK before	SMK before	SOK after	SMK after
Reg. estimate (y)	n/a	n/a	26	n/a
Proportion (p)	0.01	0.01	0.01	0.01
Density (x_i)	400	105	98	106
Area of canopy (a_i)	9	5	3	7
Area of cobble (c_i)	6	5	9	6
Depth	0	0	0	0

Percent Change = (S - 1)100% = -82.5%

Expected Abundance = 312.7×10^3

Observed Abundance = 54.8×10^3

Change in Abundance = 257.9×10^3

Std (Change in Abundance) ≈ 93.7×10^3

95 % C.I. (Change in Abundance) ≈ 257.9×10^3 +/- 187.4×10^3

APPENDIX J

SUMMARY OF BACIP RESULTS COMPARING DENSITIES OF KELP BED FISHES AT SMK AND SOKU.

Those taxa which displayed a significant ($P<0.05$) BACIP result are listed. Also listed are the alpha level of the test result, the log transformation used in the analysis and the relative percent change in mean densities from Before period to After.

TAXA	P	TRANSFORMATION	% CHANGE
BOTTOM FISH			
Barred sand bass	<0.01	log(x+1)	-69
Black perch	<0.01	log(x+1)	-79
Senorita	<0.01	log(x+1)	1253
California sheephead	0.02	log(x+1)	-51
WATER COLUMN FISH			
Halfmoon	0.01	log(x+1)	142
Kelp perch	0.03	log(x+0.01)	-76
Senorita	<0.01	log(x+1)	232

This page intentionally left blank.

APPENDIX K

ESTIMATED RELATIVE PERCENT CHANGE IN SOK OF TOTAL ABUNDANCE OF INDIVIDUAL SPECIES OF WATER COLUMN AND BOTTOM FISHES.

Estimates were made on all life-stages combined. Calculation of estimates follows procedure for Total Water Column and Total Bottom Fishes described in Section 3.5. Substrate areas and strata volumes are as in Appendix L. The density value used for an individual species is the Total Fish density (Appendix L) times the proportion of total fish that species represents. Neither confidence intervals nor statistical significance of these estimates are calculated.

WATER COLUMN

Kelp bass (*Paralabrax clathratus*)	-79
(plus young-of-the-year)	-72
Kelp perch (*Brachyistius frenatus*)	-70
White seaperch (*Phanerodon furcatus*)	101
Senorita (*Oxyjulis californica*)	-25
Halfmoon (*Medialuna californiensis*)	57
Giant kelpfish (*Heterostichus rostratus*)	-74
Pile perch (*Rhacochilus vacca*)	-77

BOTTOM

Kelp bass (*Paralabrax clathratus*)	-68
(plus young-of-the-year)	-74
Barred sand bass (*Paralabrax nebulifer*)	-77
Black perch (*Embiotoca jacksoni*)	-93
Rainbow perch (*Hypsurus caryi*)	-88
White seaperch (*Phanerodon furcatus*)	-72
Pile perch (*Rhacochilus vacca*)	-43
Rock wrasse (*Halichoeres semicinctus*)	-19
Senorita (*Oxyjulis californica*)	166
California sheephead (*Semicossyphus pulcher*)	-73

This page intentionally left blank.

APPENDIX L

DATA USED IN THE CALCULATIONS OF PERCENT RELATIVE CHANGE IN BOTTOM AREA, FISH DENSITY, TOTAL NUMBERS, AND TOTAL BIOMASS.

The entries in the right-hand block of the tables are the areas (in hectares) of the "cobble" portions (<4 kelp plants/ 100 m^2) and "kelp" portions (areas with higher densities of kelp) of the hard substrate in SMK and SOK in each of the two Before (1980 and 1981) and the two After years (1985 and 1986). Entries in the center block of the tables are either fish densities (per 1000 m^3) or fish biomass (kg/1000 m^3) for each of three categories of fish (Total, senorita and non-senorita) in each of two strata (bottom and water column, or "canopy") in each of the two kelp beds in each of the four years. The entries in the left hand block of the tables are the products, or "abundance indices", of the area of substrate x the density x times the depth of the stratum (12.9 m for canopy, 1.5 m for bottom).

KELP BED
NUM ABUNDANCE ESTIMATE
SPECIES = TOTAL

STRATUM=BOTTOM BED=SMK

YEAR	BOTTOM AREA (HA) COBBLE	BOTTOM AREA (HA) KELP	FISH DENS 1000**3M COBBLE	FISH DENS 1000**3M KELP	ABUNDANCE COBBLE	ABUNDANCE KELP	ABUNDANCE TOTAL
1980	32.40	69.00	14.88	63.31	7230.2	65522	72752
1981	72.10	31.10	27.55	117.23	29794	54688	84482
1985	65.60	69.10	20.76	88.33	20425	91553	111978
1986	54.70	79.50	16.86	71.74	13833	85554	99387

STRATUM=BOTTOM BED=SOK

YEAR	BOTTOM AREA (HA) COBBLE	BOTTOM AREA (HA) KELP	FISH DENS 1000**3M COBBLE	FISH DENS 1000**3M KELP	ABUNDANCE COBBLE	ABUNDANCE KELP	ABUNDANCE TOTAL
1980	47.20	94.50	30.06	127.92	21283	181326	202610
1981	68.60	81.00	33.31	141.76	34279	172236	206515
1985	96.70	40.50	38.21	62.27	55422	37827	93249
1986	97.90	22.70	28.52	104.58	41878	35609	77488

STRATUM=CANOPY BED=SMK

YEAR	BOTTOM AREA (HA) COBBLE	BOTTOM AREA (HA) KELP	FISH DENS 1000**3M COBBLE	FISH DENS 1000**3M KELP	ABUNDANCE COBBLE	ABUNDANCE KELP	ABUNDANCE TOTAL
1980	.	69.00	.	71.08	.	632674	632674
1981	.	31.10	.	70.58	.	283174	283174
1985	.	69.10	.	31.58	.	281535	281535
1986	.	79.50	.	29.09	.	298346	298346

STRATUM=CANOPY BED=SOK

YEAR	BOTTOM AREA (HA) COBBLE	BOTTOM AREA (HA) KELP	FISH DENS 1000**3M COBBLE	FISH DENS 1000**3M KELP	ABUNDANCE COBBLE	ABUNDANCE KELP	ABUNDANCE TOTAL
1980	.	94.50	.	28.33	.	345399	345399
1981	.	81.00	.	39.44	.	412113	412113
1985	.	40.50	.	24.86	.	129898	129898
1986	.	22.70	.	59.58	.	174467	174467

AREAL EXTENT OF BEDS BASED ON SIDESCAN SONAR SURVEYS
FISH/KELP REGRESSION NOT USED TO MAKE FISH DENSITY ESTIMATES
REQUEST DR56 SAS KBABU883

KELP BED
NUM ABUNDANCE ESTIMATE
SPECIES = SENORITA

STRATUM=BOTTOM BED=SMK

	BOTTOM AREA (HA)		FISH DENS 1000**3M		ABUNDANCE		
YEAR	COBBLE	KELP	COBBLE	KELP	COBBLE	KELP	TOTAL
1980	32.40	69.00	12.93	30.07	6284.7	31126	37410
1981	72.10	31.10	16.96	39.44	18341	18398	36739
1985	65.60	69.10	9.18	21.36	9036.3	22136	31172
1986	54.70	79.50	4.19	9.74	3434.7	11609	15044

STRATUM=BOTTOM BED=SOK

	BOTTOM AREA (HA)		FISH DENS 1000**3M		ABUNDANCE		
YEAR	COBBLE	KELP	COBBLE	KELP	COBBLE	KELP	TOTAL
1980	47.20	94.50	4.27	9.92	3021.4	14068	17089
1981	68.60	81.00	5.39	12.54	5548.3	15235	20784
1985	96.70	40.50	8.21	24.71	11908	15009	26917
1986	97.90	22.70	10.99	20.77	16135	7072.6	23207

STRATUM=CANOPY BED=SMK

	BOTTOM AREA (HA)		FISH DENS 1000**3M		ABUNDANCE		
YEAR	COBBLE	KELP	COBBLE	KELP	COBBLE	KELP	TOTAL
1980	.	69.00	.	26.37	.	234723	234723
1981	.	31.10	.	17.51	.	70235	70235
1985	.	69.10	.	23.24	.	207185	207185
1986	.	79.50	.	17.79	.	182489	182489

STRATUM=CANOPY BED=SOK

	BOTTOM AREA (HA)		FISH DENS 1000**3M		ABUNDANCE		
YEAR	COBBLE	KELP	COBBLE	KELP	COBBLE	KELP	TOTAL
1980	.	94.50	.	11.92	.	145303	145303
1981	.	81.00	.	12.56	.	131209	131209
1985	.	40.50	.	15.55	.	81240	81240
1986	.	22.70	.	43.49	.	127362	127362

AREAL EXTENT OF BEDS BASED ON SIDESCAN SONAR SURVEYS
FISH/KELP REGRESSION NOT USED TO MAKE FISH DENSITY ESTIMATES
REQUEST DR56 SAS KBABU883

KELP BED
BIOMASS ABUNDANCE ESTIMATE (KG)
SPECIES = TOTAL

STRATUM=BOTTOM BED=SMK

YEAR	BOTTOM AREA (HA)		FISH DENS 1000**3M		ABUNDANCE		
	COBBLE	KELP	COBBLE	KELP	COBBLE	KELP	TOTAL
1980	32.40	69.00	5.44	10.66	2642.8	11036	13679
1981	72.10	31.10	6.39	12.53	6908.8	5843.3	12752
1985	65.60	69.10	3.65	7.15	3590.1	7414.9	11005
1986	54.70	79.50	4.55	8.92	3733.1	10638	14371

STRATUM=BOTTOM BED=SOK

YEAR	BOTTOM AREA (HA)		FISH DENS 1000**3M		ABUNDANCE		
	COBBLE	KELP	COBBLE	KELP	COBBLE	KELP	TOTAL
1980	47.20	94.50	14.97	29.35	10598	41603	52201
1981	68.60	81.00	9.13	17.90	9391.9	21744	31136
1985	96.70	40.50	5.13	6.41	7445.3	3892.8	11338
1986	97.90	22.70	3.40	11.84	4997.1	4032.8	9029.9

STRATUM=CANOPY BED=SMK

YEAR	BOTTOM AREA (HA)		FISH DENS 1000**3M		ABUNDANCE		
	COBBLE	KELP	COBBLE	KELP	COBBLE	KELP	TOTAL
1980	.	69.00	.	4.90	.	43654	43654
1981	.	31.10	.	7.16	.	28725	28725
1985	.	69.10	.	1.93	.	17242	17242
1986	.	79.50	.	2.64	.	27058	27058

STRATUM=CANOPY BED=SOK

YEAR	BOTTOM AREA (HA)		FISH DENS 1000**3M		ABUNDANCE		
	COBBLE	KELP	COBBLE	KELP	COBBLE	KELP	TOTAL
1980	.	94.50	.	2.72	.	33159	33159
1981	.	81.00	.	3.61	.	37726	37726
1985	.	40.50	.	1.46	.	7640.7	7640.7
1986	.	22.70	.	5.42	.	15857	15857

AREAL EXTENT OF BEDS BASED ON SIDESCAN SONAR SURVEYS
FISH/KELP REGRESSION NOT USED TO MAKE FISH DENSITY ESTIMATES
REQUEST DR56 SAS KBABU883

KELP BED
BIOMASS ABUNDANCE ESTIMATE (KG)
SPECIES = SENORITA

STRATUM=BOTTOM BED=SMK

YEAR	BOTTOM AREA (HA) COBBLE	BOTTOM AREA (HA) KELP	FISH DENS 1000**3M COBBLE	FISH DENS 1000**3M KELP	ABUNDANCE COBBLE	ABUNDANCE KELP	ABUNDANCE TOTAL
1980	32.40	69.00	0.39	1.38	187.55	1426.5	1614
1981	72.10	31.10	0.35	1.26	382.07	588.59	970.67
1985	65.60	69.10	0.17	0.62	169.91	639.19	809.10
1986	54.70	79.50	0.06	0.21	49.36	256.22	305.58

STRATUM=BOTTOM BED=SOK

YEAR	BOTTOM AREA (HA) COBBLE	BOTTOM AREA (HA) KELP	FISH DENS 1000**3M COBBLE	FISH DENS 1000**3M KELP	ABUNDANCE COBBLE	ABUNDANCE KELP	ABUNDANCE TOTAL
1980	47.20	94.50	0.17	0.61	119.98	857.93	977.91
1981	68.60	81.00	0.12	0.44	125.82	530.59	656.41
1985	96.70	40.50	0.32	0.81	467.53	489.22	956.75
1986	97.90	22.70	0.54	0.88	794.75	299.62	1094.4

STRATUM=CANOPY BED=SMK

YEAR	BOTTOM AREA (HA) COBBLE	BOTTOM AREA (HA) KELP	FISH DENS 1000**3M COBBLE	FISH DENS 1000**3M KELP	ABUNDANCE COBBLE	ABUNDANCE KELP	ABUNDANCE TOTAL
1980	.	69.00	.	1.66	.	14741	14741
1981	.	31.10	.	1.09	.	4363.5	4363.5
1985	.	69.10	.	1.34	.	11944	11944
1986	.	79.50	.	1.14	.	11688	11688

STRATUM=CANOPY BED=SOK

YEAR	BOTTOM AREA (HA) COBBLE	BOTTOM AREA (HA) KELP	FISH DENS 1000**3M COBBLE	FISH DENS 1000**3M KELP	ABUNDANCE COBBLE	ABUNDANCE KELP	ABUNDANCE TOTAL
1980	.	94.50	.	0.80	.	9783.9	9783.9
1981	.	81.00	.	0.78	.	8115.2	8115.2
1985	.	40.50	.	1.04	.	5452.5	5452.5
1986	.	22.70	.	2.71	.	7932.6	7932.6

AREAL EXTENT OF BEDS BASED ON SIDESCAN SONAR SURVEYS
FISH/KELP REGRESSION NOT USED TO MAKE FISH DENSITY ESTIMATES
REQUEST DR56 SAS KBABU883

This page intentionally left blank.

APPENDIX M

COMMENTS ON THE DIFFERENCES BETWEEN THE FINAL TECHNICAL REPORT AND THE CONTRACTOR'S FINAL REPORT.

While the same databases were used in the analyses performed in the two reports, the analyses did differ and, therefore, some of the results presented differ between the two reports. The major differences are discussed below.

One of the principal subjects addressed in both reports was the kelp density-fish density relationship. In general, similar results were found. However, the differences between the two reports arise primarily from the fact that the contractor (FISH) used the density of fish integrated over the entire water column as the variate regressed against kelp density. In the MRC report we treat the two depth strata separately. When combining the strata, which have very different volumes, the contribution of the density of fish in the water column greatly outweighs and obscures any effect on fish in the bottom strata.

A second difference between the reports concerns the estimate of fish abundance in the kelp beds in the vicinity of SONGS. FISH makes estimates of the total numbers in SOK in both the Before and After period. And, in doing so, follows the procedure outlined in the MRC report. However, the estimates in the two reports differ due to the use of different fish density-kelp density regression equations.

Unlike the MRC, FISH did not attempt to estimate the numbers lost (or gained) in SOK as a result of SONGS' operation. Nor did they estimate the changes in total numbers and biomass that occurred in SOK relative to those in SMK.

Another difference between the reports was the analysis of changes in fish density. FISH employed the BACIP design in their analysis. They sampled fish densities at the same locations in SOK and SMK in both the Before and After periods. They used only data collected at the sampling sites on the same day. However, since it was not possible to sample all three locations (SOKU, SOKD, and SMK) on the same day, BACIP comparisons were made as follows: A SOKU site was compared to SMK. The SOKD site was not compared to SMK but was compared to a *second* SOKU site. Therefore the subset of fish density data used by FISH was somewhat different from that used in the ANOVA presented in the MRC report. The data used in the SOKU-SMK comparison is virtually the same in both reports.

Another factor that enters into the analysis is that the kelp density changed from Before to After at several of the sites. This was particularly apparent at the sites used by FISH in the SOKU-SOKD comparison of densities. Kelp density at the SOKD site went from 27/100 m^2 in the Before to 16/100 m^2 in the After, while at the SOKU site the density changed from 13 to 5 /100 m^2. Thus the within SOK comparisons in fish density are confounded with pronounced changes in kelp density. In the MRC report, we have strived to compare fish densities between sites where kelp populations have behaved similarly.