

This report is the second quarterly report submitted in partial fulfillment of Research Contract No. 6S-1047 between the Department of Fish and Game and the Pacific Gas and Electric Company. Through this contract the Department of Fish and Game is to conduct ecological monitoring studies to determine what changes, if any, have occurred in the base line inventory of the marine biota with special reference to fish and to abalone conducted during 1970 and 1971.

Quarterly reports will be followed by annual reports. Full tables and species lists will be included in each annual report.

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DIABLO CANYON POWER PLANT SITE ECOLOGICAL STUDY  
QUARTERLY REPORT No. 2 1/

by

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ABSTRACT

During the period October 1 - December 31, 1973, Fall surveys of permanent subtidal stations were completed with one station being surveyed. We were unable to locate 3 subtidal stations.

Intertidal studies were initiated in November. A total of 12 random stations was surveyed.

Interviews were conducted with commercial abalone fishermen working between Pt. Buchon to Pecho Rock. We continued to monitor the sea otter herd foraging between Pt. Buchon and Lion Rock.

Progress was achieved in the abalone temperature tolerance studies when a successful spawning occurred.

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1/ Marine Resources Administrative Report 74-3, February 1974

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## INTRODUCTION

During the quarter we completed fall surveys of the permanent subtidal transects, began studies in the intertidal, began interviewing commercial abalone divers, and continued monitoring the sea otter herd located south of Point Buchon. A total of 53 man-days was spent at the site during the quarter.

## OPERATIONS

One permanent subtidal station was surveyed in October, but we were unable to survey three of the permanent transects due to boat breakdowns and rough ocean conditions. Counts of red abalone, abalone predators and competitors at subtidal Station 15 were very close to those obtained by Burge and Schultz in October 1971 (Table 1). In 1971, 6 red abalone, 4 *Cancer antennarius* and 212 *Strongylocentrotus franciscanus* were observed on the station; counts for the same animals in 1973 were 4, 5 and 289 respectively.

During this quarter, random intertidal stations were established in Diablo Cove and in an area about 2.5 km (1.6 miles) north of the cove (Figure 1). Diablo Cove, where the outfall is located, was divided into three discreet areas: North Diablo Cove Intertidal (NDCI), South Diablo Cove Intertidal (SDCI) and Diablo Point Intertidal (DPI). Each of the areas was divided into nine stations. The study area to the north, North Control Intertidal (NCI), is located adjacent to Field's Ranch property and consists of 20 stations. The method of study is the same as was established for the Mendocino studies (Gotshall, et al, 1973). Stations are chosen randomly and four  $\frac{1}{4} \text{ m}^2$  (2.7  $\text{ft}^2$ ) quadrats are sampled along a

TABLE 1. Comparative Counts of Selected Invertebrates at Subtidal Station 15 - Diablo Canyon - October 1971 and October 1973.

Species	1971 Count	1973 Count
<i>Haliotis rufescens</i>	6	4
<i>Cancer antennarius</i>	4	5
<i>Pycnopodia helianthoides</i>	3	0
<i>Strongylocentrotus franciscanus</i>	212	289
<i>Scorpaenichthys marmoratus</i>	0	2

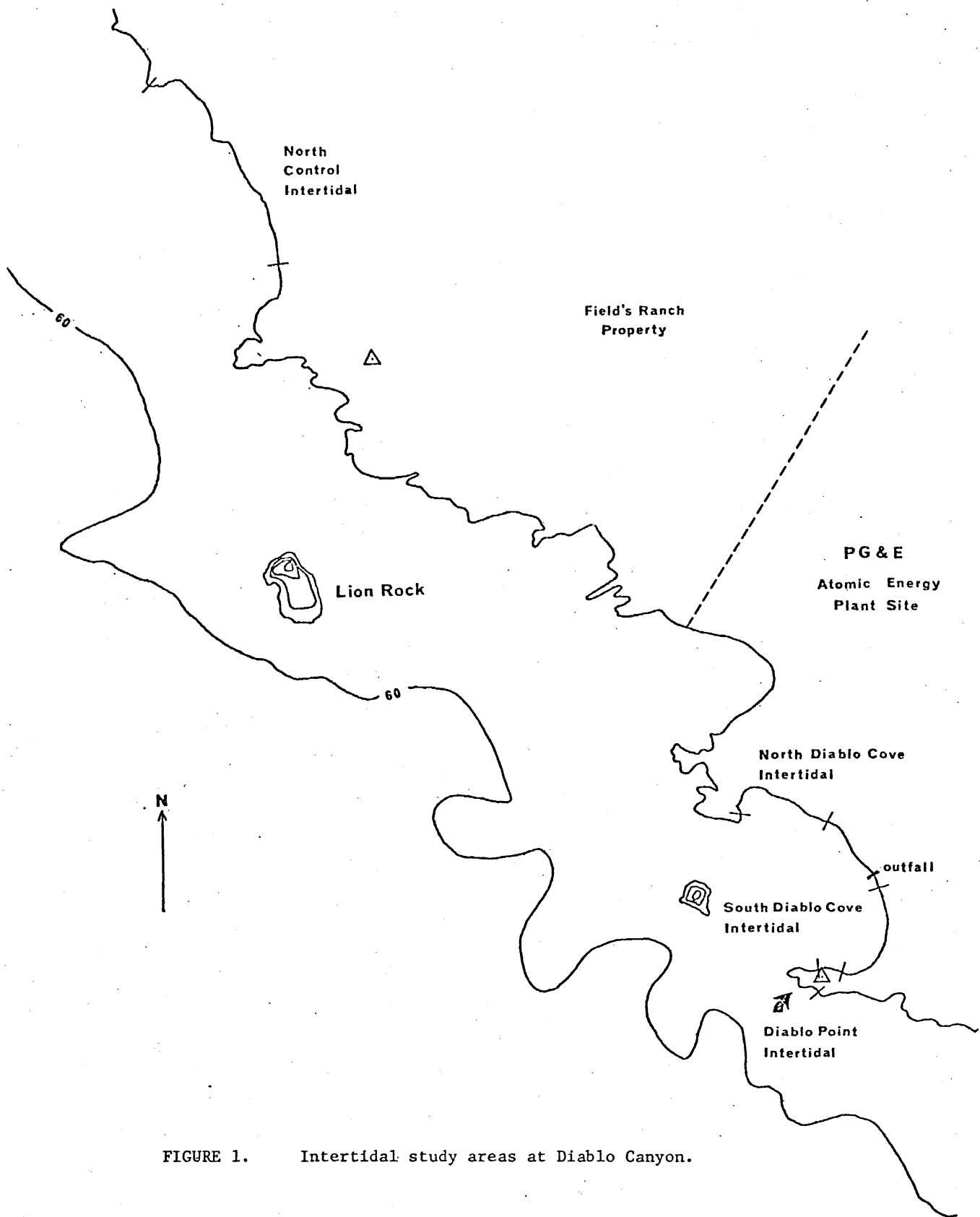


FIGURE 1. Intertidal study areas at Diablo Canyon.

linear 30 m (98 ft) transect. At each quadrat all macro-invertebrates are counted, all soft algae collected for later quantification, and the percent cover by articulated corallines and *Phyllospadix scouleri* estimated. Also, abalone are counted within one meter to either side, and along the total length, of the 30 m (98 ft) line.

A total of 12 intertidal stations was visited during the quarter: 9 in Diablo Cove and 3 in the North Control Area. The invertebrate data from these stations have been summarized (Table 2). The numbers of red and black abalone counted along the transects within the cove ranged from zero to 180 (Table 3). Thus far, black abalone have occurred with a mean of  $0.612/m^2$  and reds with a mean of  $0.147/m^2$  in the cove.

The algae collected from the quadrats are being worked up for biomass indices as time allows.

With the increase in commercial abalone diving in the Diablo Canyon area, we began interviewing commercial abalone divers to determine fishing areas and catch-per-unit-of-effort.

During the quarter we interviewed divers from 14 boats, their catch amounted to 966 red abalone. The average daily landing was 69 red abalone (Table 4). Most of the diving effort was focused on the area from Pecho Rock to Point Buchon.

Sea otters were counted at least once each week. Counts ranged from a low of 8 on October 22 to a high of 87-90 animals on August 20 (Table 5). Most of the otters that were feeding were eating red or black abalone. No otters have been observed during 16 surveys (July 20 through December 24, 1973) of the area between Lion Rock and Point San Luis.

TABLE 2. Summary of Invertebrate Numbers Found in ¼ m<sup>2</sup> Samples in the Four Study Areas During October 1, 1973 through December 31, 1973 - Diablo Canyon.

Species	NDCI			SDCI			DPI			NCI		
	Sum	Percent frequency	Mean	Sum	Percent frequency	Mean	Sum	Percent frequency	Mean	Sum	Percent frequency	Mean
COELENTERATA												
<i>Anthopleura elegantissima</i>							43	12.5	5.37			
<i>Anthopleura xanthogrammica</i>	1	8.3	0.08				14	75.0	1.75			
<i>Corynactis californica</i>							20	12.5	2.50	6	10.0	0.60
<i>Epiactis prolifera</i>	21	41.6	1.75	15	31.2	0.94						
MOLLUSCA												
Acmaeidae	3	16.6	0.25	5	12.5	0.31	26	37.5	3.25	93	50.0	9.3
<i>Aletes squamigerus</i>				2	6.2	0.12	1	12.5	0.12			
<i>Astraea gibberosa</i>										1	10.0	0.10
<i>Cadlina luteomarginata</i>							1	12.5	0.12			
<i>Fissurella volcano</i>	2	16.6	0.17	3	12.5	0.19						
<i>Haliotis cracherodii</i>	5	16.6	0.42				17	50.0	2.12	19	20.0	1.90
<i>Haliotis rufescens</i>										1	10.0	0.10
<i>Ischnochiton</i> sp.				1	6.2	0.06						
<i>Katharina tunicata</i>							3	25.0	0.37			
<i>Mopalia</i> spp.				3	18.7	0.19	11	50.0	1.37	3	30.0	0.30
<i>Mytilus californianus</i>							39	50.0	4.87	24	40.0	2.40

TABLE 2. (cont.)

Species	NDCI			SDCI			DPI			NCI		
	Sum	Percent frequency	Mean	Sum	Percent frequency	Mean	Sum	Percent frequency	Mean	Sum	Percent frequency	Mean
MOLLUSCA (cont.)												
<i>Nuttallina californica</i>				3	12.5	0.37	19	4.0	1.90			
<i>Rostanga pulchra</i>							2	10.0	0.20			
<i>Tegula brurmea</i>	9	33.3	0.75	21	37.5	1.31	11	62.5	1.37	7	30.0	0.70
<i>Tegula funebris</i>							30	60.0	3.00			
<i>Thais emarginata</i>	1	8.3	0.08				1	12.5	0.12	8	50.0	0.80
<i>Tonicella lineata</i>	2	16.6	0.17	3	12.5	0.19	4	25.0	0.50			
ARTHROPODA												
<i>Balanus</i> sp.	15	8.3	1.25				53	87.5	6.62			
<i>Cancer antennarius</i>				3	18.7	0.19						
<i>Idothea</i> sp.	1	8.3	0.08									
<i>Pollicipes polymerus</i>							60	12.5	7.50	50	30.0	5.00
<i>Pugetia producta</i>	6	25.0	0.50	18	56.2	1.12	1	12.5	0.12	4	20.0	0.40
<i>Pugetis richii</i>	3	8.3	0.25	4	18.7	0.25						
<i>Tetraclita squamosa</i>							48	37.5	6.00	18	20.0	1.80
ECHINODERMATA												
<i>Henricia leviuscula</i>	7	33.3	0.58	18	50.0	1.12				1	10.0	0.10
<i>Leptasterias</i> spp.	3	25.0	0.25	9	37.5	0.56	6	62.5	0.75	3	30.0	0.30



TABLE 2 (cont.).

Species	NDCI			SDCI			DPI			NCI		
	Sum	Percent frequency	Mean	Sum	Percent frequency	Mean	Sum	Percent frequency	Mean	Sum	Percent frequency	Mean
ECHINODERMATA (cont.)												
<i>Patiria miniata</i>	1	8.3	0.08	1	6.2	0.06						
<i>Pisaster ochraceus</i>							1	12.5	0.12			
<i>Pycnopodia hellanthis</i>	1	8.3	0.08									
<i>Strongylocentrotus purpuratus</i>	2	16.6	0.17	1	6.2	0.06	33	37.5	4.12	2	20.0	0.20
TUNICATA												
<i>Clavelina huntsmani</i>	1	8.3	0.08	3	6.2	0.19						
MEAN NUMBER OF ANIMALS/ $\frac{1}{4}$ m <sup>2</sup>			7.00			8.62			49.50			28.10
RANGE OF SAMPLES RELATIVE TO MLLW (FEET)		-0.8 to +2.0			-1.7 to +1.1			+0.4 to +3.7			-0.7 to +2.5	
TOTAL $\frac{1}{4}$ m <sup>2</sup> QUADRATS		12			16			8			10	

TABLE 3. Average Numbers and Frequencies of Two Species of Abalone Found Along 30 m transects in Diablo Cove.

Species	NDCI		SDCI		DPI	
	Percent freq.	$\bar{X}/m^2$	Percent freq.	$\bar{X}/m^2$	Percent freq.	$\bar{X}/m^2$
<i>Haliotis rufescens</i>	100	0.26	67	0.09	0	0.0
<i>Haliotis cracherodi</i>	100	1.08	67	0.06	100	0.87

TABLE 4. Summary of Commercial Abalone Fishery Interviews - Point Buchon to Point San Luis - October through December 1973.

Date	Numbers of boats sampled	Hours fished	Landings of red abalone		
			Number	Average weight	Size range (mm)
October 1, 1973	1	3.5	28	3.5	
October 4, 1973	1	--	29		
October 5, 1973	2	--	59	3.7	
October 9, 1973	1	6.5	50	3.9	
October 10, 1973	3	24.0	273	4.0	196 - 224
October 16, 1973	1	8.5	48	4.4	200 - 228
October 17, 1973	1	9.0	124	4.4	196 - 218
October 18, 1973	1	9.5	67	4.1	196 - 221
November 5, 1973	2	11.0	95	3.8	195 - 225
December 4, 1973	1	5.5	193		195 - 227
TOTALS	14		966		
MEANS		7.8	69.0	4.0	

TABLE 5. Summary of Sea Otter Counts and Feeding Habits -  
Point Buchon to Lion Rock - July through December 1973.

Date	Otter count	Number observed feeding				
		Abalone	Urchins	Crabs	Unid.	Misc.
July 16, 1973	26					
August 2, 1973	69	2			2	
August 6, 1973	56	4			1	
August 13, 1973	63	1				
August 20, 1973	87-90	4			1	
October 2, 1973	56	1				
October 8, 1973	48	1				
October 15, 1973	35	3	1	1	1	
October 22, 1973	8	2				
November 5, 1973	40	2	2			
November 14, 1973	38	1				
November 19, 1973	35-40					
November 26, 1973	49					
December 4, 1973	66					
December 11, 1973	40	1	2			
December 18, 1973	26					
December 28, 1973	36					

## ABALONE TEMPERATURE TOLERANCE STUDIES

A sample of adult red abalones was obtained from the Diablo Canyon region in October. Specimens from this sample exhibiting reproductive maturity, as evidenced by gonadal bulk, were placed in a separate reservoir and conditioned for spawning.

A successful spawning was achieved on November 30 at a temperature of 15.5C (59.9F). Developing embryos were collected at the 4 and 8 cell stage (approximately 2 to 3 hours post-fertilization). Cultures were established and maintained in 15 liter (4 gal) plastic containers at 10C, 15C and 20C (50F, 59F and 68F respectively).

Temperature tests were performed in duplicate series of finger bowls, each containing a final volume of 300 ml of filtered seawater. Test animal densities were calculated by the aliquot technique, affording an approximate equal number of test animals per unit volume, for each finger bowl. Instantaneous test temperatures were obtained by predetermination of the temperature of the seawater needed, by volume, to produce the desired test temperature when mixed with the test animal aliquot.

Test temperatures were selected at various elevations up to 11C (19.8F) above each acclimation temperature (10C, 15C or 20C) so as to encompass the maximum temperature elevations, above ambient, anticipated in Diablo Cove.

A series of temperature tolerance tests was conducted to simulate the entrainment time expected through the cooling water system planned for Diablo Canyon. These tests consisted of exposing test animals to temperature elevations for 1 minute. Immediately after 1 minute the test animals were returned to acclimation temperature water baths.

Observations of test animals were made at 2, 4, 6 and 8 hour intervals.

Observations were terminated after 48 hours.

Temperature tolerance tests were first accomplished with the embryos being acclimated at 15C (59F). These embryos had obtained the morula stage (16 to 32 cells: 6 to 7 hours old) when testing initiated. Test animals were exposed to temperature elevations up to 26C (78.8F).

No mortality was observed for the simulated entrainment time tests throughout the 48 hour observation period. However, long term (48 hour) elevated temperature exposures did cause some mortalities.

Aberrant embryo development was noted after a 6 hour exposure to temperatures of 25C and 26C (77F and 78.8F respectively). Normal development did not proceed to the trochophore larval stage at 26C (78.8F), although the bizarre forms that resulted did exhibit ciliary movement and locomotion. At 25C (77F), 17% of the test animals obtained a normal trochophore stage after 10 hours' exposure; however, no animals developed to the veliger larval stage, and all test animals succumbed after a 42 hour exposure. Test temperatures of 23C (73.6F) and below did not impair larval development nor effect any mortality (Table 7).

Test animals acclimated at 20C (68F) had reached the veliger larval stage, and were approximately 56 hours old when testing began. In this series of temperature tolerance tests the larvae were exposed to a maximum temperature of 31C (87.8F). Unfortunately the tests had to be terminated after 26 hours due to an error made in the aliquot larval sample estimate. Culture densities were approximately 3 to 4 times the desired number, causing a degradation in water quality, and larval mortality.

No mortality was observed for veliger stage larvae, acclimated at 20C (68F), and subjected to the simulated entrainment test, throughout the 26 hour observation period. However, long term (26 hour) elevated temperature exposure tests did effect mortality at the higher temperature elevations.

TABLE 7. Percent Survival of Embryonic Stage, Red Abalone, *Haliotis rufescens*, Acclimated at 15 C and Subjected to Instantaneous Elevated Temperature Shock.

Test temp. °C	No. of test animals	Percent survival									
		2	6	10	18	24	30	36	42	48	
26	100-150	100	*(100)	(86)	(75)	(75)	(50)	0	0	0	0
25	100-150	100	60(40)	17(83)	(100)	(100)	(80)	(40)	(5)	0	0
23	100-150	100	100	100	100	100	100	100	100	100	100
20	100-150	100	100	100	100	100	100	100	100	100	100
18	100-150	100	100	100	100	100	100	100	100	100	100
15	100-150	100	100	100	100	100	100	100	100	100	100

\*Parentheses denote aberrant development

After a 2 hour exposure to temperatures of 30C and 31C (86F and 87.8F respectively), test animals were extremely weak and sluggish, exhibited feeble ciliary movement, and remained on the bottom of their culture bowls. Test animals held for a similar period of time at 27C (80.6F) exhibited fair ciliary movement, but also remained on the bottom of their culture bowls. At 25C (77F) and lower temperatures the test animals were active and swimming.

Mortality ensued after a 10 hour exposure at 31C (87.8F). All test animals held at this temperature died after a 14 hour exposure. It took 22 hours for this condition to obtain at a temperature of 30C (86F) (Table 8).

Veliger stage larvae acclimated at 10C (50F) were approximately 125 hours old when temperature elevation tests began. The larvae had not yet obtained the benthonic, creeping stage, due to the depressed culture temperature.

Test animals were exposed to maximum temperature elevations of 21C (69.8F) for 48 hours. However, no mortality was observed throughout the observational period for either the short term (1 minute entrainment simulation time at maximum temperature elevation), or the long term (48 hour) exposure.





MAN-DAYS SPENT AT DIABLO CANYON POWER PLANT SITE

October 1 - December 31, 1973

Subtidal Surveys:

October 11 - 12

Participants: Gotshall, Laurent, Benech

December 10

Participants: Gotshall, Laurent, Farrens

Intertidal Surveys:

October 28 - 29

Participants: Gotshall, Laurent, Benech

November 9 - 12

Participants: Gotshall, Laurent, Benech

December 7 - 10

Participants: Gotshall, Laurent, Farrens, Benech

December 20 - 23

Participants: Benech, Farrens

Commercial Abalone Fishery Surveys:

October 1, 4, 5, 9, 10, 16, 17, 18

November 5

December 4

Participants: Benech

Sea Otter Surveys:

October 2, 8, 15, 22

November 5, 7, 14, 19, 26, 29

December 4, 11, 18, 24, 28

Participants: Benech

Total Man-Days during quarter	181*
Total Man-days at site	53
Boat-Days lost to breakdown	7
Total stations surveyed	13
Travel time Man-Days	10
Boat time (hours)	6.8
Laboratory time Man-Days	118

\*Non-project personnel Man-Days not included in totals, and totals do not include time spent on abalone temperature tolerance studies.

PROJECT PERSONNEL

Daniel W. Gotshall	Senior Marine Biologist-Project Leader
Laurence L. Laurent	Associate Marine Biologist
Margaret M. Hughes	Stenographer II
Suzanne V. Benech	Seasonal Aid
John R. Glabe	Seasonal Aid
Gary D. Farrens	Seasonal Aid

NON-PROJECT PERSONNEL

Earl E. Ebert	Senior Marine Biologist Marine Resources Region
E. E. Martindale	Lieutenant, Fish and Game boat "RAINBOW"
Kenneth Boettcher	Fish and Game Warden