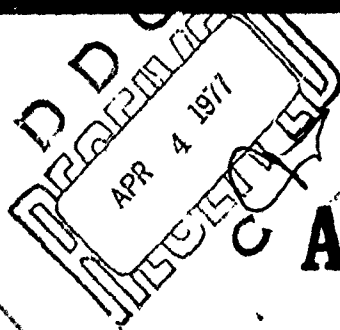
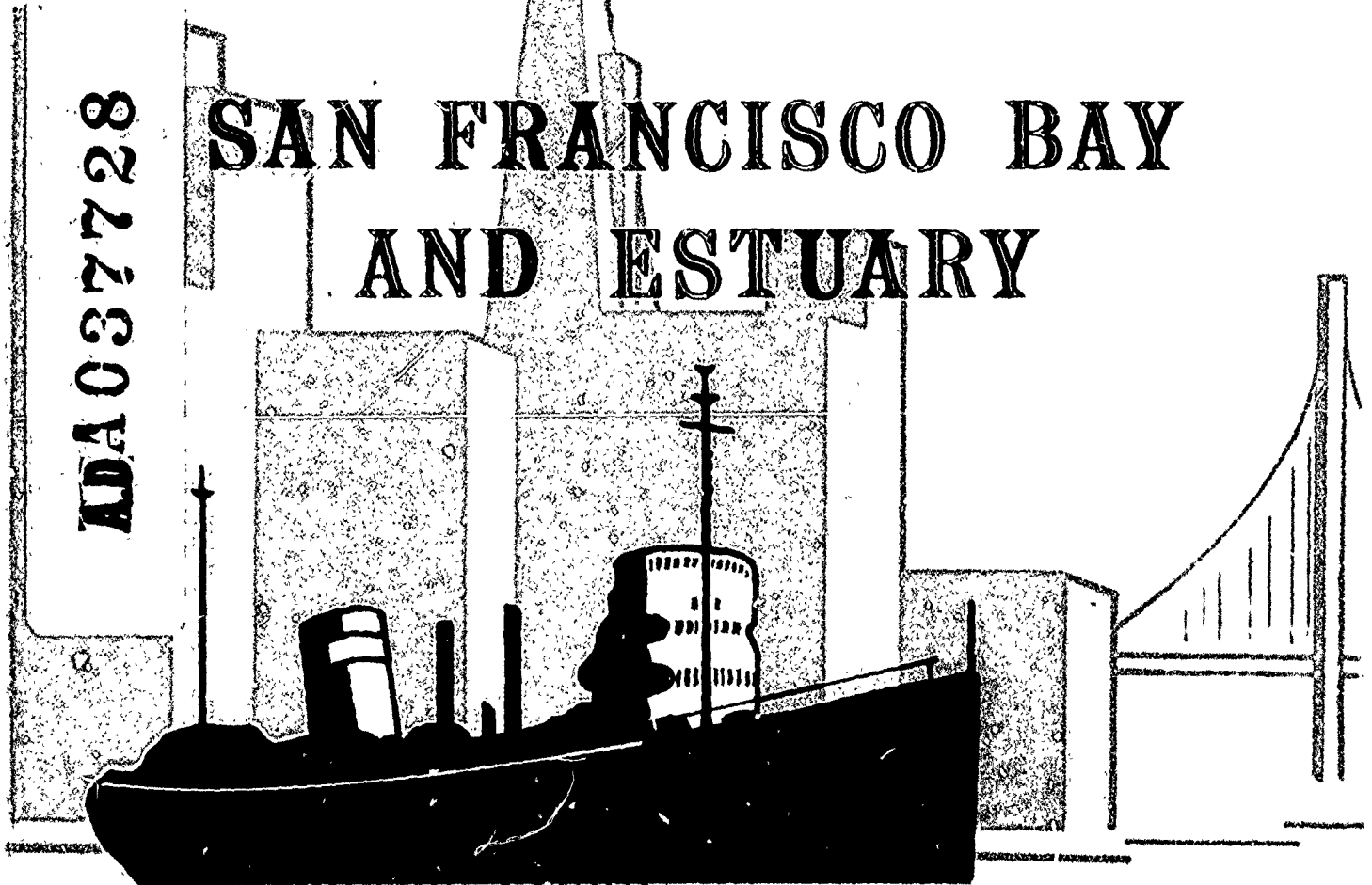


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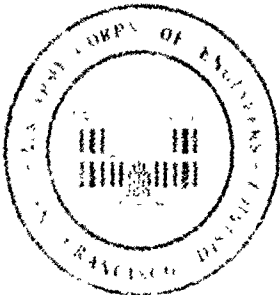
APPENDIX D

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BIOLOGICAL COMMUNITY

AUGUST 1975

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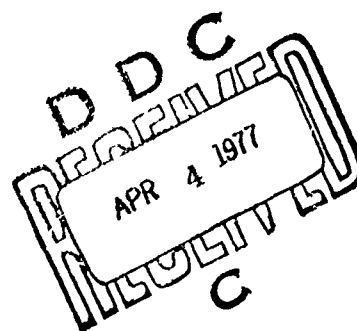
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DREDGE DISPOSAL STUDY SAN FRANCISCO BAY AND ESTUARY

APPENDIX D

BIOLOGICAL COMMUNITY STUDY

August 1975



U.S. Army Engineer District, San Francisco
Corps of Engineers
100 McAllister Street
San Francisco, California 94102

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FOREWORD

In April 1972, the San Francisco District of the United States Army Corps of Engineers initiated a three and one-half year \$3 million study to quantify the impact of dredging and dredged material disposal operations on the San Francisco Bay and Estuarine environment. The study is generating factual data, based on field and laboratory studies needed for the Federal, State and local regulatory agencies to evaluate present dredging policies and alternative disposal methods.

The study is set up to isolate the questions regarding the environmental impact of dredging operations and to provide answers at the earliest date. The study is organized to investigate (a) the factors associated with dredging and the present system of aquatic disposal in the Bay, (b) the condition of the pollutants (biogeochemical), (c) alternative disposal methods, and (d) dredging technology. The study elements are intended first, to identify the problems associated with dredging and disposal operations and, second, to address the identified problems in terms of mitigation and/or enhancement. The division into separate but inter-related study elements provides a greater degree of expertise and flexibility in the Study.

This report presents the findings of Appendix D, Biological Community. The overall study will be the basis for preparation of a composite Environmental Impact Statement for Dredging Activities in San Francisco Bay System. A draft final report on the entire study is scheduled for completion in December 1975.

The following is an index of appendices to be published in the Dredge Disposal Study:

<u>APPENDIX</u>	<u>REPORT</u>	<u>DATE PUBLISHED</u>
FINAL REPORT		
A	Main Ship Channel (San Francisco Bar)	June 1974
B	Pollutant Distribution	
C	Water Column (Water Column- Oxygen Sag)	
D	Biological Community	August 1975
E	Material Release	
F	Crystalline Matrix	July 1975
G	Physical Impact	July 1975
H	Pollutant Uptake	
I	Pollutant Availability	
J	Land Disposal	October 1974
K	Marsh Development	
L	Ocean Disposal	
M	Dredging Technology	

CONVERSION FACTORS

If conversion from the Metric to the British system is necessary, the following factors apply:

LENGTH

1 kilometer (km) = 10^3 meters = 0.621 statute miles = 0.540 nautical miles
1 meter (m) = 10^2 centimeters = 39.4 inches = 3.28 feet = 1.09 yards = 0.547 fathoms
1 centimeter (cm) = 10 millimeters (mm) = 0.394 inches = 10^4 microns (μ)
1 micron (μ) = 10^{-3} millimeters = 0.000394 inches

AREA

1 square centimeter (cm²) = 0.155 square inches
1 square meter (m²) = 10.7 square feet
1 square kilometer (km²) = 0.386 square statute miles = 0.292 square nautical miles

VOLUME

1 cubic kilometer (km³) = 10^9 cubic meters = 10^{15} cubic centimeters = 0.24 cubic statute miles
1 cubic meter (m³) = 10^6 cubic centimeters = 10^3 liters = 35.3 cubic feet = 264 U.S. gallons = 1.308 cubic yards
1 liter = 10^3 cubic centimeters = 1.06 quarts = 0.264 U.S. gallons
1 cubic centimeter (cm³) = 0.061 cubic inches

MASS

1 metric ton = 10^6 grams = 2,205 pounds
1 kilogram (kg) = 10^3 grams = 2.205 pounds
1 gr (g) = 0.035 ounce

SPEED

1 knot (nautical mile per hour) = 1.15 statute miles per hour = 0.51 meter per second
1 meter per second (m/sec) = 2.24 statute miles per hour = 1.94 knots
1 centimeter per second (cm/sec) = 1.09 feet per second

TEMPERATURE

Conversion Formulas

$$^{\circ}\text{C} = \frac{^{\circ}\text{F} - 32}{1.8} \qquad ^{\circ}\text{F} = 1.8(^{\circ}\text{C}) + 32$$

PREFACE

The Biological Community Study was designed to expand present knowledge of the resident biota in San Francisco Bay with specific attention to areas which are or have been dredged or used for material disposal. The study was initiated with a preliminary survey in March 1973 to establish sampling locations and procedures for use in a year-long investigation. The objective of the year-long survey (September 1973 to June 1974) was to identify the indigenous infauna at selected stations and to document numerical fluctuations resulting from seasonal changes and interim dredging and disposal operations. A secondary objective of the investigation was to examine the biological and physical-chemical data (sediment and water) obtained during the survey to determine if biotic-abiotic relationships might exist.

The results of the initial surveys of the study were used by other investigators (Physical Impact, Appendix G; and Pollutant Uptake, Appendix H) to help in their selection of significant species in project areas for use in their studies. Additionally the results will be used in Environmental Impact Statements for fauna lists and directing any further studies of dredging and disposal impacts. The report also contains literature reviews of previous benthic surveys in the Bay and the toxicity of selected heavy metals.

Sections in the report (methods of heavy metal analyses, turbidity determinations and particle size evaluation) point out the difficulty of comparing measurements of chemical-physical parameters because of variability in techniques used. Methodology can be influenced by the availability of equipment and/or the investigator's preference for certain techniques because of project objectives.

The statistical analyses of the biotic-abiotic relationships, although interesting, cannot be interpreted absolutely. There are contradictions between what the analyses showed and what was observed in the field (e.g., the analyses found high salinity to be correlated with small populations where in the field the inverse was found to be true).

The results of this investigation will be integrated with the results for other biological (Physical Impact, Appendix G; Pollutant Uptake, Appendix H; and Pollutant Availability, Appendix I) and physical-chemical (Water Column, Appendix C; and, Crystalline Matrix, Appendix F) studies to evaluate the impact of dredging and disposal operations in San Francisco Bay.

ERRATA

Page xv, Nomenclatural Synonymies:

Spiophanes fimbriata ≠ *S. missionensis* ≠ *S. berkeleyorum*.

These names are not synonymous, but are names of three different species. For this report, however, only *S. berkeleyorum* applies. The other two species were not found during the study; rather, they were misidentifications. The names listed as synonymous are being used interchangeably in this report.

Page 6, Table 1:

ALC Alcatraz disposal site 37°49'27" (lat) 122°25'05" (long)

not 37°40'27" (lat) 122°25'55" (long)

Final Report

May 1975

**SAN FRANCISCO BAY BENTHIC
COMMUNITY STUDY
Technical Evaluation**

By: DAVID H. W. LIU
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CONTRACT DACW 07-74-C-0005

SRI Project LSU-2894 ✓

Approved by:

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Life Sciences Division

ABSTRACT

SRI conducted a census of the benthic macrofauna in three dredged channels and four dredged-material disposal areas in San Francisco Bay in March, September, and December 1973 and in March and June 1974. During each of these periods, selected physical and chemical properties of the water and sediment were measured.

At Mare Island Strait, we established one sampling station in the dredged channel and another in the undredged portion of the Strait. At the Carquinez Strait disposal site, we fixed one station at the center of the site and another at the northern edge. Two stations each also were established at the South Bay disposal site and Redwood City Harbor. In March 1973, immediately after the first census, we had about 5,000 yd³ of sediment transferred from one of the Redwood City Harbor stations to one of the South Bay disposal-site stations; no dredging or disposal activity occurred in either area during the remainder of the study.

Sediment from Mare Island Strait and the Carquinez Strait disposal site usually was inhabited by fewer taxa than sediment from other dredged channels or dredged-material disposal sites and oligochaetes predominated. At both sites, water salinity was usually low, turbidity was usually high, and other water quality characteristics were variable.

At different sampling times, the benthic animal population at the undredged portion of Mare Island Strait was about 2 to 300 times larger than that at the dredged portion of the Strait. At both areas, the largest number of animals was collected in September 1973.

The total number of taxa and specimens collected from the "disturbed," centrally located area of the Carquinez Strait disposal site and from the "undisturbed" area located at the northern edge differed little in September 1973. However, during every other

sampling period, the population at one of these areas was 4 to 7 times larger than that at the other. The population at the disturbed area peaked in June 1974, but, at the undisturbed area, it peaked in September 1973.

The largest number of taxa inhabited sediment from Oakland Inner Harbor, the Alcatraz disposal site, and the Hunters Point disposal site. At these Central Bay locations, the average water salinity was higher and the average water temperature was lower than at the other areas studied.

The largest total number of organisms was collected at Oakland Inner Harbor, where the animal population comprised principally polychaetes, oligochaetes, and molluscs. The density of the population was at least twice that of any other area during every sampling period except during June 1974, when the population decreased to 20% of that recorded in March 1974. The largest number of animals was collected in December 1973. The sediment at Oakland Inner Harbor contained very high levels of total sulfide and heavy metals at all times. The population decline in June corresponded to a near doubling of the sediment zinc concentration.

Most of the taxa found at the Alcatraz disposal site appeared to be transient types. About 85% of the total number of specimens were collected in September 1973, and about 81% of these specimens were Hesionura sp. In March of both years, the sediment was almost devoid of benthic animals.

The Hunters Point disposal site was inhabited primarily by arthropods and polychaetes. The largest number of animals was collected in September 1973. At this station, a little over half the total number of animals collected during the study were the arthropod Ampelisca milleri.

The water temperature in the southern area of San Francisco Bay averaged about one degree higher than at other areas studied; water salinity was intermediate; and sediment sulfide levels were relatively high. The South Bay disposal area was inhabited primarily by the arthropod Ampelisca milleri, the polychaete Exogone lourei, and various oligochaetes. In March 1973, before about 5,000 yd³ of dredged sediment was disposed there, Station SB-A

was inhabited by fewer animals and taxa than the undisturbed station (SB-B). In September 1973, the population at SB-A was larger and more diverse than at SB-B. This picture reversed repeatedly in subsequent sampling months and did not appear to correspond to changes in the physical or chemical characteristics of the water or sediment.

Before sediment was removed from Station RCH-A at Redwood City Harbor, the benthic animal population was smaller and less diverse than at Station RCH-B, the control. During the next sampling period in September, the population at the dredged station increased by 124%, declined through March 1974, and peaked in June 1974. The population at the control station increased continuously between March 1973 and June 1974, but, the total number of animals collected was only about 57% of that collected at the dredged area. These differences and changes did not appear to correspond to any changes observed in the physical or chemical characteristics of the water or sediment.

Through analysis of regression coefficients obtained through application of the least-squares method, we concluded that the underlying relations among biological and environmental variables are complex and that additional field and laboratory studies would be required for thorough identification and understanding of such relationships.

The analysis did reveal some interesting trends. When considered separately, high water salinity and sediment mercury and sulfide concentrations were associated with small populations and low animal diversity; and high dissolved oxygen, turbidity, and sediment zinc and clay content were associated with large populations and great diversity of animals.

The analysis also indicated that the sediment at Mare Island Strait and the Carquinez Strait disposal site was less well populated than the sediment from Redwood City Harbor and the South Bay disposal site and that, at these four study areas, sediment at the disturbed stations tended to have less life than that from the undisturbed stations.

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NOMENCLATURAL SYNONYMIES

Scientific names assigned to organisms occasionally are changed, and sometimes taxonomists disagree on the proper name for a given organism. Listed below are names that we believe are synonymous. All the names listed are used in this report. We considered it improper to change any of the names submitted to us by our consulting taxonomists or to change the names listed in the literature, even though they referred to the same animal.

The list below may be incomplete. It was constructed after discussion with our consulting taxonomists, and other taxonomists may not agree with this list.

- Polychaeta
 - Trochochaeta multisetosum = Disoma multisetosum = D. franciscana.
 - Dorvillea annulata = Schistomeringus longicornis.
 - Nerine cirratulus = Scoelelepis squamata.
 - Spiophanes fimbriata = S. missionensis = S. berkeleyorum.
- Arthropoda
 - Crago franciscorum = Crangon franciscorum.
- Mollusca
 - Ostrea gigas = Crassostrea gigas.
 - Ostrea virginica = Crassostrea virginica.
 - Venerupis phillipinarum = Tapes japonica = T. semidecussata = T. phillipinarum = T. decussatus = Venus japonica.
 - Muculus senhousia = Modiolus senhousia.
 - Macoma balthica = Macoma inconspicua.

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We thank the taxonomic specialists who identified the benthic fauna collected during this study. These specialists were William Light of the California Academy of Sciences, who identified all the polychaetes and miscellaneous phyla of the preliminary survey and of Survey 1; Dr. Donald Reish and Michael Martin of California State University (Long Beach), who worked on the polychaetes and miscellaneous phyla collected during Surveys 2 through 4; Penny Pinter of the University of California, Berkeley, who was responsible for identifying all specimens in the phylum Ectoprocta; Barry Roth, California Academy of Sciences, who was in charge of identifying the molluscs; Ernest Iverson, also of the Academy, who identified the isopods, copepods, and tanaids collected during the preliminary survey; and John Chapman of the University of California, Berkeley, who identified all amphipods and miscellaneous arthropods collected during the investigation.

We also thank the following individuals who performed the tedious task of preliminary identification and counting of the animals after separating them from the washed debris: Karla Spangenberg, Martha Hill, Kathryn Storch, Katharine Jefferts, Robert Fish, Peter Busher, Thomas Adams, Daniel Ituarte, Dennis Tajiri, David Van Tresca, Janet Root, Michael Panietz, Dennis Leong, Janet Cross, Taffy Stewart, and Stewart Rowe. We also thank Christine Jong of the Moss Landing Marine Laboratory, who, because of her expertise in polychaete taxonomy, provided the taxonomic specialists with well-identified specimens that usually only required confirmation; Jean M. Lee and Howard Bailey for their assistance in organizing and evaluating the data; and Lorraine Watson for her help in the analysis of heavy metals.

INTRODUCTION

The benthic community study described herein is part of the Dredge Disposal Project sponsored by the Corps of Engineers, San Francisco District, to determine the environmental impact of dredging and disposal operations in San Francisco Bay.

The objective of the benthic community study was to collect "baseline" information on sediment-dwelling animals in three ship channels maintained by the Corps of Engineers and in four federally authorized disposal areas for dredged material in San Francisco Bay and Estuary. This information should provide a basis for evaluating future changes in the distribution and abundance of benthic animals and in certain physical and chemical properties of the water and sediment in these areas.

During the study, we collected replicate sediment and water samples from 11 sampling stations. The macrobenthic animals were removed from the sediment samples, identified, and counted. Temperature, pH, total sulfide content, heavy-metal content, and grain-size distribution were determined for the sediment samples; and the water samples were analyzed for temperature, salinity, dissolved oxygen content, total sulfide content, pH, and turbidity. We attempted to determine whether relationships existed between the physicochemical factors of the environment and the distribution and abundance of major animal groups.

In addition, we reviewed and summarized data from previous benthic-animal studies conducted in San Francisco Bay and data on the effects of heavy metals on benthic species found in the Bay.

The SRI study was performed in two phases, each under a separate contract. The principal objective of the preliminary phase (Contract No. DACW07-73-C-0059) was to establish the sampling stations, evaluate sampling and analytical methods, and provide the Corps of Engineers with an inventory of benthic species from which

Introduction

to select types suitable for other laboratory studies planned for the Dredge Disposal Project. Field operations for the preliminary phase were performed in March 1973.

The definitive phase of the study was performed under Contract No. DACW07-74-C-0005. Field operations for this phase of the study were performed at three-month intervals between September 1973 and June 1974.

This report presents the results of both phases of the study. A literature review of previous benthic community studies and of the effects of heavy metals on benthic animals reportedly found in the Bay also is incorporated. The appendix, which contains the raw data, is available under separate cover.

STUDY APPROACH

Study Areas

Figure 1 shows the three ship channels and four disposal sites studied. The channels are maintained almost exclusively by the Corps of Engineers, and the disposal sites are used by the Corps of Engineers as well as by a number of private dredging companies.

Mare Island Strait is located in the tidewater of the Napa River. Because of heavy shoaling, the ship channel located along the western shore is dredged frequently, and the average volume of dredged material removed from the area is about 2,500,000 yd³/yr.

Oakland Inner Harbor, located along the eastern shore of the central portion of San Francisco Bay, also is maintained heavily. About 500,000 yd³ of sediment is removed yearly from the inner and outer harbor.

Located along the western shore of the southern portion of the bay, Redwood City Harbor is dredged less frequently than the other two ship channels, about 350,000 yd³ of sediment being removed annually.

The Carquinez Strait disposal site is located along the southern tip of Mare Island. It receives most of the material removed from Mare Island Strait as well as material dredged from various adjacent, privately owned and maintained ship and boat docking areas.

The Alcatraz disposal site, located just south of Alcatraz Island, probably receives more dredged material than any other disposal site in the bay. The site is located over a deep (160-ft) depression and receives dredged material from numerous areas.

Study Approach
Study Areas

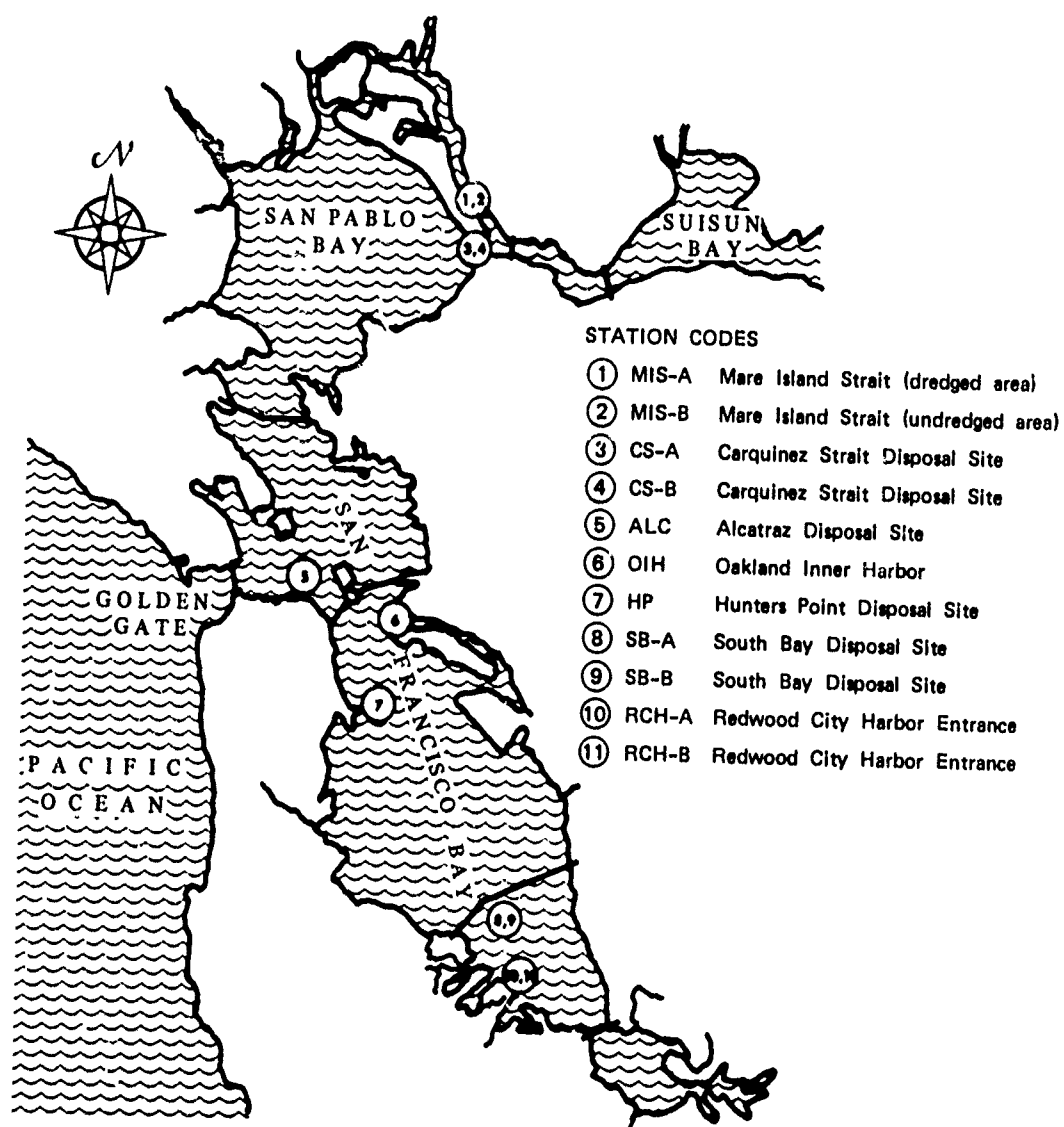


FIGURE 1 LOCATION OF SAMPLING STATIONS IN SAN FRANCISCO BAY

Study Approach Sampling Stations

The Hunters Point disposal site is used infrequently. According to the Corps of Engineers, the last date of authorized use was March 1966. The South Bay disposal area, located south of the San Mateo bridge, is no longer used for disposal of dredged material.

Sampling Stations

Table 1 presents the location of the 11 sampling stations, the codes assigned to them, and the approximate depth at the sites. All stations, except the Alcatraz disposal site (Station ALC), were established during the preliminary phase of the study. The Corps of Engineers was most interested in obtaining information on the benthic fauna and the physical and chemical characteristics of the sediment and water from the deepest (160-ft) portion of the Alcatraz disposal site. However, our sampling efforts during the preliminary phase were unsuccessful because the boat could not be anchored in such deep waters. Hence, for the definitive phase of the study, we used a shallower (60-ft) sampling station near the western edge of the disposal site.

Because of the considerable dredging in the Mare Island Strait ship channel and disposal activity at the Carquinez Strait disposal site, we established two stations in each of these areas to determine whether the benthic communities or the physical and chemical characteristics of the sediment differed in disturbed and relatively undisturbed portions of the two areas. Thus, in Mare Island Strait, Station MIS-A was established in the center of the dredged channel, and Station MIS-B was established at a point along the eastern, undredged portion of the strait. At the Carquinez disposal site, Station CS-A was located near the center of the disposal area, and Station CS-B was established near the northern edge.

We established two stations also at the South Bay disposal site and at Redwood City Harbor so as to determine whether the benthic animals were affected by dredging or by disposal of dredged material. Stations SB-A and SB-B at the South Bay disposal site and Stations RCH-A and RCH-B at Redwood City Harbor were surveyed a total of five times during the investigation, as were all other stations. However, a few days after we collected samples from these four stations, we had the hopper dredge "Biddle" remove about

Study Approach
Sampling Stations

Table 1
LOCATION AND DESCRIPTION OF SAMPLING STATIONS

Station Code	Study Area	Station Location			Depth (ft)
MIS-A	Mare Island Strait ship channel	38° 05' 38"	122° 15' 33"	(long.)	30-36
MIS-B	Mare Island Strait, eastern shore	38° 05' 42"	122° 15' 28"	(long.)	20-36
CS-A	Carquinez Strait disposal site	38° 03' 49"	122° 15' 50"	(long.)	48-50
CS-B	Carquinez Strait disposal site	38° 03' 57"	122° 15' 50"	(long.)	40-48
ALC	Alcatraz disposal site	37° 40' 27"	122° 25' 55"	(long.)	58-67
OIH	Oakland Inner Harbor ship channel	37° 20' 46"	122° 19' 04"	(long.)	30-38
HP	Hunters Point disposal site	37° 44' 15"	122° 20' 30"	(long.)	45-58
SB-A	South Bay disposal site	37° 34' 05"	122° 12' 33"	(long.)	40-42
SB-B	South Bay disposal site	37° 34' 47"	122° 13' 45"	(long.)	30-38
RCH-A	Redwood City Harbor entrance channel	37° 33' 03"	122° 11' 40"	(long.)	24-47
RCH-B	Redwood City Harbor entrance channel	37° 32' 27"	122° 11' 32"	(long.)	24-36

Study Approach
Sampling Schedule

5,000 yd³ of sediment from Station RCH-A and transfer it to Station SB-A. No dredging or disposal activity occurred in the vicinity of the four stations thereafter.

Sampling Schedule

Sediment and water samples were collected from each station at five different times during the period of performance. The first samples were collected in March 1973 during the preliminary phase. The other collections were conducted in September 1973, December 1973, March 1974, and June 1974 during the definitive phase.

Table 2 presents the day of the month, time of day, and the time of high and low tides for each survey. The sampling times are the times at which sampling was begun. In most instances, the samples at a given station were collected within about 30 minutes. The time of high and low tide was corrected for points in the Bay closest to the sampling station. The reference point for stations in Mare Island Strait and Carquinez Strait was the Mare Island Strait entrance. Alcatraz Island, Oakland Harbor (Grove Street), Point Avisadero, and the Redwood Creek entrance were reference points for stations at the Alcatraz disposal site, Oakland Inner Harbor, the Hunters Point disposal area, and Redwood City Harbor, respectively. Tide information for 1973 was supplied by tide tables of the U.S. Department of Commerce, Coast and Geodetic Survey; we obtained 1974 tide information from tide tables of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

Except where indicated in Table 2, the tide times are for the day of sample collection. Tide times were selected to bracket the sampling time. In the table, high tide occurring earlier in the day than low tide indicates an outgoing tide, and high tide occurring later in the day than low tide indicates an incoming tide.

Study Approach Sampling Schedule

Table 2
SAMPLING SCHEDULE AND TIME OF HIGH AND LOW TIDES RELATIVE TO SAMPLING TIME
(Sampling Time in Parentheses)

Station	Survey											
	P			1			2			3		
	(March 1973)			(Sept. 1973)			(Dec. 1973)			(March 1974)		
	Date	Tide*		Date	Tide		Date	Tide		Date	Tide	
	(Time)	High	Low	(Time)	High	Low	(Time)	High	Low	(Time)	High	Low
MIS-A	3/14	2309	1611	9/25	1327	1921	12/17	2022	1423	3/6	1127	1801
	(1718)			(1722)			(1615)			(1610)		
MIS-B	3/14	2309	1611	9/28	1503	0838	12/17	2022	1423	3/6	1127	1801
	(1744)			(1145)			(1643)			(1705)		
CS-A	3/14	0917	1611	9/25	1327	1921	12/17	2022	1423	3/6	1127	1801
	(1345)			(1405)			(1525)			(1450)		
CS-B	3/14	0917	1611	9/25	1327	1921	12/17	2022	1423	3/6	1127	1801
	(1600)			(1515)			(1450)			(1410)		
ALC	3/19	1214	1748	9/24	1133	0430	12/18	0647	1346	3/7	1043	1743
	(1435)			(1100)			(1235)			(1100)		
OIH	3/21	1411	0730	9/20	0833	1252	12/4	0707	1339	3/4	0805	1435
	(1258)			(1030)			(0955)			(1140)		
HP	3/21	1416	1915	9/20	0838	1257	12/4	0712	1344	3/4	0805	1440
	(1516)			(1230)			(1110)			(1315)		
SB-A	3/7	1441	0810	9/19	0809	1207	12/3	0716	1333	3/5	0953	0844
	(1320)			(1015)			(1145)			(0910)		
SB-B	3/7	1441	0810	9/19	0809	1207	12/3	0716	1333	3/5	0953	0844
	(1625)			(0905)			(1100)			(1000)		
RCH-A	3/7	1441	0810	9/19	0809	1207	12/3	0716	1333	3/5	0953	0844
	(1100)			(1125)			(1310)			(1105)		
RCH-B	3/7	1441	0810	9/19	0809	1207	12/3	0716	1333	3/5	0953	0844
	(1542)			(1240)			(1350)			(1155)		

* Sampling start time (see text).

† Corrected time (see text).

‡ Time given extended into the following day.

Study Approach
Sampling Procedures

Sampling Procedures

During the preliminary phase of the study, we collected sediment samples from all stations with the remotely controlled, 0.12-m² modified Petersen grab shown in Figure 2a. We also used diver-operated core samplers, shown in Figure 2b, at Stations OIH and HP. We used these two types of sampling devices to compare their performance and select one for use in the definitive phase of the study.

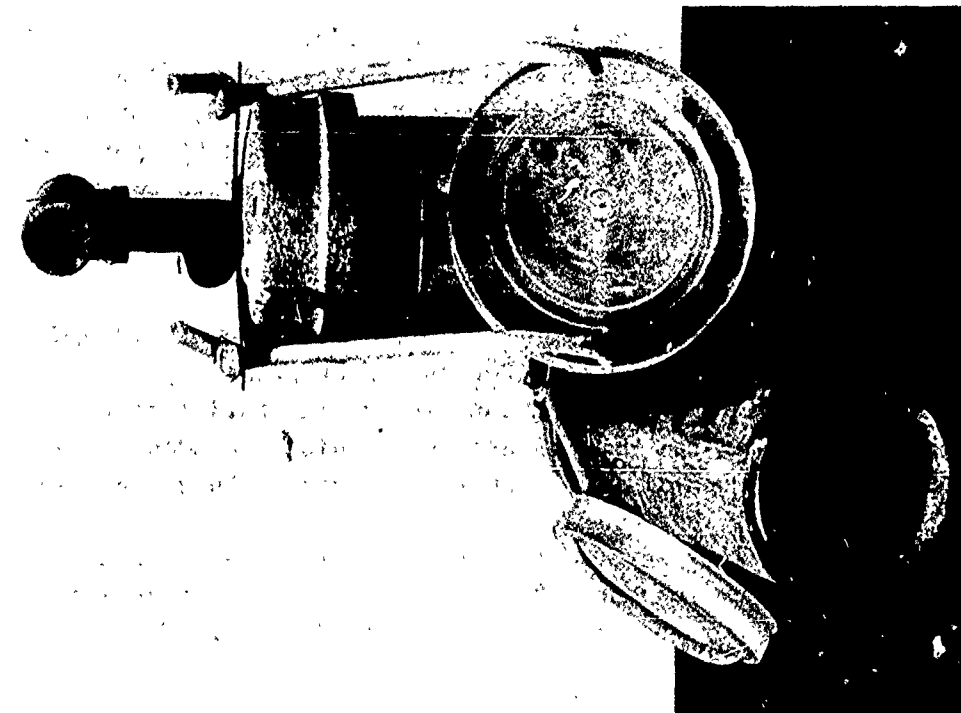
The modified Petersen grab is a clam-shell type of sediment sampler, differing from the true Petersen grab primarily in the design of the external arms that contain the triggering device. Thorsen (1957) discusses the advantages and disadvantages of the Petersen grab for quantitative sampling of macrobenthic organisms.

The core samplers were constructed of galvanized pipe and measured about 30 cm long and about 10 cm in diameter (inside). The divers used the rubber-tensioned plastic discs attached to the sampler (Figure 2b) to retain the sediment sample as the sampler was brought up through the water column.

Because of its greater area and volume-sampling capacity, the modified Petersen grab collected many more specimens and taxa of benthic animals per sample than did the diver-operated core samplers. However, Table 3 shows that sampling variability was little different relative to the number of taxa collected per liter of sediment. Both samplers collected about the same number of specimens per liter of sediment, but, with the modified Petersen grab, the number of specimens collected per liter varied less. At Station OIH, the amount of sediment collected by both samplers was about 67% of capacity, and the standard errors were essentially the same. At Station HP, where the sediment was softer, both samplers collected near-capacity volumes of sediment, although the amount of sediment in the replicate grab samples varied much less than in those collected by the core sampler.

Using the modified Petersen dredge, we collected a total of 75 taxa at Station OIH and 55 taxa at Station HP. Using the core sampler, the number of taxa collected at Stations OIH and HP were 31 and 22, respectively. Each grab sample collected from Station OIH contained an average of 50.4% of the total number of taxa found

Study Approach
Sampling Procedures



(b) CORE SAMPLERS



(a) MODIFIED PETERSEN DREDGE SAMPLER

FIGURE 2 SEDIMENT SAMPLERS

Study Approach
Sampling Procedures

Table 3

RELATIVE PERFORMANCE OF THE MODIFIED
PETERSEN GRAB SAMPLER AND THE DIVER-OPERATED
CORE SAMPLES

Based on Collection of Five Samples Using Each Sampler

	<u>Station OIH</u>		<u>Station HP</u>	
	<u>Grab</u>	<u>Core</u>	<u>Grab</u>	<u>Core</u>
Sample volume				
Mean	6.88	1.86	10.18	2.70
SE*	6.8	5.3	3.1	13.8
Taxa per liter				
Mean	544.92	143.72	64.30	22.22
SE	25.8	24.0	41.5	40.3
Specimens per liter				
Mean	5.46	6.90	2.20	2.62
SE	7.8	14.0	14.6	20.3

* Standard error in percentage of mean.

in all five grab samples; at Station HP, each grab sample contained 38% of the total number of taxa collected. Each core sample contained an average of 34.2 and 31.8% of the total number of taxa collected from Stations OIH and HP, respectively.

We concluded that, in terms of sampling reproducibility, both samplers were about equal. The core sampler might have enabled us to obtain samples of nearly equal size, to select each sampling spot, and to obtain more quantitative biological data. However, collection of core samples took about twice the time as collection of an equal number of grab samples, and the divers' safety was always in doubt. In addition, the divers were unable to observe the sampling operation--even under artificial illumination--and their

Study Approach

Identification of Animals

movements disturbed the sediment. Because of these problems, we selected the modified Petersen grab for use in the definitive phase.

Identification of Animals

The benthic animals were separated from the washed debris manually, preliminarily identified and counted, and then sent to taxonomic specialists for final identification and counting. Although we did attempt to identify each specimen to the specific level, we could not accomplish this task with all specimens. Identification of the nematodes, oligochaetes, nemerteans, copepods, ostracods, and cumaceans was especially difficult. As the study progressed, we did gain expertise in identifying the ostracods and cumaceans and, during the definitive phase, identified most of the specimens belonging to these two groups; however, throughout the study, specimens belonging to the other four groups were counted but not identified.

We limited identifications and counts to animals with heads. In the preliminary phase, we collected biological information from three to five sediment samples per station; during the definitive phase, we identified and counted animals extracted from three sediment samples per station. Table 4 shows the number of sediment samples processed for biological data.

Physical and Chemical Measurements

Measured Parameters

The temperature, pH, and color of each sediment sample were recorded immediately after sample collection. Subsamples of the sediment were analyzed later for total sulfides, grain-size distribution, and heavy metals (copper, cadmium, zinc, lead, and total mercury).

Water samples, which were collected within 3 ft of the bottom, were measured for temperature, salinity, dissolved oxygen, and pH

Study Approach
Identification of Animals

Table 4
NUMBER OF SEDIMENT SAMPLES PROCESSED DURING EACH SURVEY
TO OBTAIN CENSUSES OF THE BENTHIC POPULATIONS
Average Sample Volumes (Liters) are in Parentheses

Station	P	Survey			
		1 (Sept. 1973)	2 (Dec. 1973)	3 (March 1974)	4 (June 1974)
MIS-A	4 (10.0)	3 (9.6)	3 (10.3)	3 (10.4)	3 (9.8)
MIS-B	4 (10.1)	3 (10.5)	3 (11.1)	3 (10.3)	3 (10.7)
CS-A	5 (10.6)	3 (10.5)	3 (10.7)	3 (8.5)	3 (10.2)
CS-B	5 (9.7)	3 (10.1)	3 (10.0)	3 (10.4)	3 (9.3)
ALC	3 (6.2)	3 (7.5)	3 (7.8)	3 (9.8)	3 (8.1)
OIH	5 (7.4)	3 (11.3)	3 (8.3)	3 (8.3)	3 (10.2)
HP	5 (10.3)	3 (10.4)	3 (9.7)	3 (9.9)	3 (9.6)
SB-A	4 (11.0)	3 (11.2)	3 (10.4)	3 (10.3)	3 (11.6)
SB-B	5 (10.4)	3 (11.3)	3 (11.2)	3 (10.8)	3 (11.0)
RCH-A	5 (10.4)	3 (11.0)	3 (10.9)	3 (10.0)	3 (10.4)
RCH-B	5 (10.7)	3 (10.7)	3 (10.6)	3 (10.4)	3 (10.3)

Study Approach

Physical and Chemical Measurements

immediately after collection. Total sulfide and turbidity determinations were conducted after the samples had been brought ashore.

Chemical Analytical Methods

Total Sulfides

The total sulfide content of the sediment and water samples was determined by the method described in the Chemistry Laboratory Manual - Bottom Sediments (EPA, 1969). By this method, we analyzed for dissolved hydrogen sulfide and its ionization products as well as for acid-soluble metallic sulfides. The sediment and water samples were treated with zinc acetate immediately after collection to precipitate the sulfides and prevent generation of H_2S during storage. During the preliminary phase of the study, we stored all samples reserved for chemical analysis in tightly capped glass jars but used heavy polyethylene jars during the definitive phase.

Dissolved Oxygen

The concentration of oxygen in the water samples was determined with a Yellow Springs dissolved oxygen meter (Model 54) immediately after sample collection. The water samples were transferred to BOD bottles with the transfer tube placed under the surface to minimize entry of air. The sensing electrode was equipped with a stopper designed to prevent entry of air during stirring of the samples. A magnetic stirrer was used during analysis.

pH

We determined the pH of the water and sediment samples with a Beckman pH meter (Model 76) immediately after the samples were collected.

Study Approach
Physical and Chemical Measurements

Salinity

During the preliminary phase, we measured salinity with Yellow Springs salinometer (Model SC-T). However, during the definitive phase, we used a refractometer (American Optical) because it provided more reproducible readings. To obtain a sample of interstitial water for analysis, we extracted the water from the sediment by centrifugation. Interstitial water salinity was determined only during the March and June 1974 surveys.

Heavy Metals

We conducted exploratory studies using two analytical methods for copper, cadmium, lead, and zinc. The methods differ only in the procedures used for treating samples before actual metal analysis by atomic absorption. The method recommended by EPA (EPA, 1969) involves sediment acidification, high-temperature (400 to 425°C) ashing, and acid extraction. The method of Mathis and Cummings (1971) involves drying the sample to constant weight, acid digestion, and filtration. Heavy-metal analysis was performed on a Varian Tektronic atomic absorption spectrophotometer (Model AA-6).

We chose to use the method of Mathis and Cummings because it gave higher yields than the EPA method. The difference in yields was especially evident with lead, as shown in Table 5, and was probably due to volatilization of metals during high-temperature ashing in the EPA method.

We explored the efficiency of the Mathis and Cummings method by determining heavy-metal recovery from spiked sediment. Table 6 presents the results. The mean values for percentage of recovery were used to adjust the measured concentrations of lead, cadmium, copper, and zinc in sediment samples analyzed.

The method used for the analysis of mercury was the one recommended for water, biological tissues, and mud by the EPA Analytical Quality Control Laboratory, Cincinnati, Ohio (EPA, 1971). This method involves reducing mercury compounds to elemental mercury

Study Approach
Physical and Chemical Measurements

Table 5

EFFECT OF EXTRACTION METHOD ON RECOVERY
OF HEAVY METALS FROM BOTTOM SEDIMENTS

<u>Sample</u>	<u>Method</u>	<u>Micrograms of Metal Found per Gram of Dry Sediment</u>			
		<u>Lead</u>	<u>Cadmium</u>	<u>Copper</u>	<u>Zinc</u>
1	EPA	0	1.08	23.90	30.0
	Mathis	35.48	1.41	49.67	32.3
2	EPA	7.36	0.29	6.32	18.5
	Mathis	27.64	1.10	38.17	22.1

Study Approach
Physical and Chemical Measurements

Table 6

RECOVERY OF HEAVY METALS FROM SPIKED SEDIMENT SAMPLES
USING THE MATHIS AND CUMMINGS METHOD (1971)

<u>Sample</u>	<u>Initial Finding (μg)</u>	<u>Added (μg)</u>	<u>Recovered (μg)</u>	<u>Recovery (%)</u>
Lead				
1	175	500	500	74
2	175	500	562	83
3	275	100	425	114
4	485	100	538	92
5	335	100	412	95
6	290	100	350	90
Mean				91.33
Cadmium				
1	0	30	35	119
2	2.3	30	31	96
3	11.6	100	125	112
4	20.0	100	130	108
5	16.0	100	135	116
6	13.0	100	130	115
Mean				111.0
Copper				
1	283	280	625	111
2	104	280	365	95
3	395	100	575	116
4	498	100	562	94
5	715	100	750	92
6	569	100	762	114
Mean				103.66
Zinc				
1	790	30	772	94
2	710	30	622	84
3	1,088	100	1,520	128
4	1,544	100	1,595	97
Mean				100.75

Study Approach
Physical and Chemical Measurements

by reaction with various reagents, then sweeping the mercury vapor through a cell positioned in the light path of an atomic absorption at 253.7 nm.

As shown in table 7, testing with sediment samples spiked with inorganic mercury produced low recoveries, averaging 42%. We did not determine recovery from samples spiked with organic mercury and did not explore other analytical methods. The poor recovery of mercury was probably due to loss of ionic mercury during the overnight acid digestion step necessary with actual sediment samples. Because recovery from actual samples may be higher than that from spiked samples, we did not apply a correction factor to the data.

Table 7

RECOVERY OF MERCURY FROM SEDIMENT SPIKED
WITH INORGANIC MERCURY

Sample	Initial Hg Finding (μ g)	Added (μ g)	Recovered (μ g)	Recovery (%)
1	0.1050	1.0	0.56	51
2	4.5000	5.0	3.20	34
3	8.7000	5.0	4.95	36
4	0.7000	1.0	0.80	47

Measurement of Physical Parameters

Sediment Particle-Size Distribution

Sediment particle-size distribution was determined by wet and dry sieving and by liquid sedimentation techniques. In the preliminary phase, we treated the sediment samples with hydrogen peroxide (30%) to oxidize the organic material and added sodium

Study Approach Physical and Chemical Requirements

hexametaphosphate as a dispersing agent. Treatment of the samples with these two chemicals is recommended by Holme and McIntyre (1971). We characterized the sediment into five size categories--namely, 499, 125-499, 62-124, 4-61, and $<4 \mu$ --and performed the liquid sedimentation analysis in graduate cylinders immersed in a constant-temperature water bath.

For the definitive phase, we decided a more thorough analysis was necessary and subsequently analyzed the sediment using 12 size categories. We oven dried the wet-sieved fraction, which contained particles larger than 43μ , and subfractionated this fraction into five size categories using a nest of Ro-Tapped Tyler sieves. The pan fraction ($>43 \mu$) was added to the fraction reserved for liquid sedimentation analysis.

Liquid sedimentation analysis for samples collected during the definitive phase was performed in vacuum-jacketed glass columns designed at SRI specifically for analysis of particle size. Particles subjected to liquid sedimentation analysis were sized according to Stoke's Law regarding the time required for particles for a given size and shape to fall a specific distance through a viscous fluid. Samples removed from the column were collected on pre-weighed, $0.8\text{-}\mu$ Millipore filters. The collected sediment and filters were oven dried and weighed, and the sample weight was recorded after subtraction of the filter weight. After each sample was taken from the column, the column was refilled with water and inverted several times to redisperse the particles. Samples analyzed during the definitive phase were not treated with hydrogen peroxide or sodium hexametaphosphate.

Turbidity

Turbidity measurements were performed according to procedures described in Standard Methods (1971), but the nephelometer described in that manual was not employed. We used a Bausch and Lomb spectrophotometer (Spectronic 20) that, instead of measuring the intensity of light scattered at right angles to the path of incident light, measures the intensity of light passing through the sample.

Study Approach
Physical and Chemical Requirements

Turbidity values were obtained by comparing the percentage of light transmittance of mercuric chloride-treated water samples with that of a standard formazin suspension. The values are reported in nephelometric units (NU), which are similar but not identical to Jackson turbidity units (JTU). Our nephelometric values may not be comparable to those that might have been obtained if the recommended type of nephelometer had been used; however, they do indicate the relative differences in water turbidity among stations and sampling periods.

Temperature

Sediment and water temperature were measured with a glass thermometer.

RESULTS AND DISCUSSION

Biological Characteristics

Each of the seven dredged and disposal areas investigated contained unique benthic communities that generally differed in composition and animal numbers. Although many different organisms were found at each station, few could be considered abundant or common. In this report, we have classified as "abundant" those organisms comprising 1% or more of the total number of noncolonial specimens collected at a given station during the study; "common organisms" are those that were found during all five sampling months, regardless of their abundance.

Some of the fauna collected during the study were colonial types, the Ectoprocta being examples. Other colonial types were the sponges (Porifera) and certain kinds of cnidarians and chordates. We did not determine the number of individuals in each colony, as this would have been a formidable and fruitless task, nor did we count colonies, as this would have produced meaningless data because the colonies tend to disintegrate upon handling. In the tables in this section, the letter "P" denotes "present," indicating that a colonial organism was found.

Mare Island Strait

Station MIS-A

Table 8 presents the taxa and number of specimens collected during each of the five surveys. The total numbers of taxa and noncolonial specimens collected during each survey are shown at the bottom of the table.

At Station MIS-A, we identified 33 taxa, of which 5 were colonial and 28 were noncolonial. A total of 9,212 specimens were

Results and Discussion
Biological Characteristics
MIS-A

Table 8
DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION MIS-A

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY				SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	
PRUTUZA VORTICELLA SP.	--	--	--	p	p
CNIDARIA HYDRUZUA-UNIDENTIFIED SPP. CAMPANULARIA SP.	--	p	p	p	p p
NEMATODA NEMATODA-UNIDENTIFIED SPP.	7	269	61	23	453
ANNELIDA-OLIGUCHAETA OLIGUCHAETA-UNIDENTIFIED SPP.	9	7508	259	11	3044
ANNELIDA-POLYCHAETA STREBLOSPIC BENEDICTI HAPLUSCULOPLUS PUETTENSIS ETEONE LIGHTI NEANTHES SUCCINEA PSEUDOPOLYDOKA KEMPI CALIFORNICA EXOONE LONGEI ETEONE LONGA CALIFORNICA	-- -- -- -- -- -- --	34 1 13 1 1 -- --	1 -- 1 -- -- 1 1	1 -- -- -- -- -- --	35 1 14 1 1 1 1
ARTHROPODA CUPEPODA-UNIDENTIFIED SPP. USIRACUDA-UNIDENTIFIED SPP. BALANUS CRENATUS MYSDACEA-UNIDENTIFIED SPP. AMPLISCA MILLERI GRAMMIDIERELLA JAPONICA INSECTA-UNIDENTIFIED SPP. SYNGRUTEA LATICAUDA BALANUS SP. ARACHNIDA-UNIDENTIFIED SPP.	95 1 1 3 -- -- -- -- -- --	114 -- -- -- 14 1 1 -- -- --	279 -- -- -- -- 1 1 1 1 1	16 -- -- -- 1 -- -- -- -- -- --	527 1 1 3 16 1 3 1 1 1

Results and Discussion
Biological Characteristics
MIS-A

Table 8 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY				SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
MOLLUSCA					
MACOMA BALTHICA	11	35	10	--	17
MACOMA NASUTA	1	--	--	--	--
MYA ARENARIA	4	3	2	--	--
NASSARIUS OBSOLETTUS	--	4	3	--	--
UDUSTOMIA (EVALEA) SP. A	--	6	--	--	--
MUSCULUS SENHUSIA	--	--	5	--	--
GENIA GENIA	--	--	1	--	--
UDUSTOMIA (MENESTHO) FETELLA	--	--	1	--	--
UDUSTOMIA (EVALEA) FRANCISCANA	--	--	--	--	1
ECTOPROCTA					
CHEILUSTOMATA-UNIDENTIFIED SPP.	P	--	--	--	P
MEMBRANIPURA PERFRAGILIS	P	P	P	P	P
GRAND TOTALS SPECIMENS	132	806	628	53	333
TAXA	11	17	19	7	10
					9212
					33

Results and Discussion
Biological Characteristics
MIS-A

collected. Twenty-five of the noncolonial taxa were relatively rare, the number of specimens representing them amounting to about 2% of the total number of noncolonial specimens collected as MIS-A.

Table 9 lists the five abundant taxa, which accounted for 97.9% of the five-survey noncolonial specimen count. Because of the differences in sample numbers and volumes collected during each survey, the data in Table 9 are presented as specimens per liter of sample. Although benthic animal densities usually are presented as specimens per unit area, we believe that density so expressed is valid only when samples of equal volume are collected and when investigators can control carefully the depth and angle that the sampling device enters the sediment. We could not meet these criteria using the remotely controlled Petersen grab.

Table 9

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION MIS-A
(Individuals per Liter)

	Percentage of Population*	Survey				
		P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	4.9%	0.18	9.34	1.97	0.74	3.16
Oligochaeta	87.3	0.22	262.78	8.38	0.35	6.70
Arthropoda						
Copepoda	<u>5.7</u>	<u>2.38</u>	<u>3.96</u>	<u>9.03</u>	<u>0.51</u>	<u>0.78</u>
Total	97.9%	2.78	276.08	19.38	1.60	10.64
All organ- isms†	100.0	3.30	280.07	20.32	1.70	11.33

* Numerical percentage of all noncolonial organisms collected.

† All noncolonial organisms collected.

Results and Discussion
Biological Characteristics
MIS-B

As shown in Table 9 the population density for all non-colonial animals was greatest in September 1973 (Survey 1), and oligochaetes predominated. The population density was about 14 times greater in September 1973 than during any other sampling period. In March 1973 and 1974, we encountered the fewest number of animals per liter. In March 1973 (Survey P), copepods primarily composed the population, whereas in March 1974 (Survey 3), the nematodes were slightly more numerous. The nematodes were most abundant in September 1973. Many nematodes, copepods, and perhaps some oligochaetes are not retained by a size-30 screen, so that the data for these taxa may not be quantitative.

In December 1973 (Survey 2), the population density was 20.32 noncolonial animals per liter, and oligochaetes and copepods predominated. In June 1974 (Survey 4), we collected 11.33 non-colonial animals per liter, and at least half the number were oligochaetes.

Seven species of polychaetes were collected at MIS-A (see Table 8). All were collected in September and December 1973 and March 1974. In September, five species were taken, representing 49 specimens, 33 of which were Streblospio benedicti. This small worm was the most abundant polychaete encountered during the study. In December, we collected single specimens of four polychaete species, two of which were new; in March 1974, only one polychaete specimen (Streblospio benedicti) was found.

We collected 10 different kinds of arthropods from MIS-A. The abundant copepods were present during each sampling month, and other arthropods, represented by 28 individuals, appeared sporadically. Of the nine species of mollusc collected, only the clam Macoma balthica occurred with any frequency or abundance. Of the 106 molluscs encountered, 71 were of this species. Molluscs were absent in March 1974.

Station MIS-B

At Station MIS-B, the sediment samples contained fewer species (26) than those from MIS-A; however, the population was about six times larger, as shown in Table 10. Numerically, the

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MIS-B

Table 10

DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION MIS-B

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY				P	P	P	SPECIMENS TOTAL
	1 (3/73)	2 (9/73)	3 (12/73)	4 (6/74)				
CNIDARIA								
HYDROZOA-UNIDENTIFIED SPP.	--	--	--	--	--	--	--	
NEMATODA								
NEMATODA-UNIDENTIFIED SPP.	7	243	25	184	135			594
ANNELIDA-OLIGOCHAETA								
OLIGOCHAETA-UNIDENTIFIED SPP.	232	15122	14875	11714	11925			53868
ANNELIDA-POLYCHAETA								
STREBLOSPIO BENEDICTI	5	282	521	119	135			1062
NEANTHES SUCCINEA	--	3	2	5	7			17
ETEONE LIGHTI	--	26	--	--	4			30
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	5	5	--	--			10
HETEROMASTUS FILIFORMIS	--	1	--	--	--			1
EXOgone SP.	--	--	1	--	--			1
SIPUNCULA								
SIPUNCULA-UNIDENTIFIED SPP.	--	--	--	1	--			1
ARTHROPODA								
COPEPODA-UNIDENTIFIED SPP.	13	19	35	91	48			206
MYSIDACEA-UNIDENTIFIED SPP.	1	--	--	--	--			1
AMPELISCA MILLERI	3	9	--	--	--			12
AMPHIPODA-UNIDENTIFIED SPP.	1	--	--	--	1			1
INSECTA-UNIDENTIFIED SPP.	1	--	--	--	--			2
PYCNOGONIDA-UNIDENTIFIED SPP.	--	--	1	--	--			1
GRANDIDICRELLA JAPONICA	--	--	1	--	--			1
MELITA SP.	--	--	2	--	--			2
MOLLUSCA								
MYA ARENARIA	20	22	31	13	6			92
MACOMA BALTHICA	63	41	23	20	46			193
NASSARIUS OBSOLETUS	6	--	73	--	--			79
GEMMA GEMMA	--	--	1	--	--			1

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Biological Characteristics
MIS-B

Table 10 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMENS TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
MUSCULUS SENHOUSSIA	--	--	--	1	--	1
UDOSTOMIA (MENESTHO) PETELLA	--	--	--	1	--	1
PELECYPODA-UNIDENTIFIED SPP.	--	--	--	1	--	1
ECTOPROCTA	P	P	P	P	--	P
MENBRANIPORA PERFRAGILIS						
GRAND TOTALS	352	15773	15596	12150	12307	56178
SPECIMENS	12	12	16	12	10	26
TAXA						

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 MIS-B

population at MIS-B was relatively stable between September 1973 and June 1974 when the average number of specimens collected during each sampling period was 13,956, and the range was from 12,150 to 15,773. In March 1973, we collected only 352 specimens.

This undredged area of Mare Island Strait was inhabited almost exclusively by oligochaetes. Table 11 reflects the heavy influence of the oligochaetes relative to the population density values for all species. Numerical changes in the sampling returns for each survey resulted primarily from fluctuations in the number of these worms. In September and December 1973 and in March and June 1974, the oligochaetes comprised 95.9, 95.4, 96.4, and 96.9%, respectively, of the total number of noncolonial specimens collected. In March 1973, 65.9% of the specimens were oligochaetes.

Table 11

CONCENTRATIONS OF THE MOST ABUNDANT
 BENTHIC ORGANISMS COLLECTED AT STATION MIS-B
 (Individuals per Liter)

	Percentage of Population*	Survey				
		P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	1.1%	0.17	7.71	0.75	5.95	4.21
Oligochaeta	95.9	5.74	480.06	446.70	379.09	371.50
Polychaeta						
<u>S. benedicti</u>	<u>1.9</u>	<u>0.12</u>	<u>8.95</u>	<u>15.64</u>	<u>3.85</u>	<u>4.21</u>
Total	98.9%	6.03	496.72	463.09	388.89	379.92
All organisms†	100.0	8.71	500.73	468.35	393.20	383.40

* Numerical percentage of all noncolonial organisms collected.

† All noncolonial organisms collected.

Results and Discussion
 Biological Characteristics
 MIS-B

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All organisms [†]	100.0	8.71	500.73	468.35	393.20	383.40

* Numerical percentage of all noncolonial organisms collected.

† All noncolonial organisms collected.

Results and Discussion
Biological Characteristics
CS-A

Island Strait, but it was not as densely populated. We collected 47 species of benthic animals at Station CS-A. Table 12 presents these species and their abundance during the five sampling periods. Nine of the species from this station were colonial types.

A total of 8,450 noncolonial specimens were collected at CS-A, approximately 97% of them belonging to six taxa. Table 13 lists the taxa and the density of each. The oligochaetes predominated during all five surveys; about 66% of all noncolonial specimens encountered at this station were oligochaetes. About 74% of the 5,569 oligochaetes taken during the study were obtained in June 1974; they were least abundant in March 1973, when only 53 specimens (1/liter) were recovered.

The nematodes were the second most numerous animals, primarily because of a sudden increase in their numbers in June 1974, accounting for 16.4% of the total noncolonial specimen count at CS-A.

The polychaetes comprised 14 species, represented by 854 specimens, 10.1% of the total specimen count. The most abundant polychaete was Streblospio benedicti, which was present during all five surveys but was not particularly abundant in March of both years (seven were collected in March 1973, and only one was taken in March 1974). The largest number, 469, was collected in December 1973, and a relatively large number, 181, was collected in June 1974.

The arthropods comprised 14 species. In general, we did not encounter many arthropods at CS-A, the number found representing only 3.5% of the total noncolonial specimen count. About 88% of the arthropods were found in September; most of them were Balanus improvisus, a barnacle, found attached to a single rock. In contrast to their abundance at the Mare Island Strait area, copepods were not abundant at Carquinez Strait. The five-survey total for CS-A was three.

Molluscs constituted about 4.1% of the total specimen count. We collected seven species, five of them during the preliminary survey of March 1973. The remaining two were captured

Results and Discussion
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CS-A

Table 12
DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION CS-A

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
CNIDARIA						
HYDROZOA-UNIDENTIFIED SPP.	P	--	--	--	--	P
GONUTHYRAEA SP.	--	P	--	--	--	P
CAMPANULARIA SP.	--	--	P	--	0	P
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	9	45	27	37	1267	1385
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	53	387	846	169	4114	5559
ANNELIDA-POLYCHAETA						
HETEROMASTUS FILIFORMIS	1	--	1	1	4	7
SIREBULUS BENEDICTI	7	83	469	1	181	741
ETEONE LIGHTI	1	2	10	--	18	31
GLYCINDE SP.	--	18	7	3	4	32
NEANTHES SUCCINEA	--	2	--	1	3	6
POLYDORA LIGNI	--	4	5	--	--	9
THARYX PARVUS	--	2	1	--	1	4
CAULLERIELLA HAMATA	--	1	--	--	--	1
POLYDORA CAULLERYI	--	1	--	--	--	1
EXOGONE LOUREI	--	1	--	--	--	1
ETEONE LONGA CALIFORNICA	--	--	3	--	--	3
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	--	3	--	1	4
CHAETOGONE SP.	--	--	6	--	--	6
THARYX SP.	--	--	6	--	2	8
ARTHROPODA						
MYSIACEA-UNIDENTIFIED SPP.	1	--	--	--	--	1
SYNDIUTEA LATICAUDA	1	--	--	--	1	2
PAKAPHYXUS MILLERI	--	9	--	10	--	19
HYPERIIDEA-UNIDENTIFIED SPP.	--	1	--	--	--	1
COPEPODA-UNIDENTIFIED SPP.	--	1	--	2	--	3
AMELISCIA MILLERI	--	2	1	--	--	3
BALANUS IMPROVISUS	--	245	--	--	--	246

Results and Discussion
Biological Characteristics
CS-A

Table 12 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
LEPTOCHELIA DUBIA	--	1	--	--	--	1
GRANDIOERELLA JAPONICA	--	1	8	--	--	9
DECAPODA-UNIDENTIFIED SPP.	--	--	--	1	--	1
HALCARIDAE-UNIDENTIFIED SPP.	--	--	--	1	--	1
HALCARUS SP.	--	--	--	1	--	1
BALANUS CARIOSUS	--	--	--	6	--	6
INSECTA-UNIDENTIFIED SPP.	--	--	--	--	2	2
MOLLUSCA						
NASSARIUS OBSOLETUS	41	--	8	1	--	50
MYA ARENARIA	39	22	10	63	--	139
MACOMA BALTHICA	36	10	6	--	95	147
MYTILUS EDULIS	1	--	--	2	--	3
TAPES JAPONICA	2	--	1	--	--	3
MUSCULUS SEMHOUSIA	--	1	--	1	--	2
ODOSTOMIA (MENESTHO) FETELLA	--	--	1	--	--	1
ECTOPROCTA						
MEMBRANIPORA PEKFRAGILIS	P	P	--	P	P	P
CHEILOSTOMATA-UNIDENTIFIED SP. A	P	--	--	--	--	P
CHEILOSTOMATA-UNIDENTIFIED SP. B	P	--	--	--	--	P
CONOPEUM RETICULUM	--	--	--	P	P	P
MEMBRANIPORA VILLOSA	--	--	--	--	P	P
ELECTRA ARCTICA	--	--	--	--	--	P
ENIGMATICA						
ENIGMATICA	--	1	--	--	--	1
GRAND TOTALS	192	841	1419	300	5698	8450
SPECIMENS	16	24	20	18	19	47
TAXA						

Results and Discussion
Biological Characteristics
CS-A

Table 13

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION CS-A
(Individuals per Liter)

	Percentage of Population*	Survey				
		P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	16.4%	0.17	1.43	0.84	1.45	41.40
Oligochaeta	65.9	1.00	12.28	26.36	6.63	134.44
Polychaeta						
<u>S. benedicti</u>	8.8	0.13	2.63	14.61	0.04	5.92
Arthropoda						
<u>B. improvisus</u>	2.9	0	7.81	0	0	0
Mollusca						
<u>M. arenaria</u>	1.6	0.74	0.70	0.31	2.47	0.16
<u>M. balthica</u>	<u>1.7</u>	<u>0.68</u>	<u>0.32</u>	<u>0.19</u>	<u>0</u>	<u>3.10</u>
Total	97.3%	2.72	25.17	42.31	10.59	185.02
All organisms [†]	100.0	3.62	26.70	44.21	11.76	186.21

* Numerical percentage of all noncolonial organisms collected.

[†] All noncolonial organisms collected.

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Biological Characteristics
CS-B

in September and December. The molluscs were dominated by two species of clams, Mya arenaria and Macoma balthica, which together accounted for 82.9% of the total mollusc count. During most of the sampling months, neither species was very abundant (Table 13). M. arenaria was most abundant in March 1974, and M. balthica was most abundant in June 1974.

Station CS-B

We collected a total of 48 taxa and 7,732 noncolonial specimens at Station CS-B. Seven of the taxa were colonial types. Table 14 presents the 48 taxa and the number of specimens collected during the five surveys.

Table 15 lists taxa comprising at least 1% of the total noncolonial specimen count. Together, the six most abundant taxa accounted for 96.6% of the noncolonial specimen count. In general, the abundant taxa were the same as at CS-A. The oligochaetes again were the most abundant group; however, at CS-B, they were most abundant in September 1973, whereas at CS-A, they were most abundant in June 1974.

We recovered fewer nematodes at CS-B than at CS-A. At CS-B, these animals were most numerous in September 1973 and in March and June 1974.

We encountered the same number of polychaete species (14) at both Carquinez Strait stations. Most were common to both stations, but Caulleriella hamata and Polydora caulleryi were found only at CS-A, and Asychis sp. and Mediomastus californiensis were found only at CS-B. None were abundant or common.

The sediment at CS-B was populated more densely with polychaetes than the sediment at CS-A. Although S. benedicti was again the most abundant polychaete, the increase in population concentration was not due to an increase in the number of that species but to a sudden appearance of a large number of another polychaete, Tharyx parvus, in September when 364 individuals were collected. This species accounted for 27.5% of the total polychaete count

Results and Discussion
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CS-B

Table 14
DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION CS-B

[illegible]

Results and Discussion
Biological Characteristics
CS-B

Table 14 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
ARTHROPODA						
COPPEPODA-UNIDENTIFIED SPP.	2	1	--	--	7	10
CANCRIODAE-UNIDENTIFIED JUVENILE	1	--	--	--	--	1
PARAPHOXUS MILLER	--	2	--	--	--	2
CAPRELLIDAE-UNIDENTIFIED SPP.	--	1	--	--	--	1
COROPHIUM INSIDIOSUM	--	1	--	--	--	1
AMPELISCA MILLER	--	--	2	--	2	4
ALANUS SP., CF AMPHIKITE	--	--	2	--	--	2
BALANUS LARIOSUS	--	--	--	41	--	41
PYCNOGONIDA-UNIDENTIFIED SPP.	--	--	--	1	--	1
MYSTACEA-UNIDENTIFIED SPP.	--	--	--	--	1	1
MOLLUSCA						
MYA ARENARIA	2	85	59	50	19	215
MUSCULUS SEMMOUSIA	6	--	1	2	--	9
MYTILUS EDULIS	3	--	3	--	--	6
MACOMA BALTHICA	--	5	2	47	32	86
TAPES JAPONICA	--	1	--	1	1	3
ODOSTOMIA (MENESTHIO) FETELLA	--	1	11	11	--	23
GEMMA GEMMA	--	--	5	--	--	5
NASSARIUS OBSOLETUS	--	--	8	--	--	8
ODOSTOMIA (EVALEA) SP. A	--	--	2	--	--	2
ODOSTOMIA (EVALEA) TENUSCULPTA	--	--	--	3	--	3
ODOSTOMIA (EVALEA) FRANCISCANA	--	--	--	1	--	1
ODOSTOMIA (EVALEA) SP., CF LELIGIOSA	--	--	--	2	--	2
EUTUROCTA						
MEMBRANIPURA PERFRAGILIS	4	P	P	--	P	P
CHEILUSTOMATA-UNIDENTIFIED SPP.	P	--	--	--	--	P
MEMBRANIPURA VILLOSA	--	--	--	--	3	P
ENIUMATICA						
ENIUMATICA	--	--	--	--	1	1
GRAND TOTALS	34	4743	349	1745	414	7732
SPECIES	15	13	20	19	14	41
TAXA						

Table 15

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION CS-B
(Individuals per Liter)

	Percentage of Population*	Survey				
		P (3/13)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	4.7%	0.04	3.83	0.10	5.03	3.05
Oligochaeta	73.3	0.04	113.37	6.40	44.62	23.15
Polychaeta						
<u>S. benedicti</u>	10.0	0.16	21.82	1.00	2.21	0.22
<u>T. parvus</u>	4.7	0	12.01	0	0	0
Mollusca						
<u>M. arenaria</u>	2.8	0.04	2.80	1.97	1.60	0.68
<u>M. balthica</u>	1.1	0	0.16	0.07	1.51	1.15
Total	96.6%	0.28	153.99	9.54	54.97	28.25
All organisms†	100.0%	0.70	156.53	11.53	57.53	29.18

* Numerical percentage of all noncolonial organisms collected.

† All noncolonial organisms collected.

at CS-B. T. parvus was not encountered during any other sampling month. Only four specimens of this species were found at CS-A.

Balanus improvisus was absent from the sediment samples collected at CS-B. Although 10 species of arthropods were collected there, the total number collected amounted to less than 1% of the total specimen count. The most abundant arthropod was another barnacle, Balanus cariosus, also found on a single rock, and collected only in March 1974.

Results and Discussion
Biological Characteristics
ALC

The percentage of molluscs in the population at CS-B was about the same as that at CS-A. All the species found at CS-A also were found at CS-B; however, the sediment at CS-B contained five additional species, including the minute clam Gemma gemma. Only five G. gemma were collected, and all were found in December. The other four species were snails of the genus Odostomia, which were encountered in small numbers and only in December 1973 and March 1974.

Although CS-B was located in the same general area as CS-A, the numerical fluctuations in the benthic population differed markedly between stations. In general, the benthic population at CS-A reached a peak in June 1974, but it peaked at CS-B in September 1973. At both stations, the numerical fluctuation in the benthic population was influenced strongly by changes in the number of nematodes and oligochaetes. The September peak observed at CS-B was enhanced by the appearance of relatively large numbers of the polychaetes S. benedicti and T. parvus. At CS-A, the size of the S. benedicti population did not peak until December, and insignificant numbers of T. parvus were found. At CS-A, the mollusc M. arenaria was most abundant in September 1973; however, at CS-B, it was most abundant in March 1974.

Alcatraz Disposal Site

The Alcatraz disposal site was unique: many of the animals collected were not found elsewhere, and the composition and size of the population fluctuated markedly. Nearly all the 133 species collected at ALC could be considered transient. Only the nematodes, oligochaetes, and the mollusc Adula diegensis were found in all four surveys. The nemerteans, three polychaetes (Hesionura sp., Mediomastus californiensis, Polydora caulleryi), a mollusc (Macoma nasuta), and two bryozoans (Scrupocellaria sp. and Hippothoa hyalina) were present in three surveys.

Ninety-eight species were found only once during the four surveys. The Alcatraz disposal area was inhabited by more species of bryozoans (Ectoprocta) than any other area studied. Table 16 summarizes the biological data obtained at ALC.

Results and Discussion
Biological Characteristics
ALC

Table 16
DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION ALC

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
PROTIZOA						
FURANINIFERA-UNIDENTIFIED SPP.	--	--	4	--	1	5
PORIFERA						
KERATOSA-UNIDENTIFIED SPP.	--	P	--	--	--	P
DENDSPONGIAE-UNIDENTIFIED SPP.	--	--	--	P	--	P
CNIDARIA						
HALIPLANELLA SP.	--	1	1	--	--	2
CALYPTOBLASTEA-UNIDENTIFIED SP. A	--	P	--	--	--	P
CALYPTOBLASTEA-UNIDENTIFIED SP. B	--	P	--	--	--	P
HYDROZUA-UNIDENTIFIED SPP.	--	P	--	--	P	P
DIADUMENE SP.	--	--	1	--	--	1
CAMPANULARIA SP.	--	--	P	--	--	P
PLATYHELMINTHES						
PLATYHELMINTHES-UNIDENTIFIED SPP.	--	2	1	--	--	3
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	--	242	25	--	20	267
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	--	496	67	2	56	621
ANNELIDA-OLIGUCHAETA						
OLIGUCHAETA-UNIDENTIFIED SPP.	--	141	42	1	17	201
ANNELIDA-POLYCHAETA						
GLYCERA OXYCEPHALA	3	--	--	--	--	3
GLYCINDE SP.	3	5	8	--	--	15
MICROPHTHALMUS SP.	--	24	--	--	--	29
SPILOPHANES BUMBUX	--	1	--	--	4	5
POLYCHAETA-UNIDENTIFIED SPP.	--	2	--	--	--	2
POLYDORA SOCIALIS	--	1	--	--	--	1
GLYCERA TENJIS	--	45	--	--	23	74

Results and Discussion
Biological Characteristics
ALC

Table 16 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
HAEMULUS PUGETENSIS	--	1	--	--	--	1
SCOLELEPSIS SUAMATA	--	1	--	--	1	2
ARMANDIA BREVIS	--	31	13	--	--	44
ETLONE DILATAE	--	1	--	--	--	1
HELIOMURA SP.	--	1024	42	--	189	1250
SYLLIDES SP.	--	1265	1	--	--	1266
ARCHIANNELLIDAE-UNIDENTIFIED SPP.	--	--	--	--	--	1
MEDIOASTUS CALIFORNIENSIS	--	27	11	--	1	39
PRIONOSPION SP.	--	1	--	--	--	1
THARYX SP. CF. RUTILARI	--	1	--	--	--	1
POLYDORA CAULERYI	--	1	54	--	2	67
EXOGONE LUKKEI	--	1	14	--	--	15
ANATILDES SP.	--	--	51	--	--	51
CAPITILLA CAPITATA	--	--	4	--	--	4
LUNDA SP.	--	--	1	--	--	1
GLYCEA AMERICANA	--	--	1	--	--	1
COSSURA PYGODACTYLATA	--	--	1	--	--	1
ETLONE LONGA CALIFORNICA	--	--	1	--	--	1
STREBLUSPIO BENEDICTI	--	--	9	--	--	9
PECTINARIA CALIFORNIENSIS	--	--	1	--	--	1
ANATILDES WILLIAMSII	--	--	93	--	1	94
GYPTIS BREVI PALPA	--	--	1	--	--	1
HETEROMASTUS FILIFORMIS	--	--	1	--	--	1
LUMBRINERIS SP.	--	--	1	--	--	1
PHYLLUSCIDIACE-UNIDENTIFIED SPP.	--	--	1	--	--	1
NEAK EUMIDA SANGUINEA	--	--	1	--	--	1
SPIOPHARES SP.	--	--	1	--	--	1
NERIS LATECENS	--	--	1	--	--	1
EULALIA AVICULIDETA	--	--	1	--	--	1
POLYDORA CALIFORNICA	--	--	1	--	--	1
PRIONOSPION CIRMIFERA	--	--	3	--	--	3
LUNDA MINUTA	--	--	1	--	--	1
THARYX SP.	--	--	3	--	--	3
PALEANTUS BELLIS	--	--	1	--	--	1
STREPTOSYLLIS SP.	--	--	4	--	100	104
CHONE MOLLIS	--	--	1	--	--	1
LUMBRINERIS TETRAURA	--	--	4	--	--	4
NEAKHUS SUCULICA	--	--	3	--	--	3
NEPHYS CALIFORNIENSIS	--	--	--	--	1	1

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Table 1 (continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY				SPECIMEN TOTAL
	SURVEY				
	1 (1/74)	2 (9/73)	3 (12/73)	4 (6/74)	
ARTHROPODA					
PHOTIS BREVIDENS	--	1	141	--	142
CURCIPODA-UNIDENTIFIED SPP.	--	1	8	--	9
MELITA DENTATA	--	--	1	--	1
ISCHYROCERUS PANDIPES	--	--	1	--	1
CONOPHEUS ACHERUSIGUR	--	--	26	--	26
PARAPHOXUS PUGETENSIS	--	--	2	--	2
ACAPRELLA SP.	--	--	3	--	3
LEUCOPHORIA SP.	--	--	3	--	3
APRELLA SP.	--	--	29	--	29
MACROTURUS IDENTIFIED SPP.	--	--	3	--	3
GRACIOSUS SP.	--	--	3	--	3
STENOCEPHALUS SP.	--	--	1	--	1
AMPHIROPHUS SP.	--	--	1	--	1
ACINERUS SP.	--	--	1	--	1
MELITA	--	--	2	--	2
ASELOTA-UNIDENTIFIED SPP.	--	--	1	--	1
TIRON BIUCELLUS	--	--	1	--	1
PINNIAA FRANCISCA	--	--	1	--	1
DULICHIA SP.	--	--	1	--	1
PODOCERUS SP.	--	--	1	--	1
UPOGEBIA PUGETENSIS	--	--	2	--	2
CAPRELLA SP.	--	--	--	--	--
DIATYLOPSIS SP.	--	--	--	--	--
ISCHYROCERUS SP.	--	--	--	--	--
LIMNORIA QUADRIPUNCTATA	--	--	--	--	--
PARAPHOXUS MILLERI	--	--	--	--	--
PHOTIS SP.	--	--	--	--	--
MOLLUSCA					
MACOMA NASUTA	3	1	13	--	23
TELLINA MODESTA	--	3	--	--	3
TRANSNELLIA TANTILLA	--	113	4	2	126
MYTILUS EDULIS	--	1	3	--	4
ADULA DIEGENSIS	--	31	4	1	41
TAPES JAPONICA	--	1	--	--	1
HYSELLA FERRUGINOSA	--	17	--	--	17
HIATELLA ARCTICA	--	3	--	--	3

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Table 16 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY				SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
MACOMA DALTHNICA	--	3	2	--	--
FAKTULUM SP.	--	9	--	--	--
ZIRFAEA PILSBRYI	--	--	92	--	--
UJOSTOMIA (EVALEA) FRANCISCANA	--	--	31	--	--
PRUTHACA SIAMINEA	--	--	4	--	--
PLATYDORUS CANCELLATUS	--	--	1	--	--
MACOMA INQUINATA	--	--	10	--	--
NASSARIUS MENDICUS	--	--	1	--	--
ECTUPROCTA					
CHEILOSTOMATA-UNIDENTIFIED SPP.	P	--	--	--	--
CELLARIA MANIBULATA	P	--	--	--	--
SCOPUCELLARIA SP.	P	P	P	--	P
TRICELLARIA OCCIDENTALIS	P	P	--	--	--
CHAPPERIA PALATA	--	P	--	--	--
CRISIA MAXIMA	--	P	--	--	P
TRICELLARIA TENNATA	--	P	--	--	--
SCOPUCELLARIA CALIFORNICA	--	P	--	--	--
HIPPOTHUA HYALINA	--	P	P	--	P
CALLUPURA SP.	--	P	--	--	--
CHEILOPORA PRALLUNGA	--	P	--	--	--
SMITTUDEA PROLIFICA	--	P	--	--	--
MICROPURELLA CALIFORNICA	--	P	--	--	--
ELECTRA ARCTICA	--	P	--	P	--
CELLARIA SP.	--	P	--	--	--
PAKASMITTINA TRISPINOSA	--	P	--	--	--
HIPPOTHOA CORNUTA	--	P	--	--	--
LAGERIPURUS PUNCTULATA	--	P	--	--	--
TEGELLA ARCTIFERA	--	P	--	--	P
MEMBRANIPORA PERFRAGILIS	--	P	--	--	--
CRISIA OCCIDENTALIS	--	P	--	--	--
BUGULA SP.	--	--	P	--	--
FILICRISIA SP.	--	--	P	--	--
CONUPEUM RETICULUM	--	--	--	P	--
CALLUPORA ARMATA	--	--	--	--	P
TRICELLARIA SP.	--	--	--	--	P
SCHIZOPURELLA SP.	--	--	--	--	P
ENIGMATICA	--	--	6	--	--
ENIGMATICA	--	--	--	--	5
GRAND TOTALS	9	12764	888	7	1419
SPECIMENS	7	58	82	9	29
TAXA					
					15087
					133

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We collected a total of 15,078 noncolonial specimens during the study, most of them (84.6%) in September 1973. In contrast only seven specimens were found in the March 1974 samples. The December 1973 and June 1974 yields were 888 and 1,419, respectively. In terms of the four-survey total,* the most abundant taxa were the Nemertea, Nematoda, Oligochaeta, three polychaetes (Hesionura sp., Syllides sp., and Streptosyllis sp.), and one arthropod (Photis brevipes). We included P. brevipes in the abundant species list even though it constituted only 0.9% of the total specimen count. Table 17 presents the relative population densities and the abundant species.

The "population explosion" of September 1973 was almost entirely the result of the appearance of the polychaete Hesionura sp., an organism accounting for 457.7 of the 567.3 noncolonial specimens found per liter of sediment during that month. The numerical dominance of this species did not extend to subsequent sampling months, and, although Hesionura sp. accounted for 80.7% of the total September specimen count, it constituted only 1.4% of the noncolonial specimens collected in December, 13.3% in June 1974, and it was absent in March 1974.

The seasonal fluctuation in the number of nematodes, oligochaetes, and the polychaete Syllides sp. essentially paralleled that of Hesionura sp. All these taxa were most numerous in September; in December, their numbers decreased considerably; and, in March 1974, only two nematodes and one oligochaete were found. Syllides sp. was absent in March 1974 and June 1974, a month when other abundant species increased. Although we collected a total of 1,090 specimens of Streptosyllis sp., we found none in September 1973 and March 1974 and only four in December 1973. This was the most abundant polychaete (1,086) species collected in June.

Photis brevipes was found only in September and December 1973 and was the most abundant organism collected in December. Of the 58 benthic species collected during September, 18 were

*The March 1973 results are not included because the sampling site was not located at the same part of the disposal site as that used in the rest of the study.

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Table 17

CONCENTRATION OF THE MOST ABUNDANT BENTHIC ORGANISMS
COLLECTED AT STATION ALC
(Individuals per Liter)

	Percentage of Population*	Survey				
		P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nemertea	1.8%	0	9.87	1.07	0	0.82
Nematoda	4.1	0	22.04	2.86	0.07	2.30
Oligochaeta	1.3	0	6.27	1.79	0.03	0.70
Polychaeta						
<u>Hesionura</u> sp.	69.6	0	457.73	0.51	0	7.78
<u>Syllides</u> sp.	8.4	0	56.22	0.04	0	0
<u>Streptosyllis</u> sp.	7.2	0	0	0.17	0	44.69
Arthropoda						
<u>P. brevipes</u>	<u>0.9</u>	<u>0</u>	<u>0.04</u>	<u>6.02</u>	<u>0</u>	<u>0</u>
Total	93.3%	--	552.17	12.46	0.10	56.29
All organisms [†]	100.0	--	567.29	37.95	0.24	58.40

* Numerical percentage of all noncolonial organisms collected.

[†] All noncolonial organisms collected.

polychaetes, 2 were arthropods, 10 were molluscs, and 19 were bryozoans (Ectoprocta). As mentioned earlier, 84.6% of all non-colonial specimens found at ALC were collected during September 1973; and, of the 12,764 specimens collected, 80.7% were identified as the polychaete Hesionura sp.

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Photis brevipes and the copepoda were the only types of arthropod found in September, each being represented by one specimen. Four of the 10 mollusc species were found only in September, Mysella ferruginosa being the most abundant.

The largest number of taxa (82), represented by only 888 specimens, was collected in December 1973. Fifty-six species were not found in samples collected during the other sampling months. Of these, 24 were polychaetes, the most diverse and abundant group of December 1973. The most numerous polychaete species collected in December were Polydora caulleryi, Anaitides williamsi, and Anaitides sp. other than A. williamsi. A. williamsi, with 93 specimens, was the most abundant. Together, these three species comprised 66.2% of the total polychaete specimen count in December. Hesionura, Syllides, and Streptosyllis--which were numerous in terms of the four-survey specimen count--were not abundant in December. A total of 17 specimens were taken; these constituted only 5% of the total number of polychaetes collected in December.

Thirty different arthropod species were collected at Station ALC, and 21 of them were found only in December. The 249 specimens collected in December accounted for 95.4% of the total number of arthropod specimens collected at ALC.

Eleven mollusc species, represented by 178 specimens, were collected in December. Two of the six species that were exclusive--namely, Zirfaea pilsbryi and Odostomia (Evalea) franciscana--were the most abundant molluscs collected in December.

In March 1974, the sediment collected from the Alcatraz disposal site was almost devoid of macrobenthic organisms. We collected nine species, three of them colonial types, one an unidentified species of Porifera, and the other two the bryozoans Electra arctica and Conopeum reticulum.

The generally abundant taxa were absent, except for the nematodes (two specimens) and oligochaetes (one specimen). The sediment samples averaged 9.6 liters and did not yield a single polychaete; Diastylopsis sp. and Ischyrocerus sp. were the only arthropods present, and Macoma nasuta and Adula diegensis were

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the only molluscs present. These four species each were represented by one specimen.

We collected 77 noncolonial taxa in December 1973 and only 20 in June; however, the specimen count in June was about 60% larger than in December. Nine of the taxa collected in June were polychaetes. Nephtys californiensis, a polychaete represented by a single specimen, was found at this station only in June, and Adula diegensis (one specimen) and Tellina modesta (two specimens) were the only molluscs represented. We collected seven types of bryozoans, three of which--Collopora armata, Tricellaria sp., and Schizoporella sp.--were found only in June.

Oakland Inner Harbor

Station OIH was the most densely populated of all stations surveyed during this study. The average number of organisms per liter of sediment was 867.5. A total of 131,256 specimens were collected during the five surveys. Organism types were diverse, and the number of identified taxa (137) was only one less than that at Station HP (Hunters Point), the site of the greatest number of species. OIH also was inhabited by 23 year-round species--more than at any other station. Table 18 presents the total number of each species found at this station.

Although 137 taxa were found at this station, only six were abundant, as shown in Table 19. As at most of the other stations, large numbers of nematodes and oligochaetes were collected, but the most abundant species was the polychaete Streblospio benedicti. Other species accounting for at least 0.9% of the total noncolonial specimen count at OIH were the polychaetes Exogone lourei and Pseudopolydora paucibranchiata and the mollusc Gemma gemma. The number of specimens representing these six taxa constituted 94.3% of the total noncolonial specimen count.

In March 1973, we collected 21,153 noncolonial specimens. In September, 36.1% more were collected. Numerically, the benthic population reached a peak in December, when 41,772 noncolonial individuals were recovered from the sediment samples. In March

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Table i8
DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION OIH

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
PROTIZOA FORAMINIFERA-UNIDENTIFIED SPP.	--	--	14	2	--	16
PURIFERA KERATOSA-UNIDENTIFIED SPP. DEMOSPONGIAL-UNIDENTIFIED SPP.	P --	P --	-- --	-- P	-- --	P P
CNIDARIA PENNATULACEA-UNIDENTIFIED SPP. DIAUMENE SP. CALYPTOBLASTE-UNIDENTIFIED SPP. CNIDARIA-UNIDENTIFIED SPP. STYLATULA ELONGATA HYDROZOA-UNIDENTIFIED SPP. CAMPANULARIA SP. HALIPLANELLA SP. PLUMULARIA SP.	2 1 P P -- -- -- -- --	+ -- P -- -- -- -- -- --	-- -- -- -- 40 P -- -- --	-- -- -- -- 5 P 1 -- --	-- -- -- 1 -- -- P --	5 1 P P 46 P P 1 P
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	24	12	26	44	13	119
NEMATODA NEMATODA-UNIDENTIFIED SPP.	306	690	1347	2230	1592	6155
ANNELIDA-ULIOCHAETA ULIOCHAETA-UNIDENTIFIED SPP.	4886	9396	12244	13084	2136	41746
ANNELIDA-POLYCHAETA HETEROMASTUS FILIFORMIS MEIOMASTUS CALIFORNIENSIS MARLUSCULUS PUGETIENSIS PECTINARIA CALIFORNIENSIS POLYDORA LONGI PSEUDOPOLYDORA PAUCIORANCHIATA SCULELEPSIS SQUAMATA	3 12 35 34 4 64 36	-- -- 23 20 4 376 2	3 5 17 32 24 785 5	-- 1 23 23 1 6 4	2 1 -- 3 3 -- 4	8 19 48 112 131 1231 55

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Table 18 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY				SPECIMEN TOTAL
	1 (3/73)	2 (9/73)	3 (12/73)	4 (3/74)	
SIRENUSPIU BENEDICTI	10715	12617	21290	14624	59331
GLYCEA AMERICANA	2	--	--	1	3
GLYCEA SP.	51	65	67	17	202
NEPHYS CAECOIDES	54	24	37	5	129
PHOLUE MINUTA	24	13	15	14	71
EXOCUNE LOUREI	1971	495	1102	467	4361
SPHAEROSTYLIS SP.	392	99	398	215	919
PSEUDOPOLYDORA KEMPI CALIFORNICA	30	10	10	--	50
NEPHYS CORNUTA FRANCISCANA	31	14	35	15	101
NEPHYS PARVA	1	14	4	2	21
ETEMNE LONGA CALIFORNICA	17	62	34	10	124
CAPITELLA CAPITATA	12	2	5	7	33
THARYX SP.	2	--	2	--	4
MYRLOCHELE SP., NEAR GRACILIS	2	--	--	--	2
TRACHUCHAETA MULTISETOSUM	5	1	--	2	10
CIRKATULUS CIRKATULUS	5	--	2	--	8
THARYX PARVUS	5	2	1	1	9
SCHISTOMERINUS LUNATICORNIS	6	7	2	13	30
GLYCERA SP., NEAR ROBUSTA	1	--	--	--	1
ETEMNE DILATAE	1	1	--	3	5
HARMUTHUE IMBRICATA	1	3	3	--	10
CHAETUZONE SP.	1	5	2	--	4
ASYCHIS SP.	1	--	--	5	14
HARMUTHUE SP., CF IMBRICATA	1	--	--	--	1
PHYLLUDUCIDAE-UNIDENTIFIED SPP.	1	--	--	--	1
PULYDORA SOCIALIS	3	--	--	--	3
MEULOMASTUS CALIFORNENSIS - JUVENILE	1	--	--	--	1
HARMUTHUE SP.	--	5	2	--	96
ETEMNE LIGHTI	--	13	7	8	30
EUCHONE LINNICULA	--	16	23	--	40
ARMADIA BREVIS	--	1	1	2	4
CUSSOKA PYGODACTYLATA	--	7	1	1	12
PKOMYSTIDES SP.	--	1	--	--	1
PHILICSPID SP.	--	5	--	--	3
ANALLIUS SP.	--	--	1	--	1
CHONE GRACILIS	--	--	2	--	2
ALLIAMPHARETE GRACILIS	--	--	1	--	1
TUNION BIFOLIATA	--	--	1	--	1
SCHISTOMERINUS SP. - JUVENILE	--	--	2	--	2
GYPTIS ORCIVIPALPA	--	--	--	2	3

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Table 18 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
NEARTHES SP.	--	--	--	1	--	1
CAPITELLA SP.	--	--	--	10	--	10
MESIONELLA MCCULLUGHAI	--	--	--	4	--	4
SPIOPHANES SP.	--	--	--	1	--	1
POLYDORA CAULLINII	--	--	--	1	--	1
TEKEBELLIDAE-UNIDENTIFIED SPP.	--	--	--	1	--	1
PRIONOSPION CIRRIFERA	--	--	--	1	--	1
SPIOPHANES MISSIONENSIS	--	--	--	--	1	1
SIPUNCULA						
SIPUNCULA-UNIDENTIFIED SPP.	--	--	--	29	--	29
ARTHROPODA						
OSTRACODA-UNIDENTIFIED SPP.	234	310	--	--	--	544
CUMACEA-UNIDENTIFIED SP. A	13	--	--	--	--	13
CUMACEA-UNIDENTIFIED SP. B	8	--	--	--	--	8
AMPELISCIA MILLENI	32	532	78	6	14	662
LEPTOCHELIA DUBIA	8	11	3	4	--	26
CRANGON SP.	1	--	--	--	--	1
AMPHIPODA-UNIDENTIFIED SPP.	1	3	--	--	--	4
PHOTIS CALIFORNICA	1	--	--	--	--	1
PINNIXA FRANCISCANA	2	15	4	4	2	31
LECYTHURHYNCHUS MARGINATUS	2	--	--	--	--	2
CUMACEA-UNIDENTIFIED SPP.	3	--	--	--	--	3
PYGMAEA TUBERCULATA	1	--	--	--	--	1
EUDORELLA PACIFICA	2	--	--	--	--	2
BRACHYURA-UNIDENTIFIED SPP.	1	--	--	--	--	1
SARSIELLA ZUSTERICULA	--	1	564	458	18	1041
EUDORELLA SP.	--	9	--	5	2	13
LUMELLA VULGARIS	--	302	128	331	65	826
ANTHURIDAE-UNIDENTIFIED SPP.	--	2	--	--	--	2
COPEPODA-UNIDENTIFIED SPP.	--	9	2	4	19	34
PHOTIS BREVIPEDES	--	3	--	--	--	3
COROPHUM ACEROSICUM	--	4	--	--	10	14
GRANULOTERELLA JAPONICA	--	9	15	--	--	24
GAMMARIDAE-UNIDENTIFIED SPP.	--	1	--	--	--	1
SARSIELLA SP.	--	1	--	--	--	1
DECAPODA-UNIDENTIFIED SPP.	--	1	5	--	--	6
PHOTIS SP.	--	--	20	--	--	20
SYNDIUSIEA LATICAUDA	--	--	3	--	--	3

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Table 18 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
BALANUS CRENATUS	--	--	2	--	--	2
PYGMAEIDAE-UNIDENTIFIED SPP.	--	--	1	1	1	3
ACHAEIDAE-UNIDENTIFIED SPP.	--	--	--	1	--	1
INSECTA-UNIDENTIFIED SPP.	--	--	--	1	--	1
CALLIANASSA CALIFURNIENSIS	--	--	--	--	1	1
MOLLUSCA						
MACOMA ACULASTA	1	7	2	--	--	10
MACOMA INJUNATA	3	6	3	1	14	27
MACOMA VASUTA	136	201	112	99	85	636
TELLINA MUDESTA	2	--	2	--	1	5
TAPES JAPONICA	2	1	--	--	--	3
GEMMA GEMMA	2075	2508	2047	2913	20+	11047
TRANSENNELLA TANTILLA	12	1	--	8	--	21
MYSELLA FERRUGINOSA	11	2	7	3	5	20
MUSCULUS SEMMOUSIA	45	1	3	4	1	54
SILIQUA PATULA	1	--	--	--	--	1
MACOMA GALTHICA - JUVENILE	2	--	--	--	--	2
SILIQUA SLOATI	2	--	--	--	--	2
ADULA DIEGENSIS	1	--	--	--	--	1
MYTILUS EDULIS	3	--	3	8	4	18
PELECYPODA-UNIDENTIFIED SPP.	1	--	--	--	--	1
ODOSTOMIA (EVALCA) TENUSCULPTA	1	--	--	--	--	1
LYONSIA CALIFORNICA	--	2	--	--	--	2
ECTOPROCTA						
HIPPOTHOA HYALINA	P	--	--	--	--	P
MEMBRANIPUKA PERFRAGILIS	P	--	--	--	--	P
FILICRISIA GENICULATA	P	--	--	--	--	P
BUGULA NERITINA	--	P	P	P	--	P
BUGULA CALIFORNICA	--	P	--	--	--	P
TRICELLARIA TERNATA	--	P	--	--	--	P
BUGULA SP.	--	P	--	--	--	P
TRICELLARIA SP.	--	--	P	--	--	P
CRYPTOSULA PALLASIANA	--	--	P	--	P	P
CRISIA MAXIMA	--	--	P	--	--	P
FILICRISIA SP.	--	--	P	--	--	P
ALCYONIDIUM PARASITICUM	--	--	--	P	--	P
CUNUPEUM RETICULUM	--	--	--	--	P	P

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Table 18 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	P (3/73)	SURVEY				
		1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
ECHINODERMATA HOLOTHUROIDEA-UNIDENTIFIED SPP. CF LEPTOSYNAPTA SP.	--	341	223	65	--	629
	--	1	--	--	--	1
CHORDATA CLONA INTESTINALIS	--	--	2	--	--	2
ENIGMATICA ENIGMATICA	2	--	4	--	--	6
GRAND TOTALS SPECIMENS TAXA	21153 76	28784 66	41772 59	34311 54	5236 44	131256 137

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Table 19
CONCENTRATIONS OF THE MOST ABUNDANT BENTHIC ORGANISMS
COLLECTED AT STATION OIH
(Individuals per Liter)

Percentage of Population*	Survey				
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda					
4.7%					
Oligochaeta	8.27	20.35	54.10	89.56	52.03
31.8	132.05	277.17	491.73	525.46	69.80
Polychaeta					
<u>S. benedicti</u>	289.59	372.18	855.26	567.23	18.92
45.2	53.27	14.63	44.26	18.76	10.62
<u>E. lourei</u>	1.73	11.09	31.53	0.24	0
3.3					
<u>P. paucibranchiata</u>					
0.9					
Mollusca					
<u>G. gemma</u>	56.08	85.78	118.35	116.99	6.67
8.4	540.99	781.20	1,595.23	1,318.24	158.04
94.3%	571.70	849.08	1,677.59	1,377.95	171.11
100.0					
All organisms†					

* Numerical percentage of all noncolonial organisms collected.
† All noncolonial organisms collected.

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1974, the size of the population declined markedly, and this decline continued in June when only 5,236 noncolonial specimens were collected.

In all sampling periods except for June 1974, the polychaetes were the most diverse and abundant group, contributing 55 species to the total. Nine percent of the total noncolonial specimen count was molluscs, of which we collected 17 species. Although we collected 32 species of arthropods, only 2.5% of the total number of noncolonial animals collected belonged to this group.

In March 1973, the polychaetes numbered 34 species, represented by 13,323 individuals or about 360/liter. Six of these species were not encountered in subsequent sampling periods. As indicated in Table 19, S. benedicti and E. lourei not only were the most abundant of all species collected in March 1973, but they also were the most abundant of all polychaete species for all five surveys.

Fewer polychaete species (29) were encountered in September; two species, represented by a total of four specimens, were found only during that month. S. benedicti, E. lourei, and Pseudopolydora paucibranchiata were the most abundant species, accounting for 96.4% of the polychaete count of 13,999 specimens (412.9/liter) in September. In December, we encountered 35 species of polychaetes, represented by 23,930 individuals (or about 961/liter)--the highest polychaete concentration encountered at OIH. The most abundant polychaete species were S. benedicti, E. lourei, and P. paucibranchiata. S. benedicti accounted for 855.3/liter. Five of the species collected in December were not found during the other sampling months.

Thirty-three species of polychaete were collected in March 1974, all but six appearing also during at least one of the other surveys. The most abundant species were S. benedicti (by far the most numerous--about 567 of the 602.0 polychaetes per liter of sediment), E. lourei, and Sphaerosyllis sp. Only six specimens of P. paucibranchiata were collected.

In June, we observed a marked decline in the size of the benthic population at OIH. The polychaetes were affected more than any other group. Fewer species (22) were present, and,

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although S. benedicti was still the most abundant polychaete, it was not the most abundant species. P. paucibranchiata, which declined considerably in number in March 1974, was absent in June, and the number of E. lourei decreased slightly. In June, Spiophanes missionensis appeared for the first time and was represented by one specimen.

As mentioned earlier, we collected 32 arthropod taxa from OIH during the study. The most abundant group was the Ostracoda. Representatives of this group comprised about 47% of the total number of arthropod specimens collected at this station during the study. Only after the September 1973 sampling period did we develop the capability to identify the ostracods to the specific level and, upon identifying those collected in subsequent surveys, found that they were Sarsiella zostericola. The relatively large number of unidentified ostracods collected in March and September 1973 possibly were this species (see Table 18).

The mollusc community was composed primarily of the clam Gemma gemma (93.2% of the 11,859 mollusc specimens collected belonged to this species). The number of individuals increased from about 56/liter in March 1973 to about 118/liter in December 1973. The population density in March 1974 did not change, but as happened with other species, the concentration declined markedly in June 1974.

Macoma nasuta was another relatively abundant and common mollusc, as were Macoma inquinata, Mysella ferruginosa, and Musculus senhousia.

Hunters Point Disposal Site

We found 138 different kinds of benthic animals in the sediment samples collected at the Hunters Point disposal site. Table 20 lists the animals and their abundance. Fifty-eight of the specimens were polychaetes, 28 were arthropods, 20 were molluscs, 11 were bryozoans (Ectoprocta), and 24 belonged to other groups such as the Protozoa, Porifera, Nematoda, Cnidaria, Nemertea, Oligochaeta, Sipuncula, Echinodermata, Phoronida, and Chordata; one specimen could not be placed in any known taxonomic category.

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Table 20
DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION HP

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
PROTIZUA FOKAMINIFERA-UNIDENTIFIED SPP.	--	--	1	--	--	1
PORIFERA PORIFERA-UNIDENTIFIED SPP.	--	--	--	--	P	P
CNIDARIA DIADUMENE SP. HALIPLANELLA SP. HYDROZUA-UNIDENTIFIED SPP. GONUTHYRAEA SP. CALYPTOBLASTEA-UNIDENTIFIED SPP. CAMPANULARIA SP. BIMERIA SP.	32 32 P P P -- --	4 22 -- P -- -- --	74 23 -- -- -- P --	-- 19 -- -- -- P --	-- 20 -- -- -- P P	110 116 P P P P P
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	47	40	48	32	43	210
NEMATODA NEMATODA-UNIDENTIFIED SPP.	13	109	80	21	51	274
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	14	61	141	29	41	286
ANNELIDA-POLYCHAETA CAPITELLIDAE-UNIDENTIFIED SPP. MEDIOASTUS CALIFURNIENSIS THARYX PARVUS ASYCHIS SP. POLYDORA SOCIALIS STREBLUSPIU BENEDICTI SCHISTOMERINGOS LONGICORNIS NEPHYS CUKNUTA FRANCISCANA EUSONE LOUREI POLYCHAETA-UNIDENTIFIED JUVENILE	1 279 8 15 5 13 3 3 1404 3	-- 241 30 19 -- 51 2 2 754 --	-- 632 55 31 -- 9 10 547 --	-- 276 -- 52 -- 14 5 200 --	1 404 21 30 -- 3 6 23 754 --	2 1962 114 147 5 90 19 123 3661 3

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Table 2J (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	P (3/73)	SURVEY				
		1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
CAPITELLA LAPIDATA	10	14	2	2	3	30
CIRRIATULUS CIRRIATULUS	10	5	7	5	41	60
COSSUSA PYGMAEALTYLATA	5	2	4	1	3	15
LAUSCHMANIA SP.	1	--	--	--	--	1
IMARXA SP.	2	--	--	24	7	25
SPHACROSYLLIS SP.	2	8	9	14	20	53
GLYCEA AMERICANA	1	3	--	--	--	4
ANATIDES WILLIAMSII	1	--	--	--	--	1
HELEKOMASTUS FILIFORMIS	3	4	--	--	--	7
ARMANDIA BREVIS	1	5	10	5	1	32
GYPTIS BREVIPALPA	1	--	--	1	1	3
BOUGARJIA TRUNCATA	--	1	--	--	--	1
POLYDORA SP.	--	4	3	--	--	7
ETHEUNE LUNGA CALIFORNICA	--	1	1	3	4	6
GLYCERA SP.	--	1	--	1	1	3
NEPHIYS LAELIODES	--	1	--	--	--	1
NEPHIYS PARVA	--	1	--	--	--	1
PHOLUE MINUTA	--	1	1	2	1	5
HARMOTHOP IMBRICATA	--	2	--	--	--	2
POLYDORA SOCIALIS	--	3	11	5	2	21
GLYCIDAE SP.	--	7	3	2	27	41
SPILOPHANES FIMBRIATA	--	1	1	--	--	2
PULFODORA SOCIALIS	--	1	--	--	--	1
CAPITITA AMBIDETA	--	--	1	--	--	1
EXOGONE SP.	--	--	1	--	--	1
ATOLYTUS SP.	--	--	1	--	5	6
PSEUDOPOLYDORA FAUCIBRANCHIATA	--	--	1	--	--	1
POLYDORAE-UNIDENTIFIED SPP.	--	--	1	--	--	1
TRICHOCHAETA MULTISETOSUM	--	--	2	2	2	6
CHAEILAZONE SP.	--	--	1	--	--	1
HAPLOSULCULUS PUGETIENSIS	--	--	1	--	1	2
PRIONOSPION CIRRIFERA	--	--	2	--	--	2
ETHEUNE VILATAE	--	--	2	--	--	2
POLYDORA LONGI	--	--	--	2	52	54
GLYCEA LANCEPHALA	--	--	--	1	--	1
SPHACROSYLLIS PUGETIENSIS	--	--	--	1	--	1
NUTICIASIUS COLLEGIOMASTUS TENNIS	--	--	--	3	--	3
SPILOPHANES MISSISSIPPIENSIS	--	--	--	1	--	1
PILANGIS SP.	--	--	--	--	--	--
POLYDORA CAULENTYI	--	--	--	15	25	40

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Table 20 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY				SPECIMEN TOTAL
	1 (3/73)	2 (9/73)	3 (12/73)	4 (3/74)	
STHENELELLA UNIFORMIS	--	--	--	--	1
ANATITIDES SP.	--	--	--	--	1
PALEANGIUS BELLIS	--	--	--	--	1
PRIONOSPION SP.	--	--	--	--	1
NEAR AMPHIDURUS PACIFICUS	--	--	--	--	1
TYPOSYLLIS SP.	--	--	--	--	1
SABELLIDAE-UNIDENTIFIED SPP.	--	--	--	--	1
SABELLARIA SP.	--	--	--	--	1
SIPUNCULA	1	1	--	1	5
SIPUNCULA-UNIDENTIFIED SPP.	--	--	--	--	2
SIPUNCULUS SP.	--	--	--	--	--
ARTHROPODA	1094	8635	42	5	10445
COROPHIUM SP.	51	239	63	37	387
AMPELISCA MILLERI	15	1	1	1	18
LEPTUCHELLA DUBIA	1	4	--	--	5
PYROMATA TUBERCULATA	1	--	--	--	1
OSTRACODA-UNIDENTIFIED SPP.	1	--	--	--	1
UPOGEBIA SP.	1	--	--	--	1
CUMACEA-UNIDENTIFIED SP. B	1	--	--	--	1
EUDORELLA PACIFICA	1	--	--	--	1
SARSIELLA ZOSTERICULA	1	--	--	--	1
COROPHIUM ACHERUSICUM	--	5	52	12	129
COROPHIUM INSIDIOSUM	--	13	1	272	283
BALANUS KRENATUS	--	7	--	--	7
PHOTIS SP.	--	--	7	--	7
ALARINA-UNIDENTIFIED SPP.	--	--	1	1	2
UPOGEBIA PUGETIENSIS	--	--	1	--	43
PHOTIS SP., CF. BREVIPE	--	--	--	1	1
EUDORELLA SP.	--	--	--	1	1
PROTOMEDEIA SP.	--	--	--	14	14
PARAPLEUSTES PUGETIENSIS	--	--	--	1	1
DECAPODA-UNIDENTIFIED SPP.	--	--	--	3	3
CUMEPODA-UNIDENTIFIED SPP.	--	--	--	1	1
CUMELLA VULGARIS	--	--	--	4	4
PARAPLEUSTES SP.	--	--	--	2	2
ANUMUKA-UNIDENTIFIED LARVA	--	--	--	4	4
MYTHOPANUSPEUS HARRISII	--	--	--	1	1
CANCER JORDANI	--	--	--	1	1

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Table 20 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	1 (3/73)	2 (9/73)	3 (12/73)	4 (3/74)	5 (6/74)	
CAPRILLIDAE-UNIDENTIFIED SPP. PYCNOGONIDAE-UNIDENTIFIED SPP.	-- --	-- --	-- --	-- --	2 1	2 1
JULLUSCA						
GEMMA GEMMA	4	--	1	4	2	11
TRANSENNELLA TANTILLA	12	1	--	--	3	16
MUSCULUS SENHOUSSIA	5	1	1	1	2	10
MACOMA ACULASIA	1	--	--	--	--	1
ADULA DIEGENSIS	1	1	--	--	--	2
MYA ARENARIA	2	--	--	--	1	3
MYSELLA FERRUGINOSA	1	--	2	1	1	5
PETRICULA SP. CF. CARUTIIDES	--	1	--	--	--	1
LYNSIA CALIFORNICA	--	1	--	--	--	1
MACOMA NASUTA	--	1	--	4	--	5
MACOMA BALTICA	--	--	1	5	2	8
PUDUCUSMUS SP. - JUVENILE	--	--	1	--	--	1
MYTILUS EDULIS	--	--	1	--	11	12
ALVINIA COMPACTA	--	--	3	--	--	3
PROFUTHACA STARINEA	--	--	1	--	--	1
TAPES JAPONICA	--	--	1	--	1	2
MACOMA INQUINATA	--	--	1	--	3	4
OSTREA LURIDA	--	--	--	--	1	1
MODIOLUS SP.	--	--	--	--	1	1
MAIELLA ARCTICA	--	--	--	--	1	1
ECTOPROCTA						
BUMERANKIA GRACILIS	P	--	--	--	--	P
CYCLOSTOMATA-UNIDENTIFIED SPP.	P	--	--	--	--	P
SCROPUCCELLARIA SP.	P	--	--	--	--	P
BUGULA SP.	--	--	--	--	P	P
HIPPURIDAE MYALINA	--	--	P	--	P	P
SMITTIDIA PROLIFICA	--	--	P	--	--	P
ELECTRA ARCTICA	--	--	P	--	--	P
ALYUNIDIA PARASITICUM	--	--	P	--	--	P
SMITTINA PROLIFICA	--	--	P	--	--	P
ANASCA-UNIDENTIFIED SPP.	--	--	P	--	--	P
ORIENTISIA SP.	--	--	--	--	P	P
ENT. PROCTA						
GARENTSIA SP.	--	--	--	--	P	P
ECHINODERMATA						
HELMINTHOCA-UNIDENTIFIED SPP.	4	1	--	--	1	6

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Table 20 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY				SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
OPHIUREIDS SP.	--	--	--	--	1
PHORONIDA					
PHORONIS SP.	1	1	2	--	1
PHORONOPSIS VIRIDIS	--	--	3	--	3
PHORONIDA-UNIDENTIFIED SPP.	--	--	--	--	1
CHORDATA					
TUNICATA-UNIDENTIFIED SPP.	--	1	--	--	1
ENIGMATICA					
ENIGMATICA	--	--	1	--	2
GRAND TOTALS SPECIMENS	311	10514	1945	841	2601
TAXA	51	50	61	46	33
					19012 137

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These animals were most abundant in September. During that month, we recovered individuals at an average of about 337/liter of sediment, as shown in Table 21. About 60/liter were removed from sediment collected in March 1973; however, only about 28/liter were found in sediment collected in March 1974, the month the fewest numbers of species and specimens were collected. In December 1973 and June 1974, the average numbers of organisms per liter were 67 and 90, respectively.

Table 21 lists each taxon that constituted at least 1% of the total number of noncolonial organisms obtained at HP and the average concentration of each specimen per liter. Only eight of the taxa met the 1% criteria of abundance. Listed in order of decreasing abundance, these were Ampelisca milleri (Arthropoda), Exogone lourei (Polychaeta), Mediomastus californiensis (Polychaeta), Leptochelia dubia (Arthropoda), Oligochaeta, Corophium acherusicum (Arthropoda), Nematoda, and Nemertea. Together, these taxa constituted 91.4% of the total noncolonial specimen count for HP.

The arthropods were the most abundant group at HP, their numerical dominance being attributable primarily to one species--Ampelisca milleri. This amphipod accounted for 91.8% of the total number of arthropods collected and about 55% of the total noncolonial specimen count. The high concentration of benthic organisms in September resulted from the appearance of large numbers of this amphipod that accounted for about 84% of the total number of noncolonial specimens collected. (The numbers of A. milleri collected during the other sampling months were not outstanding.)

Totaling 2.0% of the benthic population, Leptochelia dubia was not particularly abundant except in September 1973. Corophium acherusicum was absent in March of 1973 and 1974; but in June, this amphipod was quite abundant (272 specimens, 9.4/liter).

The most diverse group encountered was Polychaeta, of which we collected 58 species. Numerically, the polychaete population constituted about 34% of the total noncolonial organism count. Eleven of the species appeared in each survey period, but only Exogone lourei and Mediomastus californiensis appeared in significant numbers, the two making up 84.6% of the total number of polychaetes collected.

Table 21
CONCENTRATIONS OF THE MOST ABUNDANT BENTHIC ORGANISMS
COLLECTED AT STATION HP
(Individuals per Liter)

Percentage of <u>Population*</u>	<u>Survey</u>					
	<u>P</u> (3/73)	<u>1</u> (9/73)	<u>2</u> (12/77)	<u>3</u> (3/74)	<u>4</u> (6/74)	
Nemertea	1.1%	0.91	1.28	1.65	1.08	1.49
Nematoda	1.4	0.25	3.49	2.75	0.71	1.77
Oligochaeta	1.5	0.27	1.96	4.84	0.97	1.43
Polychaeta						
<u>E. lourei</u>	19.2	27.26	24.17	18.80	6.73	26.25
<u>M. californiensis</u>	9.8	5.42	7.72	22.75	9.29	14.03
Arthropoda						
<u>A. milleri</u>	54.9	21.24	283.17	1.44	1.24	15.17
<u>L. dubia</u>	2.0	0.99	7.66	2.16	0.24	0.94
<u>C. acherusicum</u>	1.5	0	0.32	0.03	0	9.44
Total	91.4%	56.34	329.77	54.42	20.26	70.52
All organisms [†]	100.0	60.40	336.99	66.84	28.32	90.31

* Numerical percentage of all noncolonial organisms collected.

† All noncolonial organisms collected.

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We recovered similar numbers of E. lourei per liter of sediment in March 1973, September 1973, and June 1974. Their concentration during these months fell in the range of 24 to 27/liter. A slight decrease in concentration was observed in December; and, in March 1974, the E. lourei population fell off markedly to about 7/liter.

The density of the Mediomastus californiensis population increased from about 5.4/liter in March 1973 to a peak of about 23/liter in December 1973, decreased by about 59% in March 1974, and increased to 61.6% of peak size in June 1974.

The nemerteans, nematodes, and oligochaetes were present during all sampling months, but none were particularly abundant in any of the surveys.

South Bay Disposal Sites

Station SB-A

As shown in Table 22, we collected a total of 91 taxa and 32,646 noncolonial specimens from Station SB-A between March 1973 and June 1974. The collection included 31 polychaetes, 17 arthropods, 16 molluscs, 10 bryozoans, and 7 cnidarians. Ninety-five percent of the 32,646 noncolonial specimens belonged to 14 of the 91 taxa. The 14 taxa are listed in Table 23.

Aquatic disposal of dredged sediment can be detrimental to benthic organisms in the disposal area, but we found no evidence of adverse effects at SB-A where disposal of dredged material occurred after the first census in March 1973. However, about seven months had passed from the time of disposal to the time of population censusing, a lapse of time probably sufficient to obscure any immediate effects. In addition, March 1973 appears to have been a poor reference period, because the sediment in the southern portion of the bay was not as well populated then as during the other sampling months.

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SB-A

Table 22
DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION SB-A

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	1 (3/73)	2 (9/73)	3 (12/73)	4 (3/74)	5 (6/74)	
PROTIZOA FUKAMINIFERA-UNIDENTIFIED SPP.	--	--	15	2	--	15
Cnidaria GONATHYRAEA SP. DIADUMENE SP. HALIPLANELLA SP. CALYPTOBLASTEA-UNIDENTIFIED SPP. Cnidaria-UNIDENTIFIED SPP. CAMPANULARIA SP. SERTULARIA SP.	P 3 3 P P -- --	P -- 1 P 1 -- --	-- 3 19 -- -- P --	-- 3 52 -- -- P --	-- -- -- -- 0 P P	P 9 75 P 0 P P
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	22	--	6	4	--	32
NEMATODA NEMATODA-UNIDENTIFIED SPP.	275	22	1974	442	115	2935
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	152	357	5071	1147	1294	6970
ANNELIDA-POLYCHAETA PSEUDOPOLYDORA PAUCIBRANCHIATA POLYDORAE-UNIDENTIFIED SPP. HELEOMASTUS FILIFORMIS HELEOMASTUS CALIFORNENSIS LUSKURA PTODACTYLATA ASYCHIS SP. POLYDORA CAULIKERYI POLYDORA SOLIALIS EUDORAE LUDKEI SPHACROSYLLIS SP. CIRRATULUS CIRRATUS HAPLOSULCULUS PUGETENSIS ULYGINDE SP.	2 1 159 11 30 20 20 1 228 1 9 7 1	1 7 53 4 5 35 397 -- 1387 68 1 1 2 7	1 -- 164 -- 24 3 35 -- 618 144 -- -- 4 3	8 0 255 -- 8 16 112 -- 1557 456 -- -- -- --	-- 257 -- 2 17 23 -- 243 22 3 -- -- 13	12 6 173 23 69 91 549 1 479 721 13 15 29

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Biological Characteristics
SB-A

Table 22 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY						SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)		
CIRRIFORMIA SPIKARACHMA							
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	17	105	--	1		2
SCHISTOMERINUS LONGICORNIS	7	11	84	17	16		162
STRELOSPIR BENEDICTI	4	135	3	20	5		49
MAKMUHUE INURICATA	--	15	26	31	230		454
CAPITELLA CAPITATA	--	4	3	10	12		28
POLYDORA LONGI	--	1	1	3	42		86
ETEUNE LINGA CALIFORNICA	--	1	1	20	53		95
AUTOLYTUS SP.	--	1	2	--	65		67
POLYDORA SP.	--	1	--	--	--		3
MAKMUHUE SP.	--	2	2	--	--		1
ETEUNE OILATAE	--	2	--	5	--		12
THARYX PARVUS	--	--	8	--	--		2
ETEUNE LIGHTI	--	--	3	1	25		8
THARYX SP.	--	--	3	--	--		30
MARPHYSA SANGUINELA	--	--	3	3	2		5
CAPITELLIDAE-UNIDENTIFIED SPP.	--	--	3	3	2		9
UDONTOSYLLIS PARVA	--	--	--	4	--		4
				20	--		20
ARTHROPODA							
AMPELISCA MILLERI	154	6531	60	55	774		7574
LEPTUCHELLA DUBIA	2	5	--	5	3		15
OSTRACODA-UNIDENTIFIED SPP.	50	54	1	--	--		105
COPEPODUM ACHERUSICUM	13	14	4	8	455		494
COPEPODA-UNIDENTIFIED SPP.	--	4	24	393	12		423
SAKSIELLA ZOSTERICOLA	--	222	148	114	43		527
PYCNOGONIDA-UNIDENTIFIED SPP.	--	4	1	4	2		11
GRANDIDIELLELLA JAPONICA	--	2	3	1	15		22
PARAPLEUSTES PUGETENSIS	--	5	2	--	14		21
PYROMAIA TUBERCULATA	--	1	--	--	--		1
SYNIOIDEA LATICAUDA	--	31	4	1	3		39
CUMELLA VULGARIS	--	1	--	--	1		2
DECAPODA-UNIDENTIFIED SPP.	--	2	--	--	--		2
ALACINA-UNIDENTIFIED SPP.	--	--	43	2121	17		2121
COPEPODUM INDIUM	--	--	1	--	--		1
PARAPLEUSTES SP.	--	--	--	1	--		1
COPEPODUM SP.	--	--	--	--	1		1
MOLUSCA							
TAPES JAPONICA	113	153	701	157	73		1772

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Table 22 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
MUSCULUS SEMITRANSIA	200	3	1	700	21	1310
URUSALPINA CINEREA	2	--	--	2	--	4
ISALICA OVULIDEA	1	3	60	15	23	115
AGULA VIRGENSIS	1	--	--	--	--	1
MACOMA NASUTA	1	1	2	--	--	4
GEMMA GEMMA	--	--	60	1	3	64
MYA ARENARIA	--	--	2	1	3	6
CREPIDULA CONVEXA	--	--	4	1	3	10
UOSTOMIA (MENESIMUS) FETELLA	--	--	1	--	--	1
USITREA LUNATA	--	--	1	--	--	1
MACOMA BALTHICA	--	--	2	1	--	3
NUDULORANGIA-UNIDENTIFIED SPP.	--	--	5	--	4	11
CREPIDULA FLATA	--	--	--	1	--	1
BUSYCON CANALICULATUM	--	--	--	1	--	1
EPITOMIUM FUNCTUM	--	--	--	3	--	5
LITOPROCTA						
MEMORAVIPUKA PUNFRAGILIS	P	--	--	--	--	P
MEMORAVIPURELLA SP.	--	--	P	--	--	P
CONQUEM RETICULUM	--	--	P	P	--	P
CHEILUSTOMATA-UNIDENTIFIED SPP.	--	--	--	--	--	P
ALCYONIDIUM PULYUUM	--	--	--	P	P	P
ELECTRA CRUSTULENTA	--	--	--	--	P	P
CONQUEM COMENSALIS	--	--	--	--	P	P
ALCYONIDIUM PARASITICUM	--	--	--	--	P	P
MEMORAVIPUKA VILLOSA	--	--	--	--	P	P
SCRUPUCCELLARIA SP.	--	--	--	--	P	P
CHORDATA						
ASCIJACEA-UNIDENTIFIED SPP.	7	27	--	--	--	27
SYIELA SP.	1	--	--	--	--	1
IONICATA-UNIDENTIFIED SPP.	--	71	--	--	--	71
CIOMA INTESTINALIS	--	--	23	1	3	127
FISH LARVAE	--	--	--	3	--	3
ENIOMATICA						
ENIOMATICA	1	--	--	--	1	2
GRAND TOTALS SPECIMENS TAXA						
	1406	900	453	1000	471	3200
	39	43	55	52	51	241

Results and Discussion
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SB-A

Table 23

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION SB-A
(Individuals per Liter)

	Percentage of Population*	Survey				
		P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	8.7%	6.25	0.65	63.27	14.50	3.33
Oligochaeta	21.4	3.00	10.62	129.52	37.12	37.16
Polychaeta						
<u>E. lourei</u>	13.4	5.18	41.34	29.42	50.48	8.13
<u>H. filiformis</u>	2.7	3.61	1.73	5.26	7.60	7.38
<u>Sphaerosyllis</u> sp.	2.2	0.02	2.02	4.62	15.73	0.63
<u>P. caulleryi</u>	1.8	0.45	11.82	1.15	3.62	0.66
<u>S. benedicti</u>	1.4	0.09	4.02	2.69	1.00	5.75
Arthropoda						
<u>A. milleri</u>	23.2	3.50	194.38	1.92	1.78	22.24
Acarina	6.7	0	0	1.38	68.64	0.49
<u>S. zostericola</u>	1.6	0	6.61	4.74	3.69	1.24
<u>C. acherusicum</u>	1.5	0.30	0.42	0.13	0.26	13.07
Copepoda	1.3	0	0.12	0.77	12.39	0.34
Mollusca						
<u>T. japonica</u>	6.0	2.57	4.61	25.35	4.82	21.95
<u>M. senhousia</u>	3.1	4.54	0.24	0.03	25.24	0.60
Total	95.0%	29.51	278.58	270.25	246.87	122.97
All organisms†	100.0	33.77	288.10	283.94	255.66	135.66

* Numerical percentage of all noncolonial organisms collected.

† All noncolonial organisms collected.

Results and Discussion
Biological Characteristics
SB-A

In March 1973, we recovered only 1,486 noncolonial specimens from our sediment samples, a sampling return that amounted to only 33.8/liter. Only 39 different taxa were found. In contrast, the average concentration of organisms in March 1974 was about 256/liter and 52 different taxa were collected. In March 1973, three of the abundant species were absent, and four of them numbered less than 1/liter.

During the next three surveys, the concentration of the animals in the sediment changed very little, the average for the three surveys being 275.9/liter, but the numerically dominant species changed from month to month. In September, the most abundant species was the arthropod Ampelisca milleri, constituting 67.5% of the total noncolonial specimen count and about 95% of the total arthropod count. Sarsiella zostericola accounted for over half of the remaining arthropod count in September and gradually decreased in number in the subsequent months. The 50 unidentified ostracods collected in March 1973 may have been this species.

The polychaete Exogone lourei was the second most abundant animal collected in September, accounting for 14.3% of the total noncolonial specimen count. This organism was the most abundant polychaete for each sampling month. Approximately 68% of all specimens of Polydora caulleryi were collected in September.

In December, the oligochaetes were the most abundant, and they made up about 46% of the noncolonial organisms collected. The nematodes were the second most abundant animal type. Together, the oligochaetes and the nematodes constituted 67.9% of the total population count in December. During this month, we also observed a significant increase in the number of Tapes japonica, a mollusc present during all five surveys but most (and equally) abundant in December 1973 and June 1974.

In March 1974, we removed a large number of aquatic mites (Acarina) from our samples. These arthropods constituted 26.8% of the 7,900 noncolonial organisms collected during that month, and they were the most abundant organisms. We did not encounter any of them in the March and September 1973 samples, but we collected a total of 60 in December 1973 and June 1974.

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SB-B

The polychaete E. lourei was the third most abundant animal collected at SB-A during the study and was most abundant in March 1974. In March 1974, we also observed a sizable increase in the number of Musculus senhousia, a mollusc that accounted for about 81% of all molluscs collected during that month. Other organisms that were more abundant in March than in any other month were the polychaete Sphaerosyllis sp., the mollusc Musculus senhousia, and the copepods.

Between March and June 1974, the size of the benthic population at SB-A decreased by about 47%. Although they were no more numerous than in the previous sampling month, the oligochaetes were the most abundant organism collected in June. The arthropods Ampelisca milleri and Corophium acherusicum became more abundant than in the two previous sampling months.

Station SB-B

The sediment at Station SB-B was not disturbed by disposal operations during the study. We collected approximately the same number of noncolonial organisms and a few more taxa at this station than at SB-A. The numerically dominant taxa were essentially the same at both stations.

The taxa identified at SB-B included 35 Polychaeta, 21 Arthropoda, 18 Mollusca, and 8 Ectoprocta. The 91 taxa are shown according to survey in Table 24, and the 15 most abundant types with concentrations are presented in Table 25. These abundant forms constituted about 93% of the total number of noncolonial organisms collected.

The compositions of the benthic communities at SB-A and SB-B were different; 12 taxa belonging to the three major groups (Polychaeta, Arthropoda, and Mollusca) were found exclusively at SB-A, and 22 taxa were found only at SB-B. These mutually exclusive organisms were of little numerical significance, the total number of organisms representing these 30 taxa amounting to only 0.27% of the total number of noncolonial specimens collected at both stations.

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Table 24
DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION SB-B

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
PROTOZOA FORAMINIFERA-UNIDENTIFIED SPP.	--	--	--	--	3	3
PORIFERA KERATOSA-UNIDENTIFIED SPP. DEMOSPONGIAE-UNIDENTIFIED SPP.	P --	-- --	-- --	-- --	-- P	P P
CNIDARIA DIADUMENE SP. HALIPLANELLA SP. GONATHYKAE SP. CAMPANULARIA SP. HYDROZUA-UNIDENTIFIED SPP.	1 10 -- -- --	1 -- P -- --	-- -- P -- --	-- -- P -- --	-- -- P P	2 10 P P P
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	23	4	1	--	--	24
NEMATODA NEMATODA-UNIDENTIFIED SPP.	285	--	962	3	36	1286
ANNELIDA-ULIGUCHAETA ULIGUCHAETA-UNIDENTIFIED SPP.	461	35	2125	910	630	4241
ANNELIDA-POLYCHAETA CAPITELLA CAPITATA HETEROMASTUS FILIFORMIS COSSURA PYGODACTYLATA ASYCHIS SP. PSEUDOPOLYDORA NEMPI CALIFORNICA PSEUDOPOLYDORA PAUCIBRANCHIATA STREBLASPION BENEDICTI NEMPHYS CAECUIDES EXOGONE LOUREI SPHAEROSYLIS SP. SCHISTOMERINGOS LONGICORNIS	6 40 7 6 1 184 3 9 1094 36 3	2 123 9 19 5 -- 71 -- 224 -- 5	11 498 116 102 84 2 783 -- 2159 274 99	2 281 14 45 75 -- 101 -- 401 41 13	91 171 16 69 111 -- 1534 -- 645 98 12	112 1113 162 241 276 186 2492 8 4523 449 132

Results and Discussion
Biological Characteristics
SB-B

Table 24 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY				SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
MEDJMASTUS CALIFORNENSIS	1	--	--	--	1
ETEUNE LONGA CALIFORNICA	1	--	28	3	155
HAPLOSCULOPUS PUGETTENSIS	1	--	11	4	3
GLYLINDE SP.	2	1	1	1	22
CIRKATULUS CIRKATUS	--	8	301	44	41
PULYDORA CAULERYI	--	229	--	15	52
HARMUTHUE IMBRICATA	--	1	5	2	22
ETEUNE LIGHTI	--	--	20	3	27
PULYDORA LIGNI	--	--	206	233	151
PULYDORIDAE-UNIDENTIFIED SPP.	--	--	2	--	--
CIRKIFURIA SPIKABRANCHIA	--	--	1	--	--
LURKINERIDAE-UNIDENTIFIED SPP.	--	--	1	--	--
NEPHIYS CONNOTA FRANCISCANA	--	--	1	--	--
SCHISTOMERINUS SP. - JUVENILE	--	--	4	--	--
LYSIDICE NINETTA	--	--	30	--	1
PULYDORA CAECA	--	--	2	--	--
AUTULYTUS SP.	--	--	3	--	--
LUMIDA SP.	--	--	1	--	--
HARMUTHOE SP.	--	--	1	2	--
THARYX SP.	--	--	1	1	--
CHAETUZONE SP.	--	--	1	1	--
THARYX PARVUS	--	--	1	1	--
MARPHYSA SANGUINEA	--	--	--	2	--
TRUCHUCHAETA MULTISETUSUM	--	--	--	--	1
AKTHRUPUDA	22	30	--	--	--
OSTRACODA-UNIDENTIFIED SPP.	158	4	2	--	58
CURUPHIUM ACHENSICUM	7	4	5	--	1051
GRANULITIKELLA JAPONICA	252	5323	345	73	31
AMPELISCA MILLEKI	2	3	--	--	10900
SYNDOTEA LATICAUDA	1	--	--	--	8
CUNACEA-UNIDENTIFIED SPP. A	5	3	--	--	1
CURUPHIUM INSIDIOSUM	1	--	--	--	8
INSECTA-UNIDENTIFIED SPP.	1	--	--	--	1
SARSIELLA /OSTERIKULA	--	9	121	57	330
LEPTUCHELLA DUBIA	--	4	78	10	30
PYGODONTIDA-UNIDENTIFIED SPP.	--	4	7	3	20
PARAPLEUSTIS PUGETTENSIS	--	5	--	8	77
ARACHNIDA-UNIDENTIFIED SPP.	--	1	--	--	1
LIMNOPA JAPONICOPULATA	--	--	1	--	1

SB-E

Table 24 (Continued)

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Table 24 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY				SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
TUNICATA-UNIDENTIFIED SPP.	--	40	--	--	--
CLONA INTESTINALIS	--	--	4	--	25
AMARJUCIUM SP.	--	--	P	--	--
FISH LARVAE	--	--	--	1	--
ENIGMATICA	1	--	--	--	--
ENIGMATICA					1

GRAND TOTALS	2765	6344	10569	2456	15124	32662
SPECIMENS	43	35	60	43	47	99
TAXA						

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SB-B

Table 25

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION SB-B
(Individuals per Liter)

	Percentage of Population*	Survey				
		P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	3.9%	5.48	0	28.63	0.09	1.09
Oligochaeta	13.0	8.87	1.92	63.24	28.09	20.61
Polychaeta						
<u>E. lourei</u>	13.8	21.04	6.61	64.26	12.38	19.55
<u>S. benedicti</u>	7.6	0.06	2.09	23.30	3.12	46.48
<u>H. filiformis</u>	3.4	0.77	3.63	14.82	8.67	5.18
<u>P. ligni</u>	1.8	0	0	6.13	7.35	4.27
<u>C. cirratus</u>	1.4	0	0.24	10.74	1.36	1.24
<u>Sphaerosyllis</u> sp.	1.4	0.69	0	8.15	1.27	2.97
<u>P. caulleryi</u>	0.9	0	6.76	0	0.56	1.88
Arthropoda						
<u>A. milleri</u>	33.4	4.85	157.02	10.27	2.25	148.70
Acarina	5.7	0	0	55.24	0	0.24
<u>C. acherusicum</u>	3.2	3.04	0.12	0.06	0	26.88
<u>S. zostericola</u>	1.0	0	0.27	3.60	2.07	4.21
Mollusca						
<u>M. senhousia</u>	1.1	1.90	0.35	6.10	0.43	0.73
<u>T. japonica</u>	0.9	0.12	2.77	3.30	1.82	1.18
Total	92.5%	46.82	181.79	297.84	69.46	285.21
All organisms†	100.0	53.17	187.26	326.46	75.80	306.79

* Numerical percentage of all noncolonial organisms collected.

† All noncolonial organisms collected.

Results and Discussion
Biological Characteristics
RCH-A

Although we collected a similar number of organisms at both stations, the size of the benthic population at SB-B fluctuated much more than that at SB-A. In March 1973, each liter of sediment contained an average of 53 organisms; in September, the average increased to about 187/liter; in December, the size of the population peaked at approximately 326/liter (Table 25). After a 76.8% decline in March 1974, the animal concentrations increased again to about 307/liter.

In March 1973, the benthic community at SB-B was dominated by the polychaete Exogone lourei, which constituted approximately 40% of the 2,765 organisms collected (Table 24). The size of the E. lourei population decreased considerably in September, when the arthropod Ampelisca milleri appeared in very large numbers (nearly 84% of the total number of noncolonial organisms).

Environmental conditions between September and December 1973 appeared to be favorable for population growth of many species, with 11 of the 13 generally abundant species showing marked numerical increases by December. Six arthropod and 14 polychaete species, including the polychaete Polydora ligni, appeared for the first time. That month we also encountered a large number of Acarina (aquatic mites), which were absent in the two preceding sampling months and in March 1974.

Redwood City Harbor

After we first surveyed the Redwood City Harbor area in March 1973, a substantial amount of sediment was removed from RCH-A by hopper dredge. Nevertheless, when we conducted the second survey of the area in September 1973, the numbers of the taxa and of specimens collected were not reduced. If our second survey had been conducted sooner after removal of the sediment, we might have found a reduction at least in the number of animals.

Station RCH-A

Table 26 lists the taxa collected at Station RCH-A by survey. The most abundant species in all surveys was the arthropod

Results and Discussion Biological Characteristics

RCH-A

Table 26
DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION RCH-A

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
PROTOZOA FOKAMINIFERA-UNIDENTIFIED SPP.	--	4	1	7	11	23
PORIFERA HEXACTINELLIDA-UNIDENTIFIED SPP. POKIFERA-UNIDENTIFIED SPP.	-- --	-- --	-- --	-- --	P P	P P
UNIDARIA DIAOURENE SP. HALLIPLANELLA SP. JUNUTHYNAEA SP. CAMPANULARIA SP. HYDROZUA-UNIDENTIFIED SPP. CNIDARIA-UNIDENTIFIED SPP. SERTULARIA SP.	15 9 P -- -- -- --	-- P -- -- -- -- --	2 -- -- P -- -- --	2 -- -- P -- -- --	-- -- -- P P 1 P	19 15 P P P 1 P
PLATYHELMINTHES ? ACUELA-UNIDENTIFIED SPP.	1	--	--	--	--	1
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	21	3	--	1	--	25
NEMATODA NEMATODA-UNIDENTIFIED SPP.	58	741	462	517	1322	3200
ANNELIDA-ULIGOCHEA ULIGOCHEA-UNIDENTIFIED SPP.	78	2449	2166	1261	4381	15835
ANNELIDA-POLYCHAETA CAPITELLA CAPITATA HETEROMASTUS FILIFORMIS HETEROMASTUS SP. CUSCORA PYGODACTYLATA PSEUDOPOLYDORA PAUCIBRANCHIATA SCHISTOMERINUS LONGICORNIS	8 23 1 52 42 1	1 163 -- -- 15 --	-- 91 -- 19 37 --	2 53 -- 210 1 2	37 2+3 -- 102 -- 15	42 523 1 483 163 19

Results and Discussion
Biological Characteristics
RCH-A

Table 26 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
EXOGONE LOUREI	177	1739	589	882	1030	4417
HAPLOSCOLOPLUS PUGETTENSIS	2	--	--	2	1	5
HARPHYSA SANGALINEA	1	16	5	--	27	49
GLYCINDE SP.	2	5	1	2	22	33
ASYCHIS SP.	19	4	3	40	10	76
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	4	1	47	220	273
NEPHIYS CAECOIDES	1	--	--	--	--	1
SPHAERUSYLLIS SP.	2	104	146	345	257	654
DORVILLEIDAE-UNIDENTIFIED SPP.	1	--	--	--	--	1
THARYX SP.	1	--	--	5	--	6
ETEONE LUNGA CALIFORNICA	--	7	2	4	170	183
POLYNOIDAE-UNIDENTIFIED JUVENILE	--	1	--	--	--	1
POLYDORA CAULLEKYI	--	4	--	--	--	4
HARNUTHOE IMBRICATA	--	13	--	5	29	47
STREBLOSPIO BENEJICTI	--	30	3	313	2139	2485
POLYDORA LIGNI	--	258	462	175	88	983
POLYCIRRUS SP.	--	2076	4	1	3	2087
DURVILLEA SP.	--	1	--	--	--	1
POLYCHAETA-UNIDENTIFIED SPP.	--	1	--	--	--	1
POLYCIRRUS SP., NEAR TENUISETIS	--	1	--	--	--	1
ETEONE LIGHTI	--	--	1	2	110	113
PYGUSPIO SP.	--	--	1	--	--	1
POLYNOIDAE-UNIDENTIFIED SPP.	--	--	--	2	--	2
TEREBELLIDAE-UNIDENTIFIED SPP.	--	--	--	4	--	4
HARNUTHOE SP.	--	--	--	3	--	3
CAPITELLA SP.	--	--	--	2	1	3
AUTOLYTUS SP.	--	--	--	1	--	1
STREPTUSYLLIS SP.	--	--	--	--	1	1
SYLLIDAE-UNIDENTIFIED SPP.	--	--	--	--	1	1
ARTHROPODA						
COROPHIUM INSIGIOSUM	3	10	1	--	--	20
AMPELISCIA MILLERI	339	11553	5934	1975	4165	24026
PYRUNAIA TUBERCULATA	1	--	--	--	--	1
OSTRACODA-UNIDENTIFIED SPP.	6	--	--	--	--	6
LEPTOCHELIA DULIA	1	--	3	1	--	5
CUKUPHIUM ACHERUSICUM	1	15	--	13	296	325
SARSIELLA ZOSTERICOLA	--	165	183	229	264	842
INSECTA-UNIDENTIFIED SPP.	--	1	--	--	2	3
GRANDIDIERELLA JAPONICA	--	10	31	2	20	69

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Table 26 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
CURPHIUM SP.	--	2	4	1	--	7
PARAPLEUSTES PUGETTENSIS	--	1	--	--	10	11
SYNDIATEA LATILAUDA	--	24	--	2	1	27
PHYCNOGONIA-UNIDENTIFIED SPP.	--	1	--	2	--	3
COPEPODA-UNIDENTIFIED SPP.	--	4	36	72	182	294
CUMELLA VULGARIS	--	1	--	--	20	21
ACARINA-UNIDENTIFIED SPP.	--	--	185	569	957	1611
SARSIELLA SP.	--	--	4	--	--	4
SYNDIATEA SP.	--	--	1	--	6	7
BALANUS IMPROVISUS	--	--	--	--	1	1
HEMIGRAPSPUS UREGONENSIS	--	--	--	--	1	1
MOLLUSCA						
EPITONTIUM TINCTUM	1	--	--	--	--	1
URUSALPINX CINEREA	5	1	--	--	--	6
NASSARIUS OBSOLETUS	2	--	--	--	1	3
ODOSTOMIA (MENESTHO) FETELLA	2	--	--	--	--	2
MYA ARENARIA	1	--	1	--	2	4
TAPES JAPONICA	73	47	20	27	340	507
GEMMA GEMMA	1	1	--	1	7	10
MUSCULUS SENHOUSSIA	414	141	143	28	10	736
MACOMA NASUTA	4	--	--	5	3	12
MACOMA BALTHICA	1	--	--	--	--	1
ODOSTOMIA (EVALEA) VALDEZI	1	--	--	--	--	1
CHEPIDULA CONVEXA	--	6	--	--	--	6
MACOMA BALTHICA - JUVENILE	--	--	1	--	--	1
MYTILUS EDULIS	--	--	--	--	2	2
ECTOPROCTA						
MEMBRANIPORA MEMBRANACEA	--	P	--	--	--	P
ELECTRA ARCTICA	--	--	P	--	P	P
ECTOPROCTA-UNIDENTIFIED SPP.	--	--	--	P	--	P
MEMBRANIPORA VILLOSA	--	--	--	--	P	P
MEMBRANIPURELLA SP.	--	--	--	--	P	P
CHORDATA						
ASCIDIACEA-UNIDENTIFIED SPP.	2	--	--	--	--	2
CIOMA INTESINALIS	--	--	1	--	2	3

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Table 26 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY				SPECIMEN TOTAL
	SURVEY				
	1 (3/73)	2 (9/73)	3 (12/73)	4 (3/74)	
ENIGMATICA	1	--	--	--	1
GRAND TOTALS	1425	19671	10614	21914	60545
SPECIMENS	42	43	36	53	91
TAXA					

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RCH-A

Ampelisca milleri. This amphipod constituted 39.7% of the total noncolonial specimen count. The oligochaetes were also very numerous, accounting for 26.2% of the benthic organisms collected. Table 27 lists other abundant organisms including the oligochaetes and A. milleri.

In March 1973, we collected 42 types of organisms at RCH-A. These organisms comprised the nemerteans, nematodes, and oligochaetes, as well as 16 species of polychaetes, six species of arthropods, and 11 species of molluscs. A total of 1,425 noncolonial organisms, amounting to about 27 organisms/liter, were collected. The mollusc Musculus senhousia and the arthropod Ampelisca milleri were the most abundant species, constituting 52.8% of all noncolonial organisms collected during March 1973. A relatively large number of the polychaete Exogone lourei also was found.

In September 1973, we collected about the same number of species as in March, but the concentration of organisms was about 20 times greater in September. The taxa included 19 species of polychaetes, 12 species of arthropods, and 5 species of molluscs.

Ten of the polychaetes collected in September 1973 were not present during the preliminary survey (Table 26). These included three of the species we classified as abundant, Streblospio benedicti, Polydora ligni, and Polycirrus sp., the latter accounting for 46.5% of the total number of polychaetes collected in September. Only three of the 15 species of arthropods collected in March and September 1973 were common to both months. Of the nine collected in September, Grandidierella japonica, Corophium insidiosum, Synidotea laticauda, and possibly Sarsiella zostericola* were absent in March. Tapes japonica and Musculus senhousia were the most abundant molluscs in March and September 1973. In March, we collected 14 species of molluscs, but, in September, we collected only 5 species of which one was not present in March.

* The unidentified ostracods may have been this species.

Results and Discussion
Biological Characteristics
RCH-A

Table 27

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION RCH-A
(Individuals per Liter)

	Percentage of Population*	Survey				
		P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Nematoda	5.3%	1.12	22.45	14.13	20.57	42.37
Oligochaeta	26.2	1.50	74.21	66.24	42.03	316.70
Polychaeta						
<u>E. lourei</u>	7.3	3.40	52.70	18.01	29.40	33.01
<u>S. benedicti</u>	4.1	0	0.91	0.09	10.43	68.56
<u>Polycirrus</u> sp.	3.4	0	63.00	0.12	0.03	0.10
<u>P. ligni</u>	1.6	0	7.82	14.13	5.83	2.82
<u>Sphaerosyllis</u> sp.	1.4	0.04	3.15	4.46	11.50	8.24
Arthropoda						
<u>A. milleri</u>	39.7	6.52	350.09	183.30	65.83	133.49
Acarina	2.7	0	0	5.66	18.97	27.47
<u>S. zoostericola</u>	1.4	0	5.03	5.60	7.63	8.46
Mollusca						
<u>M. senhousia</u>	1.2	7.96	4.27	4.37	0.93	0.32
Total	94.3%	20.54	583.63	316.11	213.15	641.54
All organisms†	100.0	27.40	596.09	324.59	230.70	702.37

* Numerical percentage of all noncolonial organisms collected.

† All noncolonial organisms collected.

Results and Discussion
Biological Characteristics
RCH-B

Fewer species--36--were collected in December 1973 than in the previous sampling period. Our collection included 15 polychaete, 10 arthropod, and 4 mollusc species. Seven of the polychaete species present in September 1973 were absent in December, and two--namely, Eteone lighti and Pygospio sp.--were absent in March and September 1973. In December, we found three types of arthropod for the first time, and one of them, the Acarina, was relatively numerous. The decline in population size in December was caused primarily by a decrease in the number of Ampelisca milleri, Exogone lourei, and Polycirrus sp. The additional reduction observed in March 1974 was attributable to a 81.1% decrease in the size of the Ampelisca milleri population.

In June 1974, the size of the benthic population peaked. We collected approximately 702/liter. A total of 53 taxa--more than collected in any other month--were identified. The increased benthic population was attributable to a considerable increase in the number of nematodes, oligochaetes, Ampelisca milleri, and Streblospio benedicti. S. benedicti was absent in March 1973 and numbered less than 1/liter in September and December. The number collected increased significantly in March 1974, but the largest number was collected in June.

Station RCH-B

At Station RCH-B, we collected fewer species and about half the number of organisms as we did at RCH-A. Table 28 lists the types of organisms collected and the number recovered during each survey. As at RCH-A, the arthropod Ampelisca milleri was the most abundant organism at RCH-B, accounting for 32.3% of all noncolonial specimens and 84.9% of all arthropods. Although we found a large number of oligochaetes, we collected a larger number of the polychaete Streblospio benedicti, which constituted about 25% of all noncolonial organisms collected. Table 29 lists the 12 most abundant organisms found at RCH-B. Together, they constituted 95.5% of total noncolonial organisms collected.

The density of the benthic population was least in March 1973, when we collected organisms at the rate of about 38/liter of sediment (about 10 more than at RCH-A). The population

Results and Discussion
Biological Characteristics
RCH-B

Table 28
DISTRIBUTION AND ABUNDANCE OF SPECIES AT STATION RCH-B

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	2 (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
PROTISTOA						
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	44	38	520	662
CNIDARIA						
HYDROZOA-UNIDENTIFIED SPP.						
DIADUMENE SP.	P	--	--	--	P	P
MALIPLANELLA SP.	62	--	--	--	--	62
GONATHYRAEA SP.	20	--	--	--	--	20
CALYPTOBLASTEA-UNIDENTIFIED SPP.	P	--	--	--	--	P
CAMPANULARIA SP.	P	--	--	--	--	P
SYNCORYNE SP.	--	--	P	P	--	P
	--	--	--	--	P	P.
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	32	9	17	11	8	77
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	114	47	251	232	1584	2208
ANNELIDA-OLIGUCHAETA						
OLIGUCHAETA-UNIDENTIFIED SPP.	302	129	649	1429	2421	5430
ANNELIDA-POLYCHAETA						
HETEROMASTIUS FILIFORMIS	334	62	37	37	51	551
LUSSURA PYGODACTYLATA	24	46	204	229	76	570
ASYCHIS SP.	52	2	--	--	4	58
HAPLUSCLOPLUS PUGETTENSIS	5	1	--	--	--	6
POLYDORA SOCIALIS	2	--	--	--	--	2
PSEUDOPOLYDORA KEMPI CALIFORNICA	14	24	48	58	24	173
PSEUDOPOLYDORA SP.	1	--	--	--	--	1
STREBL-SP10 HENEDICTI	3	693	2655	3444	1242	6777
SCHISTOMERIDUS LONGICORNIS	17	--	2	2	2	23
GLYCIDOE SP.	2	--	--	--	4	11
MANULINDE IMBICATA	2	--	--	--	--	2
EXUGONE LUKEI	350	41	273	58	439	1147
SPHAEROSYLLIS SP.	6	--	53	4	334	431

Results and Discussion
Biological Characteristics
RCH-B

Table 28 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
POLYDORA CAULLERYI	7	--	--	--	--	7
POLYDORA SUCIALIS	6	--	--	--	--	6
PSEUDOPOLYDORA PAUCIBRANCHIATA	12	23	38	--	1	74
CIRKATULUS LIRRATUS	5	--	--	--	--	5
CIRKIFURMIA SPIRABRANCHIA	1	--	1	--	--	2
CHAETUZONE SP.	1	--	--	--	--	1
NEPHYTIS CAEGOIDES	1	1	--	1	--	3
LAPITELLA CAPITATA	--	2	19	9	21	51
THARYX PARVUS	--	--	1	--	--	1
POLYDORA LIGNI	--	--	4	1	9	14
CAPITELLIDAE-UNIDENTIFIED SPP.	--	--	--	2	2	4
ETEUNE LIGHTI	--	--	--	1	244	245
NEANTHES SUCCINEA	--	--	--	2	--	2
ETEUNE LONGA CALIFURNICA	--	--	--	--	5	5
HARMOTHUE SP.	--	--	--	--	1	1
SPIONIDAE-UNIDENTIFIED JUVENILE	--	--	--	--	1	1
MEDUSASTUS CALIFOKNIENSIS	--	--	--	--	3	3
SIPUNCULA	1	--	--	--	--	1
SIPUNCULA-UNIDENTIFIED SPP.	--	--	--	--	--	--
ARTHROPODA	2	--	55	2	677	736
COPEPODA-UNIDENTIFIED SPP.	2	--	--	--	--	2
LEPTUCHELIA DUBIA	4	--	--	--	--	4
PYROMAIA TUBERCULATA	10	7	--	--	4	21
OSTRACODA-UNIDENTIFIED SPP.	65	1195	2254	2241	5438	11193
AMPELISCA MILLERI	1	--	--	2	245	248
COROPHIUM ACHERUSICUM	2	--	--	--	--	2
COROPHIUM SP.	3	--	--	1	1	6
HYDRALGINA-UNIDENTIFIED SPP.	15	--	1	--	--	15
SYNDOTEA BICUSPIDA	--	1	--	--	--	1
SARSIELLA ZOSTERICOLA	--	14	270	146	380	790
GRANDIDIERELLA JAPONICA	--	8	2	--	72	80
SYNDOTEA LATICAUDA	--	2	--	--	--	2
ARACHNIDA-UNIDENTIFIED SPP.	--	--	1	--	--	1
CUMELLA VULGARIS	--	--	--	--	--	64
ACARINA-UNIDENTIFIED SPP.	--	--	--	--	64	17
SYNDOTEA HAKFUKUI	--	--	--	--	1	1

Results and Discussion
Biological Characteristics
RCH-B

Table 28 (Concluded)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
MOLLUSCA						
TAPES JAPONICA	91	3	4	4	1	103
MUSCULUS SENHOUSSIA	360	25	29	28	61	503
ODOSTOMIA (EVALEA) VALDEZI	1	--	--	3	1	5
NASSARIUS OBSOLETUS	2	--	1	--	1	4
ISELICA OVOIDEA	1	--	--	--	--	1
MYA ARENARIA	--	1	1	--	39	41
MACOMA NASUTA	--	1	4	1	6	12
MACOMA BALTHICA	--	1	--	4	--	5
ODOSTOMIA (EVALEA) SP. A	--	--	1	--	--	1
GEMMA GEMMA	--	--	5	4	16	25
ODOSTOMIA (EVALEA) FRANCISCANA	--	--	1	--	1	2
ODOSTOMIA (EVALEA) TENUSCULPTA	--	--	1	--	--	1
ODOSTOMIA (EVALEA) SP.	--	--	--	1	--	1
SILIQUA PATULA	--	--	--	--	1	1
MYTILUS EDULIS	--	--	--	--	1	1
PHORONIDA	--	1	--	--	--	1
CF PHORONOPSIS SP.						
CHORDATA						
URCHORDATA-UNIDENTIFIED SPP.	13	--	--	--	--	13
STYELA SP.	1	--	--	--	--	1
ASCIDIACEA-UNIDENTIFIED SPP.	3	--	--	--	--	3
TUNICATA-UNIDENTIFIED SPP.	P	--	--	--	--	P
CIGNA INTESTINALIS	--	--	--	1	--	1
ENIGMATIC- ENIGMATICA	2	--	--	--	--	2
GRAND TOTALS SPECIMENS TAXA	1965 48	2337 25	7236 32	8526 31	14532 44	34546 81

Table 29

CONCENTRATIONS OF THE MOST ABUNDANT
BENTHIC ORGANISMS COLLECTED AT STATION RCH-B
(Individuals per Liter)

	Percentage of Population*	Survey				
		P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
Protozoa						
Foraminifera	1.9%	0	0	1.38	3.14	16.83
Nematoda	6.4	2.13	1.46	8.21	6.47	51.26
Oligochaeta	15.8	5.64	4.02	21.98	45.80	94.53
Polychaeta						
<u>S. benedicti</u>	25.3	0.06	21.59	89.78	126.41	41.49
<u>E. lourei</u>	3.4	6.65	1.28	9.21	1.86	14.21
<u>C. pygodactylata</u>	1.7	0.45	1.43	6.42	7.34	2.46
<u>H. filiformis</u>	1.6	6.24	1.93	1.16	1.19	2.62
<u>Sphaerosyllis</u> sp.	1.2	0.11	0	2.61	0.13	10.94
Arthropoda						
<u>A. milleri</u>	32.3	1.21	37.23	70.88	71.83	175.99
<u>S. zostericola</u>	2.3	0	0.44	8.49	1.68	11.65
Copepoda	2.1	0.04	0	1.73	0.06	21.91
Mollusca						
<u>M. senhousia</u>	<u>1.5</u>	<u>6.73</u>	<u>0.78</u>	<u>0.91</u>	<u>0.90</u>	<u>1.97</u>
Total	95.5%	29.26	70.16	222.76	269.81	445.86
All organisms†	100.0	36.73	72.80	227.55	273.27	471.91

* Numerical percentage of all noncolonial organisms collected.

† All noncolonial organisms collected.

Results and Discussion
Biological Characteristics
RCH-B

was dominated by several species, including Exogone lourei and Heteromastus filiformis, which are polychaetes; Musculus senhousia, a mollusc; and the oligochaetes. The concentration of each of these organisms fell in the range of 5.6 to 6.7/liter.

In September, the concentration of the organisms approximately doubled, and, in subsequent sampling months, the benthic population continued to increase in density, reaching a peak of about 472/liter in June 1974. The twofold increase in September was attributable principally to growth in the Streblospio benedicti and Ampelisca milleri populations. The animals that were abundant in March 1973 were considerably less numerous in September. In March, only 3.5% of the noncolonial organisms were S. benedicti and A. milleri, the two species that constituted nearly 81% of the September census.

The population in December 1973 was a little over three times greater than it was in the previous sampling month. Most of the generally abundant taxa were more numerous. About 80% of the animals collected were S. benedicti, A. milleri, and oligochaetes. Of these three taxa, S. benedicti was the most numerous, and the oligochaetes were the least numerous.

In March 1974, the S. benedicti population peaked. About 46% of the noncolonial animals collected during that month were of that species. The sediment samples contained twice as many oligochaetes per liter than the samples collected in December, but about the same number of A. milleri. Most of the organisms collected in March were S. benedicti, oligochaetes, and A. milleri.

In June 1974, 7 of the 11 taxa listed in Table 29 were more numerous than in any other month. These were the nematodes, oligochaetes, Exogone lourei, Sphaerosyllis sp., Ampelisca milleri, Sarsjella zostericola, and copepoda. Ampelisca milleri was the most abundant species, followed by the oligochaetes and nematodes.

Results and Discussion
Biological Characteristics
Common Taxa

Common Taxa

Table 30 lists the organisms present during each of the five surveys. Of the approximately 341 taxa collected at the 11 stations between March 1973 and June 1974, only 43 were common.

The oligochaetes and nematodes were most widely distributed, the oligochaetes being common at all stations and the nematodes being common at all stations except SB-B, where they were generally few and were absent in September 1973. The polychaete Streblospio benedicti was common at seven of the stations.

The Central and South San Francisco Bay stations, excluding ALC, generally attracted the greatest variety of year-round resident organisms. However, the northern stations, including ALC, seemed to be suitable for certain species that were not found commonly elsewhere. The copepods were present during each survey only at MIS-A and MIS-B. The clam Mya arenaria was common only at MIS-B, CS-A, and CS-B; and another clam, Macoma balthica, was common only at MIS-B. ALC was inhabited by only three common benthic forms--the nematodes, the oligochaetes, and the mollusc Adula diegensis, which was not common at any other station. Another species common to only one station was the bryozoan Membranipora perfragilis, present at MIS-A during all five surveys.

Physical and Chemical Characteristics

Water and Sediment Temperature

Figure 3 shows the fluctuations in average water and sediment temperatures measured at the 11 sampling stations during the five sampling periods. Water temperatures were determined on 2 water samples per station survey; the samples were collected about 3 ft off the bottom. Sediment temperatures were determined on 4 to 7 sediment samples. All temperatures were determined immediately after sample collection.

Results and Discussion
Biological Characteristics
Common Taxa

Table 30
COMMON BENTHIC ORGANISMS COLLECTED DURING ALL FIVE SURVEYS

	station										
	MIS-A	MIS-B	CS-A	CS-B	ALC	OIH	HP	SB-A	SB-B	RCH-A	RCH-B
CNIDARIA											
<u>Haliplanella</u> sp.							x				
NEMERTEA						x	x				x
NEMATODA	x	x	x	x	x	x	x	x		x	x
OLIGOCHAETA	x	x	x	x	x	x	x	x	x	x	x
POLYCHAETA											
<u>S. benedicti</u>		x	x	x		x	x	x	x		x
<u>E. lourei</u>						x	x	x	x	x	x
<u>M. californiensis</u>											
<u>H. filiformis</u>							x	x	x	x	x
<u>P. cauleryi</u>								x			
<u>Sphaerosyllis</u> sp.						x	x	x	x	x	
<u>C. pygodactylata</u>											
<u>P. californiensis</u>						x					
<u>P. ligni</u>						x					
<u>P. kemp</u> <u>californica</u>								x	x	x	x
<u>S. squamata</u>						x					

Results and Discussion
Biological Characteristics
Common Taxa

Table 30 (Continued)

	Station										
	MIS-A	MIS-B	CS-A	CS-B	ALC	Oia	HP	SB-A	SB-B	RCH-A	RCH-B
POLYCHAETA (continued)											
<u>Glycinde</u> sp.						x			x	x	
<u>N. caecoides</u>						x					
<u>P. minuta</u>						x					
<u>N. cornuta franciscana</u>						x	x				
<u>E. longa californica</u>						x					
<u>C. capitata</u>						x	x		x		
<u>S. longicornis</u>						x	x	x	x		
<u>Asychis</u> sp.							x	x	x		
<u>C. cirratus</u>							x				
<u>A. brevis</u>							x				
ARTHROPODA											
Copepoda											
<u>A. milleri</u>	x	x				x	x	x	x	x	x
<u>L. dubia</u>							x				
<u>C. acherusicum</u>								x			
<u>P. franciscana</u>						x					

Results and Discussion
Biological Characteristics
Common Taxa

Table 30 (Concluded)

	Station										
	MIS-A	MIS-B	CS-A	CS-B	ALC	OIH	HP	SB-A	SB-B	RCH-A	RCH-B
ARTHROPODA (continued)											
<u>P. tuberculata</u>							x				
<u>G. japonica</u>									x		
MOLLUSCA											
<u>M. arenaria</u>		x	x	x							
<u>M. balthica</u>		x									
<u>G. gemma</u>						x					x
<u>T. japonica</u>								x	x	x	
<u>M. senhousia</u>						x	x	x	x	x	x
<u>M. nasuta</u>						x					
<u>M. inquinata</u>						x					
<u>M. ferruginosa</u>						x					
<u>I. ovoidea</u>								x			
<u>A. diegensis</u>					x						
ECTOPROCTA											
<u>M. perfragilis</u>	x										
Total	4	6	4	4	3	23	19	16	24	11	11

Results and Discussion
Physical and Chemical Characteristics
Water and Sediment Temperature

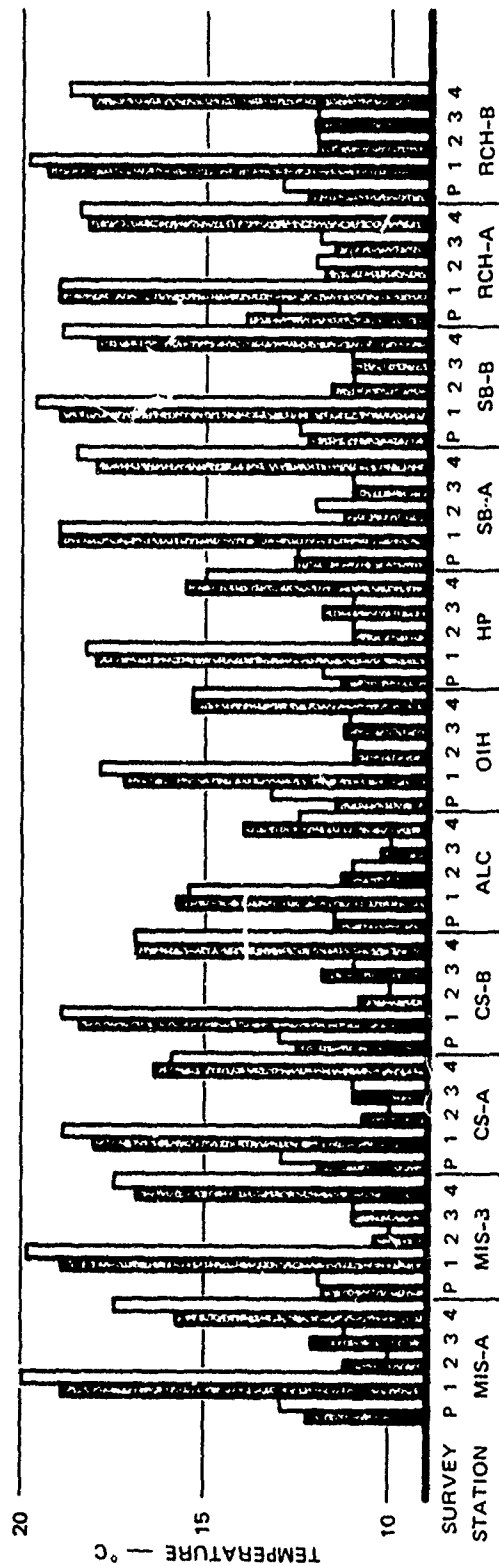


FIGURE 3 MEAN SEDIMENT AND WATER TEMPERATURE AT SELECTED DREDGE AND DISPOSAL AREAS IN SAN FRANCISCO BAY

Shaded bars = sediment temperature; unshaded bars = water temperature. Recording dates: P = March 1973; 1 = September 1973; 2 = December 1973; 3 = March 1974; 4 = June 1974.

Results and Discussion
Physical and Chemical Characteristics
Water and Sediment Temperature

Table 31 presents the means and ranges of water temperature at each station. Generally, temperature at ALC, OIH, and HP fluctuated less than that at other stations. The differences between the highest and the lowest mean temperatures recorded during the study ranged from 5.6°C at ALC to 7.8° at HP (Table 31). The water at these three Central San Francisco Bay stations was somewhat colder on the average than the water at the other stations.

Table 31
WATER TEMPERATURES: MEANS AND RANGES
(Degrees Celsius)

Station	Water Temperature		
	Mean (March 1973- June 1974)	Range*	
		Low	High†
MIS-A	14.2	9.9‡	20.0
MIS-B	14.1	10.0‡	19.8
CS-A	13.9	10.0‡	19.0
CS-B	14.0	10.0‡	19.0
ALC	12.1	10.0§	15.6
OIH	13.8	11.0‡	17.8
HP	13.4	11.0**	18.3
SB-A	14.6	11.0§	19.0
SB-B	14.6	11.0‡	19.7
RCH-A	14.9	11.8§	19.2
RCH-B	15.1	11.9§	19.8

* Values represent the average temperature of 2 water samples.

† All values recorded in September 1973.

‡ Recorded in December 1973.

§ Recorded in March 1974.

** Recorded in December 1973 and in March 1974.

Results and Discussion
Physical and Chemical Characteristics
Water and Sediment Temperature

At the northern section of the Bay, the water temperatures at the sites in Mare Island Strait and the Carquinez Strait disposal sites fluctuated as much as about 10° . At MIS-A, we recorded mean temperatures of 9.9° in December and 20.0° in September--the lowest and highest mean temperatures encountered during the study. In general, the average "seasonal" water temperature at the four northern stations was somewhat higher than that at the Central Bay stations.

The difference between the high and low mean temperatures at the stations at the South Bay disposal site and at Redwood City Harbor ranged from 7.4° at RCH-A to 8.7° at SB-B. On the average, the water temperature at these stations was higher than that at any other station.

Table 32 presents the mean "seasonal" sediment temperatures and the range for each station. As we found for water temperature, the sediment temperature fluctuated most at the northern stations and least at the central stations; and, on the average, the sediment was coldest at the central stations and warmest at the southern stations.

Salinity

We determined water salinity on two water samples per station per survey and collected the water samples from about 3 ft off the bottom. During March and June 1974, we also determined the salinity of the interstitial water, which was extracted from the sediment by centrifugation. Because of adverse weather conditions and other problems, we could not always collect samples during the same tide conditions.

Water salinity at MIS-A, MIS-B, CS-A, and CS-B was usually much lower and more variable than the salinity at other stations, as indicated in Figure 4. At MIS-A, the average salinity in the winter months was about 4 ‰; in June, the average salinity was 7.5 ‰; and, in September, it was 10.0 ‰. At MIS-B, the salinities during corresponding months (except September) were lower, ranging from 1.8 to 3.3 ‰ in the winter and averaging 6.3 ‰ in June.

Results and Discussion
Physical and Chemical Characteristics
Water and Sediment Temperature

Table 32

SEDIMENT TEMPERATURES: MEANS AND RANGES
(Degrees Celsius)

Station	Mean (March 1973- June 1974)	Range*	
		Low	High [†]
MIS-A	13.9	11.0 [‡]	18.8
MIS-B	13.8	10.4 [‡]	19.0
CS-A	13.6	10.7 [‡]	18.1
CS-B	14.0	10.8 [‡]	18.4
ALC	12.6	10.2 [§]	15.8
OIH	13.2	11.0 [‡]	17.2
HP	13.5	11.0 [‡]	18.0
SB-A	14.4	11.0 [§]	19.0
SB-B	14.2	10.6 [‡]	19.0
RCH-A	14.9	11.5 [§]	19.0
RCH-B	14.7	11.9 [‡]	19.3

* Values represent the average temperature of 3 to 7 sediment samples.

[†] All values recorded in September 1973.

[‡] Value recorded in December 1973.

[§] Value recorded in March 1974.

Results and Discussion
Physical and Chemical Characteristics
Salinity

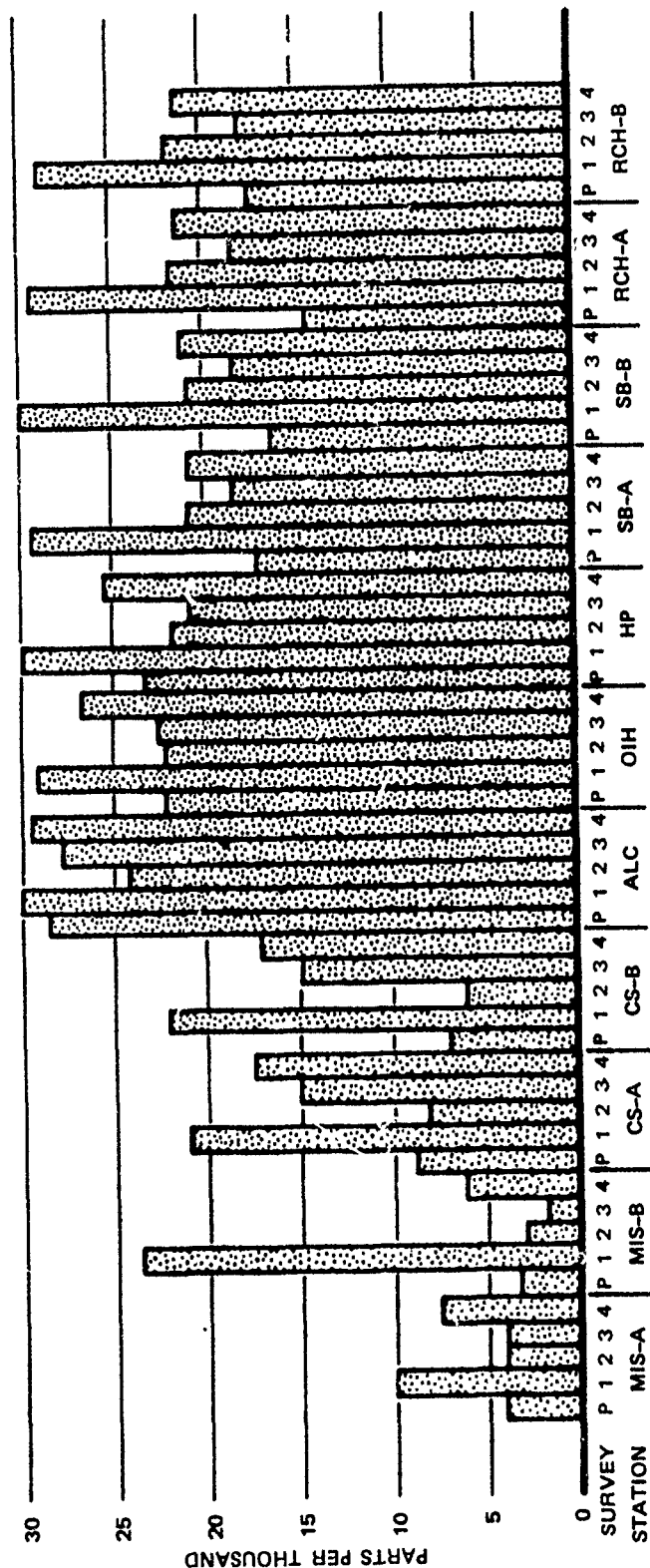


FIGURE 4 MEAN WATER SALINITY AT SELECTED DREDGE AND DISPOSAL AREAS IN SAN FRANCISCO BAY, 1973 and 1974

Recordings were made on water samples collected within three feet of the bottom. Recording dates:
P = March 1973; 1 = September 1973; 2 = December 1973; 3 = March 1974; 4 = June 1974.

Results and Discussion
Physical and Chemical Characteristics
Salinity

The large difference in the salinity of the water collected from MIS-A and MIS-B in September probably is attributable to tide conditions. As shown in Table 33, we collected water samples from MIS-A during an outgoing tide and took samples from MIS-B during an incoming tide. Because Mare Island Strait is located in the tidewater region of the Napa River, tide conditions should have a great influence on salinity. However, during the winter, when rainfall is the heaviest, an incoming tide appears to have less influence on the salinity of water in tidewater areas than during drier periods. In March 1973, we collected water samples at MIS-A and MIS-B during an incoming tide; however, the salinity was no more than 4.2 ‰.

We found little difference between the salinity of water collected from CS-A and CS-B during the same sampling period. At these stations, the salinity was lowest in December, averaging about 6.6 ‰. The highest salinity was recorded in September and averaged about 21.5 ‰ for the two stations. Salinities recorded in March 1973 and March 1974 differed almost twofold. During these two months, we collected the water samples during an outgoing tide. In March 1973, however, the difference between high and low tide was 5.3 ft on the day of sampling, whereas a year later, the difference was 6.1 ft, which might account for the higher salinity observed in March 1974.

The Central San Francisco Bay stations at ALC, HP, and OIH appear to be influenced greatly by coastal marine conditions. The water in these areas was characterized by consistently high year-round salinity.

The water at ALC was quite saline throughout the study, ranging from 24.0 to 30.5 ‰ and averaging 27.8 ‰. Salinity was highest in September and lowest in December. The salinity readings taken at OIH and HP were essentially the same from survey to survey, and the average salinity over the five-survey period was 24.4 ‰ at both stations. During the winter months (March and December), the salinity was lower than during the summer months (June and September). In the winter, ranges were from 21.0 to 23.0 ‰ at OIH and from 20.5 to 24.0 ‰ at HP. In the summer, salinity ranged from 26.5 to 29.0 ‰ at OIH and from 25.0 to 30.0 ‰ at HP. At both stations, highest salinities were recorded in September.

Table 33

MEAN WATER SALINITY (PARTS PER THOUSAND) AND TIDE STATUS

Table 33

Station	Survey														
	P			1			2			3			4		
	(March 1973)		Tide	(Sept. 1973)		Tide	(Dec. 1973)		Tide	(March 1974)		Tide	(June 1974)		Tide
Salinity	Status	Salinity	Status	Salinity	Status	Salinity	Status	Salinity	Status	Salinity	Status	Salinity	Status	Salinity	Status
MIS-A	4.2	I	10.0	0	4.0	I	4.0	I	4.0	0	7.5	LS			
MIS-E	3.3	I	23.5	I	3.0	I	1.8	LS	6.3	LS					
CS-A	8.8	0	21.0	0	7.0	I	15.2	0	17.5	0					
CS-B	7.2	0	22.0	0	6.2	HS	14.8	0	17.0	0					
ALC	28.5	LS	30.2	HS	24.2	0	27.8	0	29.5	HS					
OIH	22.0	I	29.0	0	22.0	0	22.2	0	26.5	0					
HP	23.6	0	30.0	LS	22.0	0	20.8	0	25.5	0					
SB-A	17.3	I	29.5	0	21.0	0	18.5	HS	21.0	I					
SB-B	16.5	0	30.0	0	21.0	0	18.5	HS	21.3	I					
RCH-A	14.6	I	29.5	0	22.0	LS	18.5	0	21.5	I					
RCH-B	17.6	0	29.0	I	22.0	LS	18.0	0	21.5	I					

Note: I = Incoming
O = Outgoing
HS = High slack
LS = Low slack

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Salinities at all stations in the southern portion of San Francisco Bay were very similar during any given sampling month (Table 33). The lowest salinities were in March 1973. During this month, the average salinity ranged from 14.6‰ at RCH-A to 17.6‰ at RCH-B, and the mean for the four South Bay stations was 16.5‰. In March 1974, the average salinity at these stations was 18.4‰--slightly higher than in March of the previous year. In September 1973, the salinity was about as high as that encountered at the Central Bay stations. The four-station average was 29.5‰, and the range was 29.0 to 30.0‰. The salinity of the water at these stations was about the same in December 1973 and June 1974, when the averages for the four stations were 21.5 and 21.3‰, respectively.

Interstitial water salinity, determined on water extracted from sediment samples by centrifugation, was determined only during March 1974 and June 1974. In general, little difference existed between the salinity of the interstitial and the water from 3 ft above the bottom, as shown in Table 34. Relatively large differences were confined to stations in Mare Island Strait, where the salinity of the water is influenced greatly by tidal changes.

At MIS-A, the salinity of the water, taken during an outgoing tide on 6 March 1974, was 4.0‰. Interstitial water salinity averaged 9.1‰. At MIS-B, the salinity of the interstitial water was also higher than that of the water column, but the difference was only 3.6‰, which is not much greater than observed at some of the Central Bay stations. In June, the salinity of the interstitial water was also higher than water salinity, although the water and sediment samples were taken during an incoming tide. To determine how great an influence tidal changes have on interstitial water salinity requires a more extensive sampling schedule than that used in this study. With respect to the benthic organisms, knowing how much exchange occurs between the overlying water and interstitial water would be worthwhile.

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Table 34

MEAN WATER AND INTERSTITIAL WATER SALINITIES
AT 11 STATIONS IN SAN FRANCISCO BAY*
(Parts per Thousand)

<u>Station</u>	<u>Survey 3</u>		<u>Survey 4</u>	
	<u>Water</u>	<u>Sediment</u>	<u>Water</u>	<u>Sediment</u>
MIS-A	4.0	9.1	7.5	10.8
MIS-B	1.8	5.4	6.2	9.9
CS-A	15.2	12.4	17.5	16.4
CS-B	14.8	13.7	17.0	15.5
ALC	27.8	23.4	29.5	29.6
OIH	22.2	24.0	26.5	26.7
HP	20.8	24.0	25.5	26.7
SB-A	18.5	18.4	21.0	21.9
SB-B	18.5	18.8	21.2	21.8
RCH-A	18.5	17.9	21.5	21.8
RCH-B	18.0	18.1	21.5	20.4

* Measurements were made in March and June 1974
(Surveys 3 and 4, respectively).

pH

The pH of the water collected from the 11 stations fell within a relatively narrow range. With the exception of one reading of 6.9, the range was 7.3 to 8.2, as shown in Table 35. In March 1973, the range was 7.7 to 8.0. In September 1973, the water at all stations was slightly more acidic than in the previous sampling period, the pH ranging from 7.3 to 7.7. In December 1973, we observed little or no change in the pH compared with the September recordings. The water was more alkaline in March and June 1974 than in previous months. In March 1974, the pH ranged from 7.6 to 8.2;

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pH

Table 35

pH OF DUPLICATE WATER SAMPLES

Station	Survey									
	P		1		2		3		4	
	(3/73)		(9/73)		(12/73)		(3/74)		(6/74)	
	Sample									
	1	2	1	2	1	2	1	2	1	2
MIS-A	7.7	7.8	7.4	7.3	7.5	7.5	7.7	7.8	7.8	7.8
MIS-B	7.7	7.8	7.5	7.6	7.5	7.4	7.6	7.6	7.8	7.8
CS-A	7.9	7.8	7.7	7.7	7.5	7.5	7.9	7.9	7.9	7.9
CS-B	7.8	7.8	7.5	7.4	7.5	7.5	7.9	8.0	7.8	7.9
ALC	8.0	--	7.6	7.6	7.3	7.4	8.0	8.0	7.8	7.8
OIH	7.7	7.9	7.5	7.5	7.4	7.6	8.0	8.0	7.9	7.8
HP	7.9	7.9	7.4	7.6	7.7	7.7	8.2	8.1	7.9	7.9
SB-A	7.8	7.9	7.5	7.5	7.7	7.8	8.0	8.0	7.9	7.8
SB-B	7.7	7.8	7.5	7.5	6.9	7.5	7.8	7.9	7.8	7.9
RCH-A	7.8	7.8	7.6	7.6	7.8	7.7	8.0	7.9	7.8	7.9
RCH-B	7.8	7.9	7.5	7.6	7.7	7.7	7.9	7.9	7.9	7.9

however, at most stations, the pH was at least 7.9. In June 1974, the pH of the water was almost the same at all stations and ranged from 7.8 to 7.9.

Sediment pH was, in general, lower than water pH, ranging from 6.1 at SB-A in March 1973 to 7.8 at OIH in March 1974, as shown in Table 36. We found relatively large differences in the pH of replicate sediment samples; in one case, the difference was as much as 1.4 pH units, indicating that the chemical characteristics of the sediment, even from the relatively small areas that we sampled, may not be homogeneous.

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pH

Table 36

RANGES OF SEDIMENT pH,
FROM THREE TO SEVEN SEDIMENT SAMPLES

Station	Survey				
	P	1	2	3	4
	(3/73)	(9/73)	(12/73)	(3/74)	(6/74)
MIS-A	7.0-7.1	6.7-6.9	7.0-7.1	7.0-7.1	7.3-7.5
MIS-B	7.1-7.3	7.0-7.1	7.2-7.3	7.2-7.3	7.1-7.2
CS-A	7.1-7.2	6.4-6.7	6.8-6.9	7.0-7.4	7.0-7.1
CS-B	7.3	6.6-6.8	6.9-7.0	7.0-7.2	7.0-7.2
ALC	7.2-7.9	6.9-7.3	7.0-7.7	7.1-7.4	7.2-7.4
OIH	7.2-7.3	7.1-7.3	7.3-7.4	7.7-7.8	7.3-7.4
HP	7.0-7.4	6.9-7.1	7.0-7.4	7.2-7.3	7.1-7.3
SB-A	6.1-7.5	6.7-7.0	7.1-7.3	7.2-7.5	6.9-7.3
SB-B	7.2-7.4	6.4-7.0	7.3-7.5	7.1-7.5	6.9-7.4
RCH-A	7.3-7.4	6.9-7.1	7.2-7.3	7.5-7.6	7.2-7.4
RCH-B	7.3-8.4	6.9-7.1	7.0-7.3	7.2-7.4	7.0-7.1

Dissolved Oxygen

We measured for dissolved oxygen in water samples only, using a dissolved oxygen meter (YSI, Model 54). All readings were corrected for salinity and an atmospheric pressure of 760 mm Hg. Table 37 presents the mean values for each station.

Throughout the study, corrected dissolved oxygen concentrations were at or near saturation. During any given sampling month, the oxygen content of the water varied by no more than 3.5 mg/liter among stations. As expected, higher dissolved oxygen levels were recorded during the winter, when the water temperature and salinity were low. In March and December 1973 and March 1974, the average dissolved oxygen concentrations for all stations were 8.32, 8.82, and 8.72 mg/liter, respectively. In September 1973 and June 1974, the average was 7.15 and 7.86 mg/liter.

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Dissolved Oxygen

Table 37

MEAN DISSOLVED OXYGEN CONCENTRATIONS OF WATER
COLLECTED FROM WITHIN THREE FEET OF BOTTOM AT SELECTED
DREDGE AND DISPOSAL AREAS IN SAN FRANCISCO BAY
(Milligrams per Liter)

Station	Survey				
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
MIS-A	8.6	8.2	9.6	7.1	8.4
MIS-B	9.0	7.2	9.8	10.1	8.6
CS-A	8.0	7.4	9.4	9.1	8.2
CS-B	8.2	7.4	9.8	9.0	8.4
ALC	7.4	7.7	8.6	8.3	7.8
OIH	7.2	6.9	7.8	8.0	7.8
HP	7.4	7.1	8.0	8.4	8.0
SB-A	8.8	6.8	8.4	9.2	7.5
SB-B	9.0	6.6	9.0	8.9	7.4
RCH-A	9.0	6.8	8.2	9.0	7.1
RCH-B	8.6	6.7	8.2	8.7	7.2

Total Sulfides

Sulfides are produced naturally in aquatic systems through the action of bacteria on organic matter and/or inorganic sulfates under anaerobic conditions. The major product of this action is hydrogen sulfide (H_2S), which dissociates in water to the SH^- and $S^{=}$ ions. The proportion of H_2S , SH^- , and $S^{=}$ in water depends on pH. Below pH 10, H_2S and SH^- predominate; and, as pH decreases, the ratio of H_2S to SH^- increases. At pH 5, the compound exists almost entirely as H_2S (McKee and Wolfe, 1963). Under certain conditions, sulfides combine with metal ions to form insoluble metallic sulfides, which can represent a large fraction of the total sulfide content of water or sediment.

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Total Sulfides

Table 38 lists the concentration of total sulfides (H_2S and its ionization products as well as acid-soluble metallic sulfides) of water collected at each station. During each survey, we collected two water samples, both from within 3 ft off the bottom. We found that the sulfide content often varied considerably between duplicate samples. We are not certain whether these differences were real or simply artifacts due to possible improper handling or analysis of the samples. We found even greater differences in the total sulfide content of replicate sediment samples.

The highest sulfide concentration measured was 10 $\mu g/liter$ in March 1973 for one of the two water samples collected from MIS-A. In general, we encountered higher levels of water sulfides at most stations in March 1973 than in the other sampling periods. Sulfide

Table 38

TOTAL SULFIDE CONTENT OF WATER SAMPLES COLLECTED
FROM SELECTED DREDGE AND DISPOSAL AREAS
IN SAN FRANCISCO BAY
(Micrograms per Liter)

Station	Survey									
	P		1		2		3		4	
	(3/73)		(9/73)		(12/73)		(3/74)		(6/74)	
	Sample									
	1	2	1	2	1	2	1	2	1	2
MIS-A	10.0	4.2	2.1	3.0	4.0	3.5	--	1.8	0	0
MIS-B	6.1	8.6	3.0	2.5	2.5	4.3	0	--	1.1	0
CS-A	2.6	7.3	0.5	0.2	1.9	2.8	1.4	0.2	1.1	1.3
CS-B	7.6	15.0	0.4	0.4	1.9	2.6	0.6	1.6	1.4	0
ALC	2.1	--	0.2	0	5.5	4.4	0.4	0.2	0	0
OIH	0.7	2.4	0.6	0.5	4.1	2.1	0	--	0	0
HP	2.7	2.3	0	0.8	0.6	--	1.8	0.4	0	0
SB-A	2.8	3.2	2.8	3.2	1.5	2.7	0.3	1.5	0	0
SB-B	3.3	4.4	1.4	1.7	1.1	1.3	0.5	0.5	0	0
RCH-A	4.9	6.3	1.9	3.5	3.4	1.5	0	0	0	0
RCH-B	3.7	2.2	4.2	2.5	3.5	4.9	0	0	0	0

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Total Sulfides

levels generally decreased in September 1973 and slightly increased in December 1973. Most conspicuous, however, were the very low sulfide concentrations found at all stations in March and June 1974. Table 38 shows these general trends.

In the presence of oxygen, sulfides are oxidized readily (Sverdrup et al., 1942). Although the amounts of sulfides in our water samples were relatively low, we should not have found any because of the high levels of dissolved oxygen in the samples (see Table 37). The sulfide and dissolved oxygen analyses were performed properly, so sulfides possibly were generated during some stage between sample collection and sample analysis.

Sediment sulfide concentrations were determined on three to seven sediment samples per station per survey. Table 39 presents the averages and standard deviations for each station. At many stations, the measured levels of total sulfide varied considerably. In some instances, we could predict the occurrence of differences by noting differences in the color of the sediment samples as they were collected. As we expected, the samples with more darkly colored material contained more sulfides than the samples with a high proportion of lightly colored material.

In general, the sediment from stations south of and including OIH contained a greater amount of sulfides than the sediment collected from stations to the north. At the southern stations, we observed no consistent relationship between the sulfide content of sediment collected from the dredged areas and from the dredged-material disposal areas. However, we found that the sulfide concentration of sediment from OIH was consistently high, ranging from an average of 442 mg/kg to 730 mg/kg; whereas at HP, at the stations located at the South Bay disposal site, and at the Redwood City Harbor entrance channel, the sediment sulfide content fluctuated markedly from sampling period to sampling period.

At MIS-A and at CS-A--sites where considerable dredging and disposal of dredged material occur--the average sulfide content of sediment ranged from 0 to 18 mg/kg* and from 10 to 313 mg/kg,

* The zero value may be an artifact.

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Total Sulfides

Table 39

AVERAGE TOTAL SULFIDE CONCENTRATIONS OF SEDIMENT
COLLECTED FROM SELECTED DREDGE AND DISPOSAL AREAS
IN SAN FRANCISCO BAY
One Standard Deviation in Parentheses*
(Milligrams per Kilogram Wet Weight)

Station	Survey				
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)
MIS-A	2 (1)	18 (14)	2 (5)	16 (9)	0 (0)
MIS-B	17 (34)	172 (42)	80 (52)	61 (3)	8 (3)
CS-A	123 (71)	313 (79)	124 (84)	10 (14)	219 (192)
CS-B	1 (1)	191 (95)	73 (83)	121 (88)	315 (7)
ALC	60 (69)	6 (7)	71 (82)	76 (44)	3 (1)
OIH	442 (264)	527 (149)	488 (89)	570 (26)	730 (134)
HP	370 (16)	63 (46)	208 (72)	257 (122)	71 (19)
SB-A	365 (156)	148 (54)	151 (60)	600 (270)	313 (136)
SB-B	278 (34)	545 (52)	77 (14)	490 (277)	443 (108)
RCH-A	261 (43)	148 (25)	237 (39)	183 (166)	373 (86)
RCH-B	173 (79)	535 (110)	628 (318)	125 (19)	113 (21)

* Rounded to nearest whole number.

The sediment from CS-A contains considerably more sulfide than the sediment from MIS-A except in March 1974, when the sulfide content of the sediment from both stations was about the same. The March 1974 sampling occurred at a time of intensive dredging activity at Mare Island Strait, and most of the dredged material was taken to the Carquinez Strait disposal site.

Sediment from the undredged area of Mare Island Strait, MIS-B, contained a higher level of sulfides than sediment from MIS-A during all sampling periods. The sulfide content of sediment

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Heavy Metals

collected from the center of the disposal site, CS-A, was greater than that of the sediment collected from the presumably less disturbed area near the northern edge of the disposal site (CS-B) only during the 1973 sampling months.

Of all disposal areas studied, ALC contained the lowest average amount of sediment sulfide.

Heavy Metals

During each survey of each station, we took one subsample from each of three to five replicate sediment samples and analyzed them for copper, cadmium, lead, zinc, and mercury--the metals of greatest interest to the Corps of Engineers, San Francisco District. We did not analyze the sediment for zinc or mercury during the March and September 1973 surveys, nor did we determine the sediment concentrations of any of the metals in samples collected from SB-A or from RCH-A.

Generally, the relative abundance of the five metals followed the order zinc > copper > lead > cadmium > mercury. The average concentration of zinc ranged from 69 mg/kg dry weight to 239 mg/kg. The range for copper was 12 to about 98 mg/kg. Ranges for lead, cadmium, and mercury were 10 to 81 mg/kg, 0.77 to 2.61 mg/kg, and 0.02 to 0.44 mg/kg, respectively. On an area-by-area basis, we compared the range of average concentrations of each metal as measured in our study with those obtained by other investigators and found ours to be similar to those of others. Table 40 presents these data.

Table 41 shows the mean concentration of each metal by station and survey. At most stations, we did not observe any general pattern to the fluctuations in heavy-metal content of the sediment. However, we did find some interesting trends at the stations in Mare Island Strait and the Carquinez Strait disposal site.

Comparison of the average values presented for each metal in Table 40 shows that, although the concentrations of the metals fluctuated with the time of sampling, little difference existed

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Heavy Metals

Table 40
HEAVY-METAL CONCENTRATIONS OF SEDIMENT IN SAN FRANCISCO BAY
(Milligrams per Kilogram Dry Weight)

Location	Copper	Cadmium	Lead	Zinc	Mercury	Reference
Mare Island Strait	44-66	0.71-2.1	22-47	97-175	0.016-0.44	Present study ¹
	80-99	1.2-3.0	36-55	140-163	0.45-0.49	Anderslini et al., 1974 ²
	117	0.61	51	171	0.64	Battelle Northwest Laboratories, 1974 ³
	70	--	100	--	0.64	Peterson et al., 1972
Carquinez Strait	22-98	0.77-2.1	19-52	82-152	0.017-0.39	Present study ¹
	30	--	20	--	0.06	Peterson et al., 1972
Alcatraz	12-35	0.95-1.7	13-47	69-90	0.054-0.10	Present study ¹
	5	--	10	--	0.08	Peterson et al., 1972
Oakland Inner Harbor	28-90	0.90-2.6	35-81	115-239	0.018-0.36	Present study ¹
	166	1.3	117	222	1.6	Battelle Northwest Laboratories, 1974 ³
	--	--	14-136	41-274	0.1-0.3	Lee and Plumb, 1974 ⁴
	50	--	70	--	0.44	Peterson et al., 1972
Hunters Point	42-71	1.0-1.4	41-51	136-158	0.28-0.34	Present study ¹
	5-50	--	None	--	0.08-0.19	Peterson et al., 1972 ⁵
South bay area	29-52	0.78-1	22-32	81-126	0.23-0.39	Present study ¹
	30-50	--	30-50	--	0.23-1.0	Peterson et al., 1972
Redwood City Harbor	35-57	0.88-1.4	28-46	107-148	0.03-0.37	Present study ¹
	95	0.89	49	176	0.63	Battelle Northwest Laboratories, 1974 ³
	100-150	--	70-200	--	0.25-0.54	Peterson et al., 1972

¹Means for 3-4 samples at one station; 3-5 surveys conducted between March 1973 and June 1974.

²Means for 6-13 stations; nine surveys conducted between October 1973 and April 1974.

³Mean for 2 core samples (cadmium values are tentative).

⁴Range of values obtained for several locations.

⁵Range of values for sediment collected immediately north of SRI station.

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Table 41

MEAN HEAVY-METAL CONCENTRATIONS IN SEDIMENT
Standard Deviation in Parentheses
(Milligrams per Kilogram Dry Weight)

Survey	Station								
	MIS-A	MIS-B	CS-A	CS-B	ALC	OIH	HP	SB-B	RCH-B
P (March 1973)									
Copper	49.6 (7.9)	57.0 (5.1)	98.2 (13.3)	74.3 (9.2)	35.4 (17.2)	89.8 (10.6)	71.4 (6.5)	51.6 (7.9)	53.8 (5.4)
Cadmium	0.98 (0.09)	0.99 (0.11)	1.69 (0.36)	2.11 (0.26)	1.72 (0.21)	2.44 (0.22)	1.38 (0.12)	0.96 (0.17)	1.01 (0.22)
Lead	22.4 (1.5)	22.6 (2.3)	42.8 (5.8)	35.1 (4.6)	47.3 (0.80)	77.1 (5.7)	44.6 (5.3)	29.0 (3.6)	27.6 (6.0)
1 (Sept. 1973)									
Copper	60.3 (13.3)	61.4 (7.5)	94.8 (7.3)	95.3 (17.1)	16.9 (1.5)	89.1 (33.0)	55.3 (5.8)	41.9 (5.5)	56.6 (10.1)
Cadmium	0.86 (0.19)	1.00 (0.06)	1.94 (0.17)	1.81 (0.38)	1.40 (0.11)	2.61 (0.51)	1.22 (0.14)	1.21 (0.26)	1.25 (0.23)
Lead	26.1 (8.2)	28.4 (3.3)	50.4 (0.30)	51.9 (26.2)	34.3 (6.4)	76.3 (15.8)	48.1 (15.7)	25.1 (3.1)	40.4 (6.5)
2 (Dec. 1973)									
Copper	47.7 (25.6)	44.0 (11.3)	54.7 (7.2)	39.0 (1.0)	23.0 (9.2)	28.3 (3.5)	42.3 (12.7)	39.7 (16.5)	35.0 (7.8)
Cadmium	0.99 (0.38)	0.71 (0.14)	1.27 (0.49)	1.07 (0.20)	0.97 (0.50)	0.89 (0.16)	1.01 (0.24)	0.78 (0.19)	1.03 (0.24)
Lead	26.7 (10.3)	26.0 (3.0)	40.0 (8.5)	30.0 (4.6)	13.0 (7.3)	35.0 (6.0)	40.7 (6.5)	31.7 (6.8)	40.0 (6.0)
Zinc	107.0 (62.1)	118.3 (35.0)	142.0 (15.7)	112.0 (5.0)	77.3 (17.6)	115.0 (13.1)	145.0 (18.7)	125.7 (32.9)	130.0 (7.0)
Mercury	0.32 (0.11)	0.44 (0.31)	0.39 (0.08)	0.26 (0.03)	0.07 (0.01)	0.36 (0.04)	0.28 (0.12)	0.39 (0.15)	0.22 (0.14)
3 (March 1974)									
Copper	65.7 (16.4)	64.0 (4.4)	21.7 (8.1)	39.0 (6.2)	31.0 (1.7)	33.0 (12.2)	49.7 (1.5)	29.0 (1.7)	43.0 (13.1)
Cadmium	2.07 (0.32)	1.67 (0.06)	0.77 (0.06)	0.93 (0.04)	1.23 (0.06)	1.23 (0.15)	1.25 (0.27)	1.03 (0.39)	1.40 (0.43)
Lead	40.7 (4.2)	47.3 (8.1)	19.0 (1.0)	29.3 (1.2)	25.0 (1.0)	48.3 (3.5)	43.3 (6.4)	31.8 (13.1)	46.0 (7.0)
Zinc	175.3 (16.8)	166.3 (2.5)	82.0 (9.5)	109.3 (11.0)	89.7 (8.5)	126.3 (24.2)	136.0 (5.3)	99.7 (13.6)	148.0 (7.0)
Mercury	0.14 (0.03)	0.27 (0.05)	0.02 (0.01)	0.16 (0.18)	0.10 (0.03)	0.30 (0.24)	--	0.23 (0.20)	0.03 (0.03)

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Table 41 (Concluded)

Survey	Station								
	MIS-A	MIS-B	CS-A	CS-B	ALC	OIH	HP	SB-R	RCH-B
4 (June 1974)									
Copper	49.7 (2.1)	49.0 (3.5)	66.3 (11.0)	56.3 (3.1)	12.0 (1.0)	83.7 (21.7)	57.7 (15.0)	30.7 (11.2)	42.3 (4.7)
Cadmium	0.77 (0.03)	0.83 (0.13)	1.43 (0.06)	1.15 (0.23)	0.95 (0.13)	2.20 (0.78)	1.24 (0.39)	0.81 (0.20)	0.88 (0.02)
Lead	24.0 (1.0)	22.0 (2.6)	34.0 (4.6)	42.0 (9.8)	33.7 (5.7)	81.0 (18.4)	51.3 (18.1)	22.0 (6.0)	32.3 (2.5)
Zinc	106.0 (13.5)	97.0 (12.8)	151.7 (30.7)	145.7 (2.9)	69.0 (10.1)	238.7 (57.0)	157.7 (46.3)	81.0 (30.8)	107.0 (15.1)
Mercury	0.02 (0.03)	0.03 (0.05)	0.21 (0.36)	0.20 (0.21)	0.05 (0.07)	0.02 (0.03)	0.34 (0.42)	0.38 (0.36)	0.37 (0.53)

between the concentration of a given metal during a given sampling period at MIS-A in the dredged ship channel and MIS-B in the undredged portion of Mare Island Strait. In March 1973, September 1973, and June 1974, we found the same to be true at the disturbed area (CS-A) and at the undisturbed area (CS-B) of the Carquinez Strait disposal site. However, in December 1973, we found noticeably higher concentrations of copper, cadmium, and zinc at CS-A than at CS-B; and, in March 1974, the concentrations of all five metals were noticeably higher at CS-B than at CS-A.

In the dredged area of Mare Island Strait (MIS-A), the average concentration of all metals was lower than in the center of the Carquinez Strait disposal site (CS-A) during all sampling months except March 1974. In March 1974, the average concentration of all metals, except mercury, were significantly higher ($p = 0.05$) at MIS-A than at CS-A. Although we did not test for significance, we found that, in March 1974, the concentration of all heavy metals at both stations in Mare Island Strait were higher than the concentration at the two stations in the Carquinez Strait disposal site and that the trend was just the opposite during the other four sampling months.

The high levels of heavy metals found in the Mare Island Strait sediments in March 1974 may have resulted from storm water runoff from cities along the shore of Mare Island Strait and along the

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lower reaches of the Napa River. The estimated amounts of copper, lead, and zinc washed off annually from the streets of the City of Vallejo, located along the eastern shore of Mare Island Strait, are 1,900, 43,000, and 8,700 lb, respectively (URS Research Company, 1974). During March 1974, precipitation in the Mare Island Strait area amount to at least 5 in. (Anderlini et al., 1974).

Turbidity

As stated in "Study Approach," the optical instrument we used to measure turbidity did not meet the requirements of a true nephelometer; hence, whereas the data are presented in nephelometric units (NU), they cannot be compared with turbidity values obtained by other investigators using a true nephelometer. However, the data are of value in comparing the relative turbidity between the stations and between the sampling periods used in this study.

Although the standard method for estimating turbidity is use of the Jackson candle turbidometer, this procedure does not permit direct estimation of turbidity less than 25 Jackson turbidity units (JTU); it is best suited for work with highly turbid water. The nephelometric method has a wider working range, precision, and sensitivity (APHA, 1971).

Throughout the study, we often found considerable disagreement in the turbidity readings of the replicate water samples and attribute this problem to our method of collecting the samples. To minimize drift of the van Dorn sampler during sample collection and to fix the depth of sample collection, we attached a heavy concrete weight to the sampler. This weight extended about 2 ft below the sampler and was lowered to the bottom before the sampler trigger mechanism was released. The presence of the weight on the soft sediment encountered at most stations may have disturbed the sediment enough to cause contamination of the sample.

We estimated the turbidity of two water samples per station, and Table 42 presents the results. During the preliminary survey, we did not measure turbidity above 500 NU.

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Table 42

TURBIDITY OF WATER COLLECTED FROM SELECTED
DREDGE AND DISPOSAL AREAS IN SAN FRANCISCO BAY
Values Are Given in Nephelometric Units (NU)

Station	Survey									
	P		1		2		3		4	
	(3/73)		(9/73)		(12/73)		(3/74)		(6/74)	
	Sample									
	1	2	1	2	1	2	1	2	1	2
MIS-A	450	65	100	120	190	110	37,500	10,000	85	70
MIS-B	130	65	100	85	65	95	500	500	60	30
CS-A	240	85	21	15	130	150	160	130	120	150
CS-B	>500	>500	10	10	110	120	100	140	390	260
ALC	11	--	5	5	24	23	5	10	11	12
OIH	2	3	6	5	24	24	18	18	35	37
HP	5	2	8	6	7	12	45	45	35	35
SB-A	14	11	2	2	7	7	45	40	11	13
SB-B	10	9	1	2	2	1	23	34	--	10
RCH-A	11	17	2	1	7	6	33	33	40	40
RCH-B	11	11	5	5	7	7	14	21	28	17

On the average, the water at Mare Island Strait and Carquinez Strait was much more turbid than water from other areas. At MIS-A, the average turbidity ranged from 78 NU in June 1974 to 23,750 NU in March 1974. In Mare Island Strait the extremely turbid water observed in March 1974 coincided with heavy dredging activity and high rainfall. The turbidity of the water at MIS-B, located in an undredged area east of MIS-A, was lower than at MIS-A during the same sampling months.

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Turbidity

Monthly turbidity averages ranged from 45 NU in June 1974 to 500 NU in March 1974 at MIS-B. Although turbidity at MIS-B also rose markedly in March 1974, the lower turbidity reading indicates that water from the ship channel does not mix readily with water outside the channel. However, some of the difference may have resulted from greater disturbance by taking the water samples near a soft, recently dredged bottom than near the more consolidated sediments of an undredged bottom.

At Carquinez Strait, average monthly turbidity values ranged from 18 to 162 NU at CS-A and from 10 to at least 500 NU at CS-B. The water was least turbid in September 1973, and, during the other sampling months, turbidity did not vary much at CS-A but fluctuated considerably at CS-B.

Although water from Mare Island Strait enters Carquinez Strait we did not observe any evidence at the Carquinez Strait stations of the highly turbid conditions in Mare Island Strait in March 1974. In fact, at both Carquinez Strait stations, the water in March 1974 was about as turbid as in December 1973.

Turbidity at the Alcatraz disposal site did not vary as much seasonally as at other areas. Average monthly turbidity values ranged from 5 to 24 NU. Water in this area was least turbid in September and most turbid in December. According to information provided by the U.S. Army Corps of Engineers and the Dredging Contractors Association, the Alcatraz disposal site is used throughout the year. However, during our field surveys, we did not observe any disposal activity in the area. Dredged material transferred to the site appears to disperse rapidly. Hence, determining the degree of turbidity created in the area by disposal activity would require sampling at the time of disposal or very shortly thereafter.

At OIH, turbidity increased from an average 2.5 NU in March 1973 to 24 NU in December. In March 1974, turbidity decreased slightly (to 18 NU) and then increased to 36 NU in June. Information provided by the Dredging Contractors Association shows that Oakland Inner Harbor is dredged frequently. Although we could not obtain information on the exact dredging dates and sections that

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were dredged during the study period, we did obtain project record information indicating that dredging occurred during every month between July 1973 and November 1974.

Between March 1973 and March 1974, the average turbidity at station HP in the Hunters Point disposal site increased from 4 NU to 45 NU, then decreased to 35 NU in June. Fluctuation in turbidity at this station probably is influenced most by wind and wave action as well as land runoff. We have no records of official use of the Hunters Point disposal area during the study period.

Seasonal fluctuations in turbidity at the stations located at the southern portion of San Francisco Bay followed similar patterns. In general, the water was least turbid in September. Highest turbidities at SB-A and SB-B occurred in March 1974 and in June 1974 at RCH-A and RCH-B. At all these stations, the mean turbidity values were much higher in March 1974 than in March 1973.

Sediment Grain Size

In the preliminary survey, we used a different method of determining grain-size distribution than in the subsequent surveys, and we did not categorize the sizes as extensively. We have chosen not to present the preliminary data graphically because a sufficient number of data points is lacking to describe properly the distribution. We have, however, tabulated these data. The tabulated sand, silt, and clay categories for preliminary data are not based on the same grain-size groupings as the data obtained in subsequent surveys. According to the Wentworth scale of particle size classification (Holme and McIntyre, 1971), sand consists of particles measuring from 63 to 2,000 μ in diameter. Particles measuring from 4 to 62 μ in diameter are classified as silt, and those measuring less than 4 μ in diameter are called clay. This scheme was used to classify the sediment obtained in the preliminary survey into the sand, silt, and clay categories. In the surveys that followed, the smallest grain size considered was 5 μ . Although this size of particle is classified as silt, we have elected to consider all particles less than 5 μ as clay. In the last four surveys, we did not determine specifically the percentage of the sample less than 62 μ , the sand-silt boundary. Instead, the largest

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silt particle measured was $43\ \mu$. Because of this, we chose to classify all particles larger than $5\ \mu$ but smaller than $43\ \mu$ as silt and all particles $125\ \mu$ or larger in diameter as sand.

During this investigation, we found the sediment at both Mare Island Strait stations to be composed primarily of silt and clay, as shown in Table 43. Together, these fractions comprised at least 90% of the total dry sample weight. The proportion of silt and clay varied from month to month, and ranged from 1:0.07 to 1:1.69 (silt:clay) at MIS-A. The differences in the grain-size distribution curves shown in Figure 5 are due primarily to changes in the silt-to-clay ratio.

Usually, the sediment at MIS-A had less silt than clay. In March 1973, the sediment contained approximately the same amount of silt and clay. The most marked change in the silt-to-clay ratio occurred in December, when the sediment consisted of 90% silt and 6.3% clay. A large rise in the December silt fraction also was observed at MIS-B, where in all other months the sediment contained from 1.1 to 1.53 times more clay than silt (Table 43). Figure 6 shows clearly this shift.

The sediment from the stations in Carquinez Strait contained a much larger proportion of sand than the sediment from Mare Island Strait (Table 43). We were interested especially in the March 1974 grain-size distribution at Station CS-A because of the large amount of sediment that was transferred to the Carquinez Strait disposal site from Mare Island Strait during that period. We found the sediment from the two areas to have considerably different grain-size distributions (Figures 5 and 7). Whereas the sediment at MIS-A was composed of 96.8% silt and clay, the sediment at CS-A contained only 22.1% silt and clay and a large (77.9%) amount of sand. The amount of sand in the March 1974 sediment was about 4.2 times the average for the other four sampling months.

We found the March 1974 silt-to-clay ratios for sediment from MIS-A and CS-A to be quite similar--1:1.69 for MIS-A and 1:1.63 for CS-A; we also found a similarity in the ratios in March 1973 and in December 1973. A transfer of sediment from Mare Island Strait to Carquinez Strait occurred in February and November 1973. About $845,000\ \text{yd}^3$ was transferred in November, and we do not know how

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Table 43

PROPORTION OF SAND, SILT, AND CLAY IN SEDIMENT
FROM STATIONS AT MARE ISLAND STRAIT AND CARQUINEZ STRAIT

<u>Survey</u>	<u>Date</u>	<u>Percent</u>			<u>Silt:Clay Ratio</u>
		<u>Sand</u>	<u>Silt</u>	<u>Clay</u>	
MIS-A					
P	3/73	2.8%	48.9%	48.3%	1:0.99
1	9/73	8.0	41.7	50.3	1:1.21
2	12/73	3.7	90.0	6.3	1:0.07
3	3/74	3.2	36.0	60.8	1:1.69
4	6/74	1.2	42.2	56.6	1:1.34
MIS-B					
P	3/73	3.0	46.3	50.7	1:1.11
1	9/73	3.8	38.0	58.2	1:1.53
2	12/73	5.1	90.1	4.8	1:0.05
3	3/74	5.8	38.4	55.0	1:1.45
4	6/74	3.0	43.0	54.0	1:1.25
CS-A					
P	3/73	8.1	46.9	45.0	1:0.96
1	9/73	18.7	32.5	48.8	1:1.50
2	12/73	12.4	79.7	7.9	1:0.099
3	3/74	77.9	8.4	13.7	1:1.63
4	6/74	34.1	25.3	40.6	1:1.60
CS-B					
P	3/73	79.9	9.8	10.3	1:1.05
1	9/73	47.8	23.2	29.0	1:1.25
2	12/73	34.8	63.1	2.1	1:0.03
3	3/74	51.8	17.8	30.4	1:1.70
4	6/74	52.2	18.3	29.5	1:1.61

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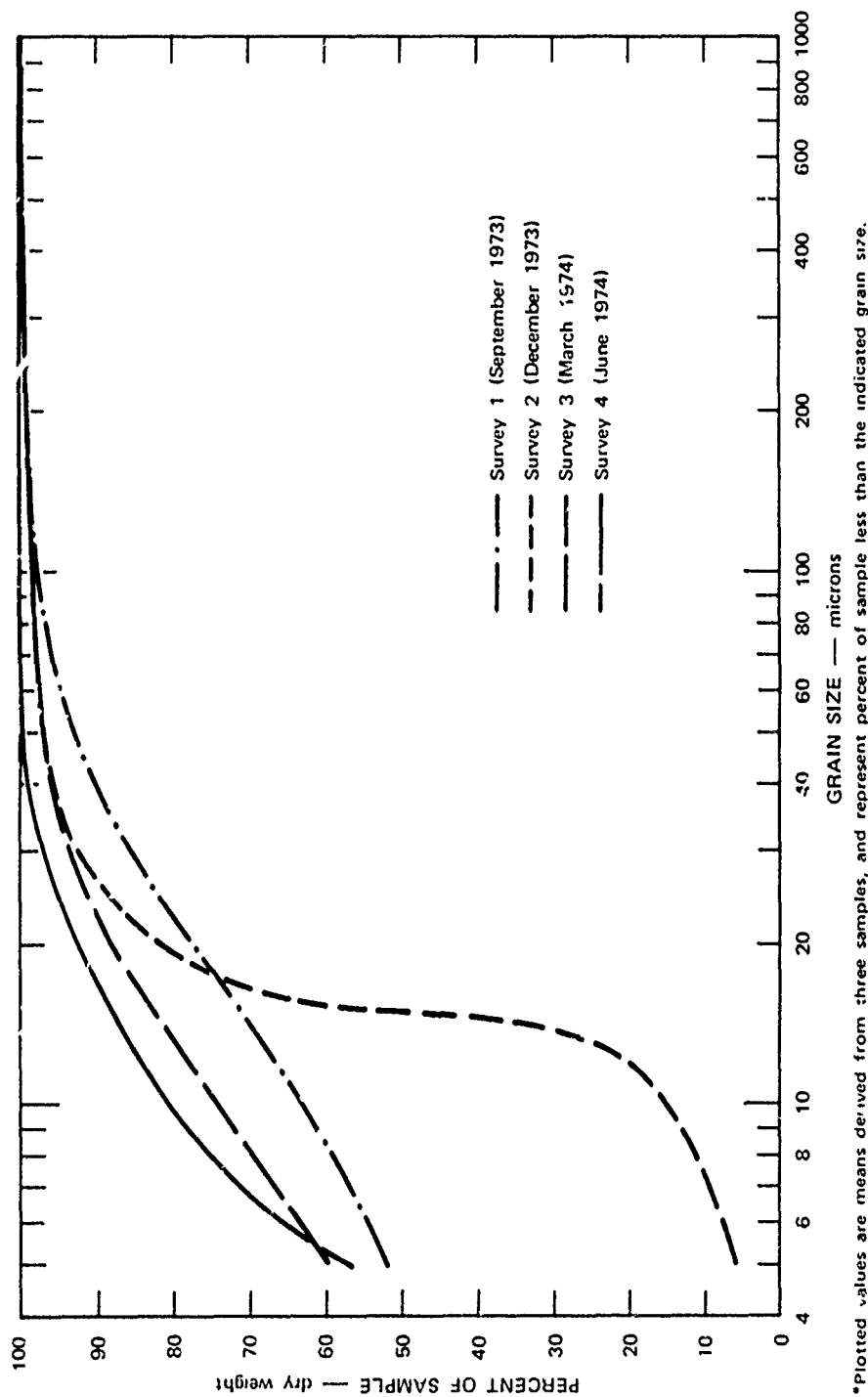
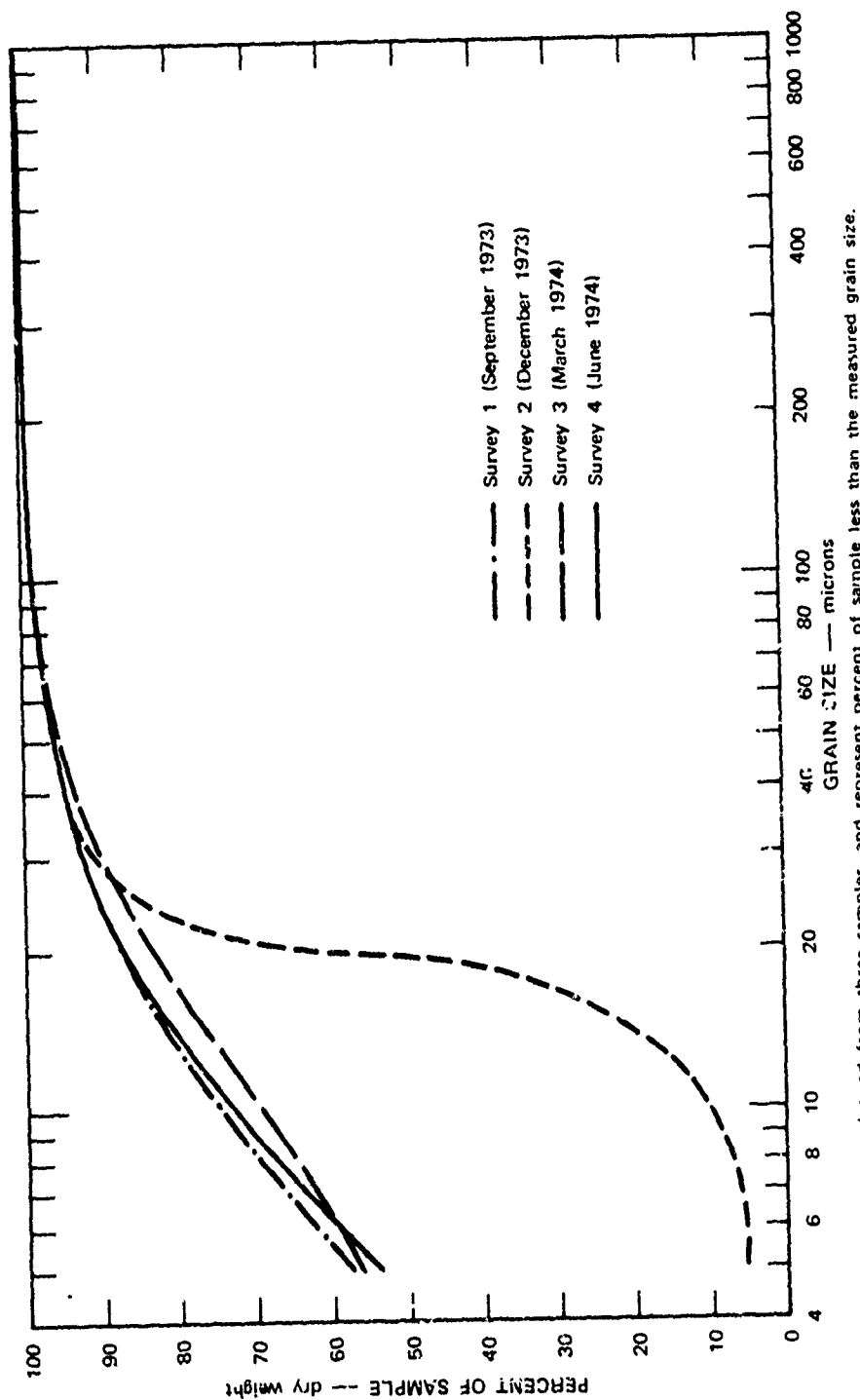


FIGURE 5 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION MIS-A*

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*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 6 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION MIS-B*

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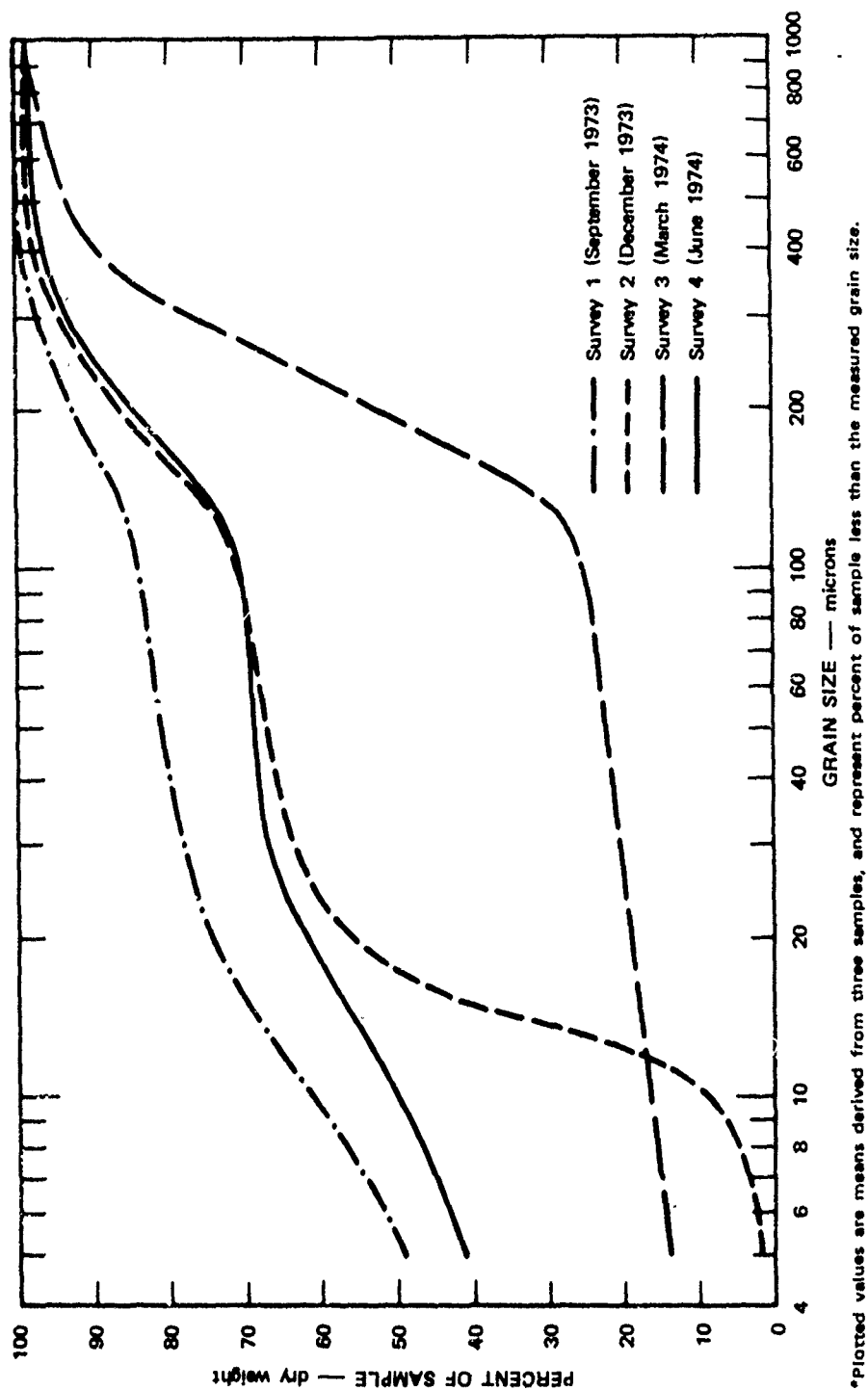


FIGURE 7 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION CS-A*

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much was transferred in February. Although the similarity in the ratios suggests that the sediment in both areas was of the same origin, the similarity could have been a coincidence.

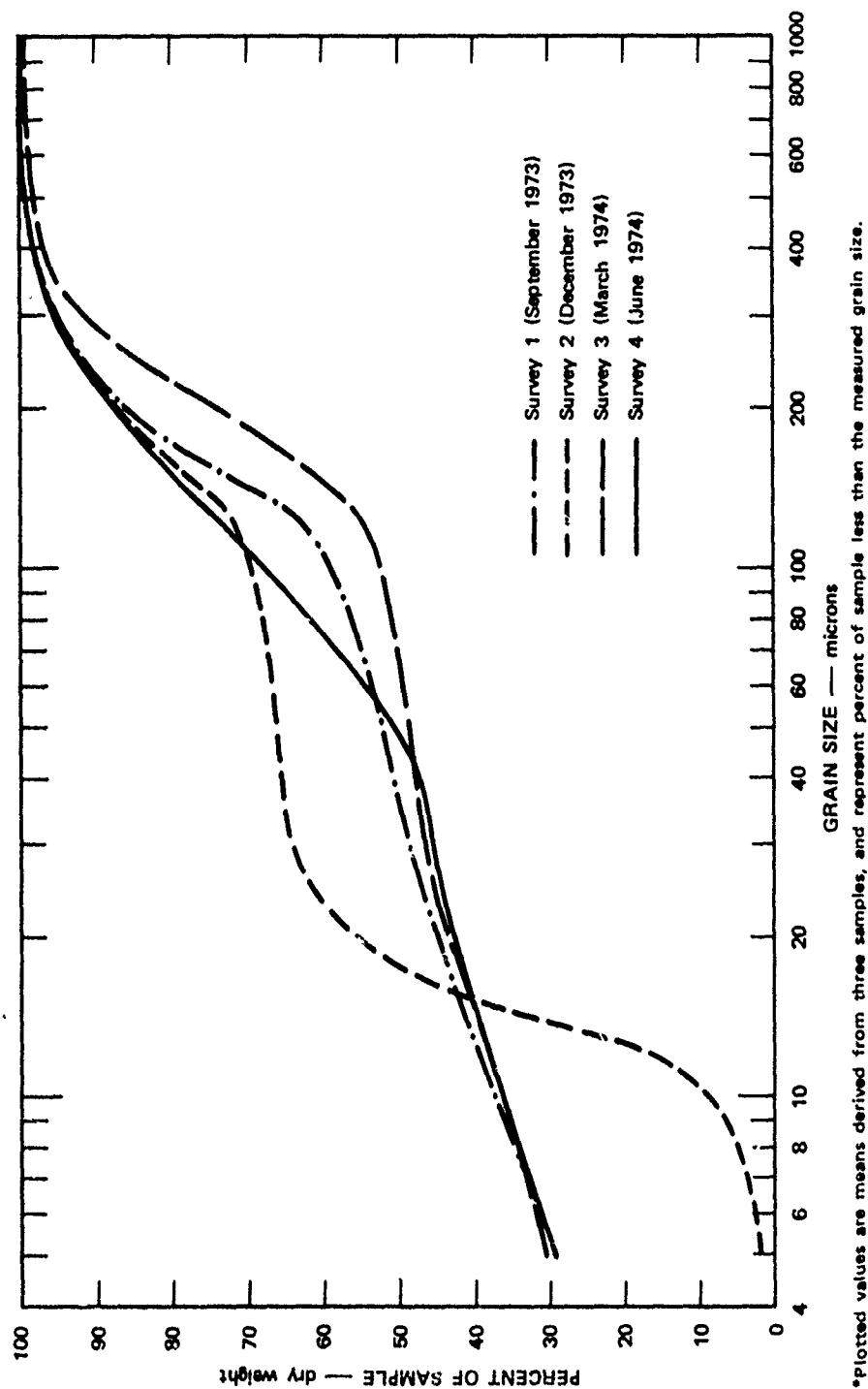
Although the sediment from Carquinez Strait was sandier than that from Mare Island Strait, the proportion of sand at CS-A during the month of active sediment transfer was about 4.2 times greater than the average for the other four months. Although we have no direct evidence, we believe that sand from Mare Island Strait may account for the difference. This sand, because of its greater density, has a greater chance of being deposited on the bottom than the lighter silt and clay.

The large increase in the proportion of silt, observed in December at MIS-A and MIS-B, also was observed at CS-A and CS-B (Figures 7 and 8). This increase in the silt fraction was noticeable in the color of the sediment (in December, it contained a larger amount of tan fines than in other months). We believe that that the tan material represented fresh silt washed into the Mare Island and Carquinez strait areas by the Napa and the Sacramento-San Joaquin Rivers.

The sediment from the Alcatraz disposal area was composed almost entirely of sand during September 1973 and June 1974 and almost entirely of silt and clay during December 1973 and March 1974. Table 44 and Figure 9 present these data. We also found a high proportion of sand in the sediment collected during March 1973; however, this sediment was collected from an area near deepest (160 ft) area of the disposal site. In December 1973, the sediment was very silty, containing 81% silt and only 3.7% clay. In March 1974, the sediment contained less silt than clay, but the difference between these two fractions was much less than in December.

Sediment from OIH also contained a considerable amount of sand (Table 44, Figure 10). The five-survey average was 65.5% sand, and the range was 55.1% to 72.3%. In September 1973 and March and June 1974, the sediment contained less silt than clay. During these months, the sediment was composed of an average of 16.5% silt and 21.6% clay. In March and December 1973, however, about nine times more silt than clay was in the sediment.

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*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

FIGURE 8 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION CS-B*

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Table 44

PROPORTION OF SAND, SILT, AND CLAY IN SEDIMENT
OF CENTRAL SAN FRANCISCO BAY

<u>Survey</u>	<u>Date</u>	<u>Percent</u>			<u>Silt:Clay Ratio</u>
		<u>Sand</u>	<u>Silt</u>	<u>Clay</u>	
ALC					
P	3/73	88.8%	6.5%	4.7%	1:0.72
1	9/73	97.6	1.1	1.3	1:1.18
2	12/73	14.9	81.4	3.7	1:0.04
3	3/74	13.2	37.0	49.8	1:1.34
4	6/74	95.0	0.4	0.1	1:0.25
OIH					
P	3/73	72.3	23.4	4.3	1:0.18
1	9/73	55.1	19.7	25.2	1:1.28
2	12/73	69.9	28.7	1.4	1:0.05
3	3/74	64.1	15.4	20.5	1:1.33
4	6/74	66.2	14.7	19.1	1:1.30
HP					
P	3/73	8.5	71.4	20.1	1:0.28
1	9/73	28.3	28.4	43.3	1:1.52
2	12/73	30.9	64.7	4.4	1:0.07
3	3/74	23.4	32.7	43.9	1:1.34
4	6/74	19.7	28.9	51.4	1:1.78

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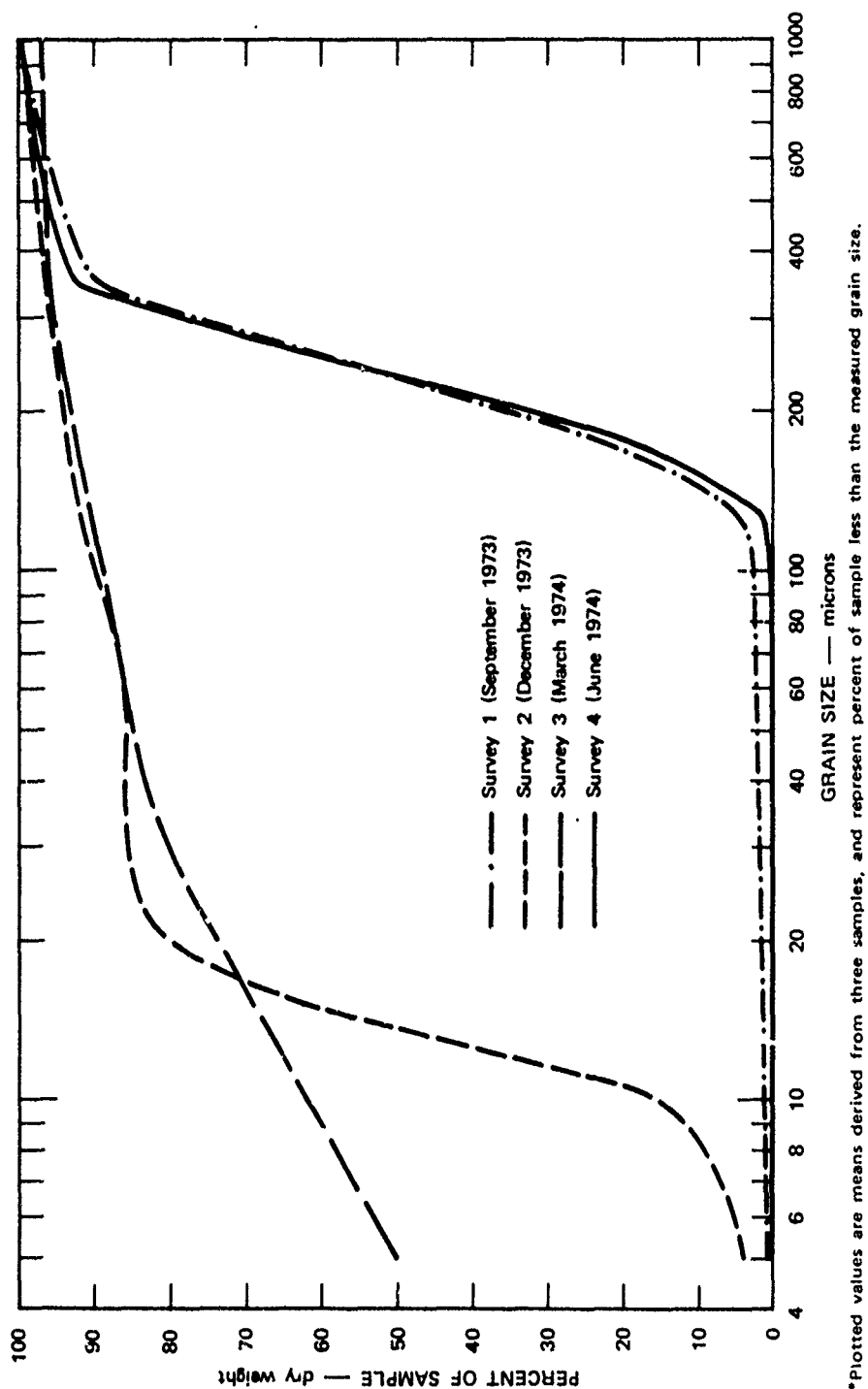


FIGURE 9 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION ALC*

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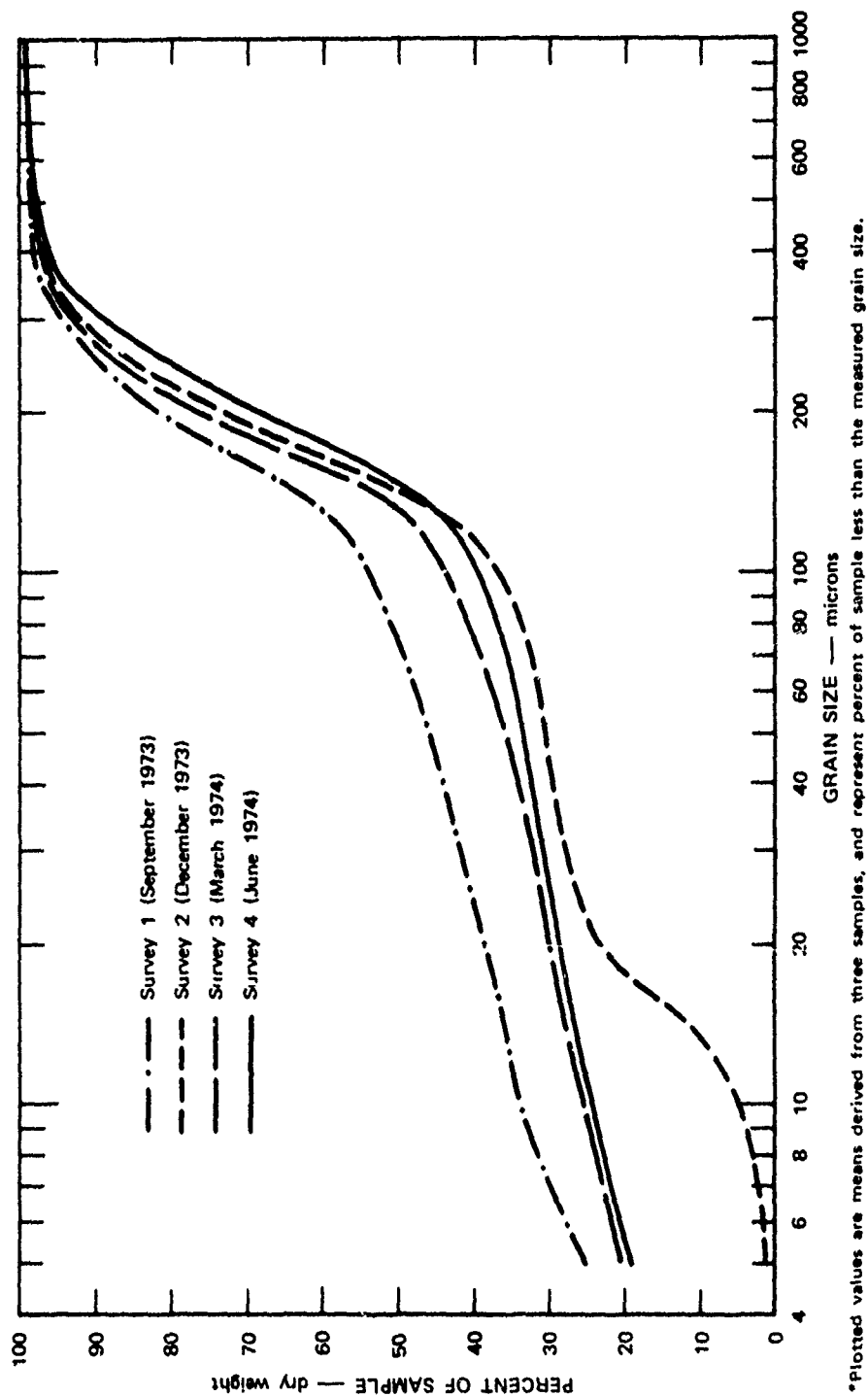


FIGURE 10 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION OIH*

*Plotted values are means derived from three samples, and represent percent of sample less than the measured grain size.

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We encountered less sand at HP than at OIH. The average sand content of the sediment at HP was 22.2%. Sediment silt and sand content and ratios varied considerably during the study.

In March and December 1973, the sediment at HP was very silty, the respective percentages being 71.4% and 64.7%. In September 1973 and March and June 1974, the amount of silt in the sediment varied very little, ranging from 28.4% to 32.7%. During these three months, a larger percentage of clay than silt was in the sediment. In December 1973, the ratio of silt to clay was only 1:0.04, as shown in Figure 11. This high proportion of silt to clay was observed at all 11 stations in December 1973 and at some stations in March 1973.

Figure 12 shows that, at the South Bay disposal site, the grain-size distribution of sediment collected from SB-A changed from month to month. In March 1973 (distribution not shown), the silt-to-clay ratio was 1:1.20, and these particles made up 96.3% of the total dry weight of the sample. Table 45 presents the percentages of sand, silt, and clay for the South Bay region. In September, the proportion of sand increased, and the silt-to-clay ratio shifted markedly. The proportion of clay was a little more than twice that of silt; and, together, the silt and clay fraction constituted 91.7% of the sample weight. The proportion of sand, silt, and clay in the March 1974 sediment samples was closer to that calculated in September 1973 than in March 1973.

As at all the other stations, we observed a very marked change in the silt-to-clay relationship in December 1973. The sediment usually contained more clay than silt, but, in December, the sediment contained less than 1% clay and about 33% silt. During this month, we also observed a considerable increase in the sand fraction, which comprised nearly a third of the sample. In June, the sediment was composed of nearly equal parts sand, silt, and clay.

The sediment from SB-B did not vary greatly in sand content from month to month and contained an average of 2.4% to 10.0% sand (Table 45). The largest changes occurred in the relative proportions of silt and clay, as shown in Figure 13. The sediment was very silty in March 1973, December 1973, and June 1974. In September 1973 and March 1974, the sediment was more clay-like.

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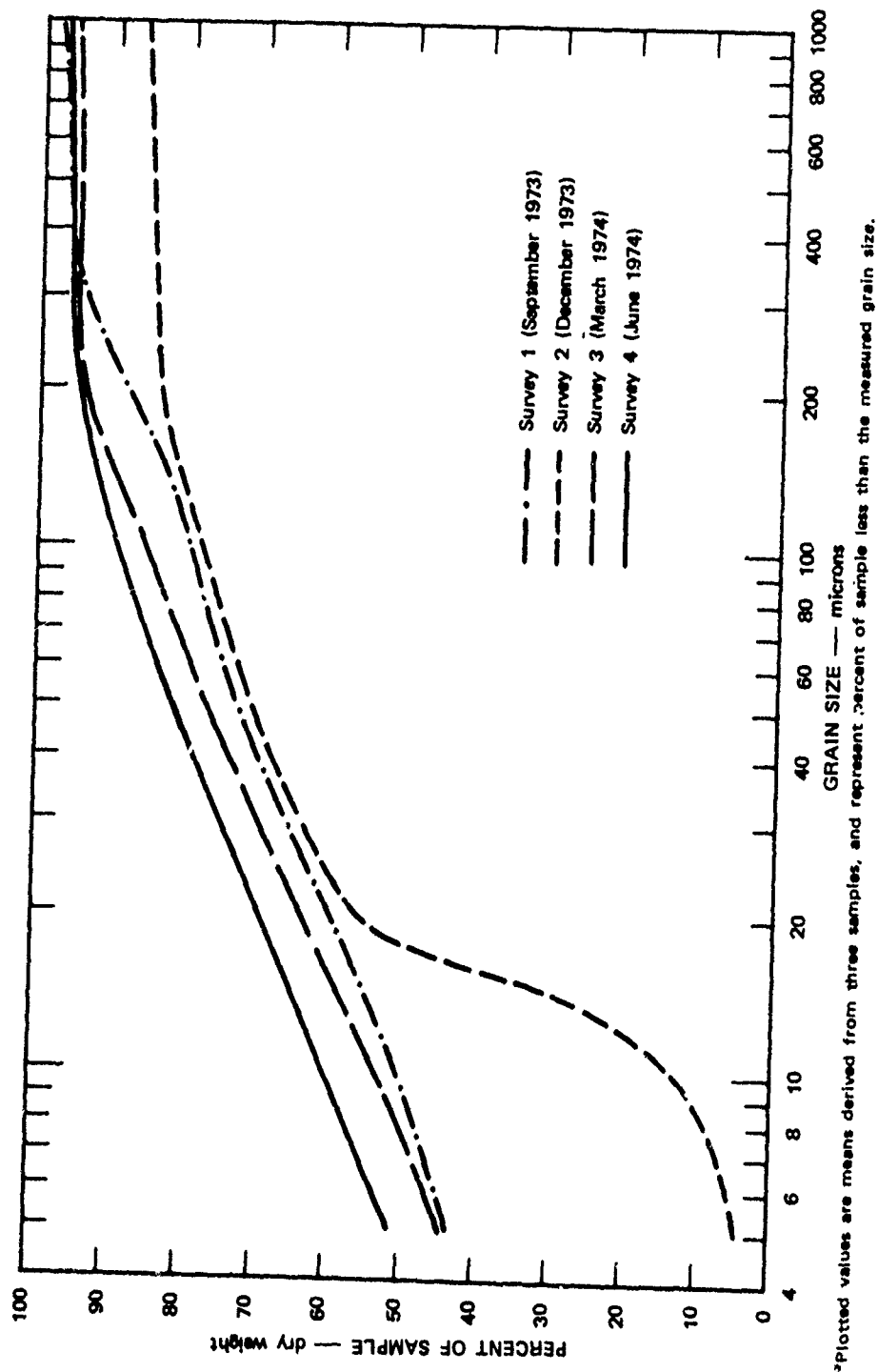


FIGURE 11 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION HP*

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Sediment Grain Size

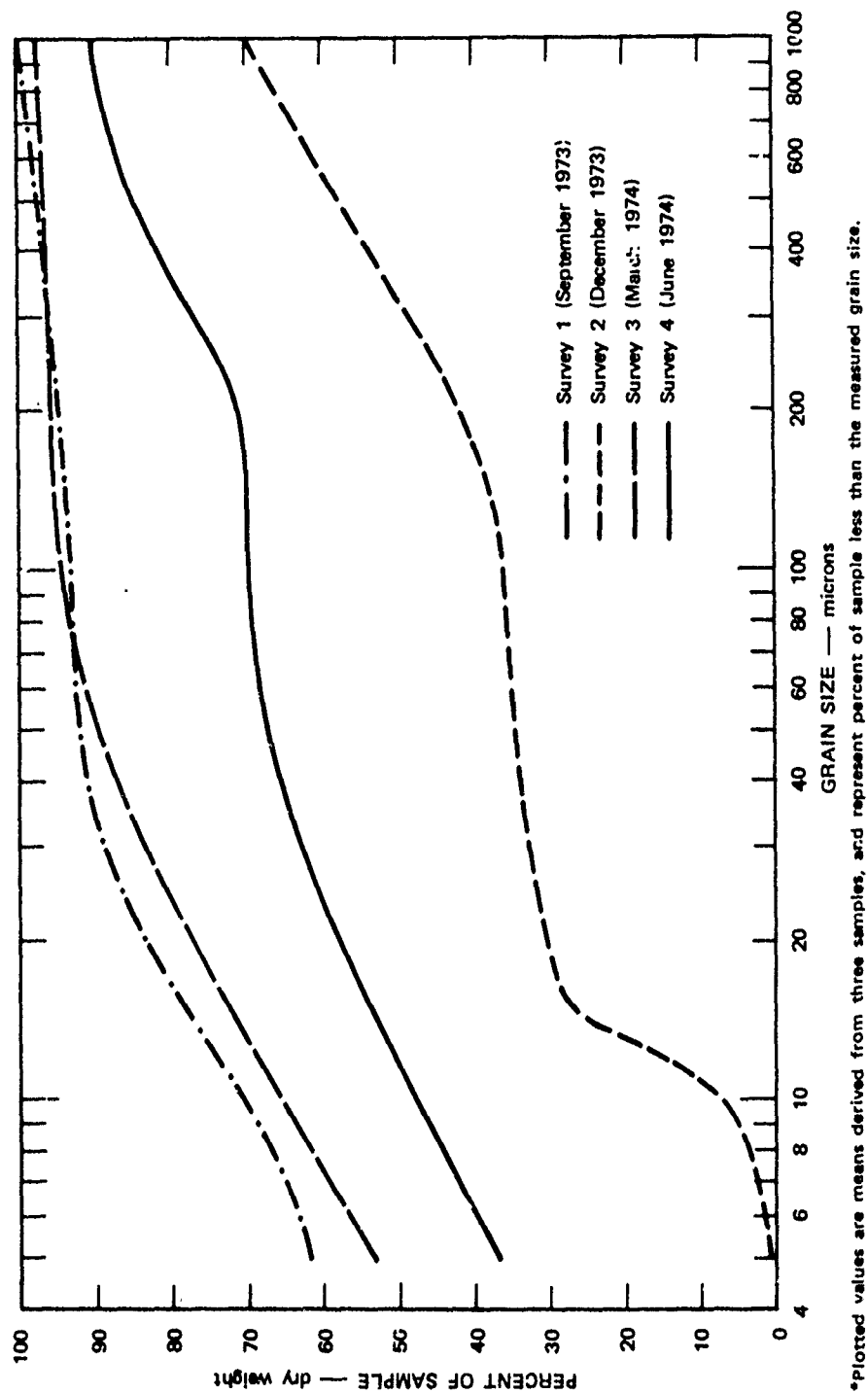


FIGURE 12 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION SB-A*

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Sediment Grain Size

Table 45

PROPORTION OF SAND, SILT, AND CLAY IN SEDIMENT
OF SOUTH SAN FRANCISCO BAY

<u>Survey</u>	<u>Date</u>	<u>Percent</u>			<u>Silt:Clay Ratio</u>
		<u>Sand</u>	<u>Silt</u>	<u>Clay</u>	
SB-A					
P	3/73	3.7%	43.8%	52.5%	1:1.20
1	9/73	8.3	29.6	62.1	1:2.10
2	12/73	6.1	33.1	0.8	1:0.02
3	3/74	8.3	37.9	53.8	1:1.42
4	6/74	32.9	30.3	36.8	1:1.21
SB-B					
P	3/73	2.4	93.7	3.9	1:0.04
1	9/73	4.8	41.4	53.8	1:1.30
2	12/73	10.0	87.2	2.8	1:0.03
3	3/74	5.7	39.6	54.7	1:1.38
4	6/74	2.9	75.2	29.1	1:0.39
RCH-A					
P	3/73	6.6	40.6	52.8	1:1.30
1	9/73	11.1	30.8	58.1	1:1.89
2	12/73	8.0	78.3	3.7	1:0.05
3	3/74	9.3	34.8	55.9	1:1.61
4	6/74	30.0	26.3	43.7	1:1.66
RCH-B					
P	3/73	5.2	50.4	44.4	1:0.88
1	9/73	6.0	36.7	57.3	1:1.56
2	12/73	3.0	91.2	5.8	1:0.06
3	3/74	3.7	36.0	60.3	1:1.66
4	6/74	2.8	37.5	59.7	1:1.59

Results and Discussion
Physical and Chemical Characteristics
Sediment Grain Size

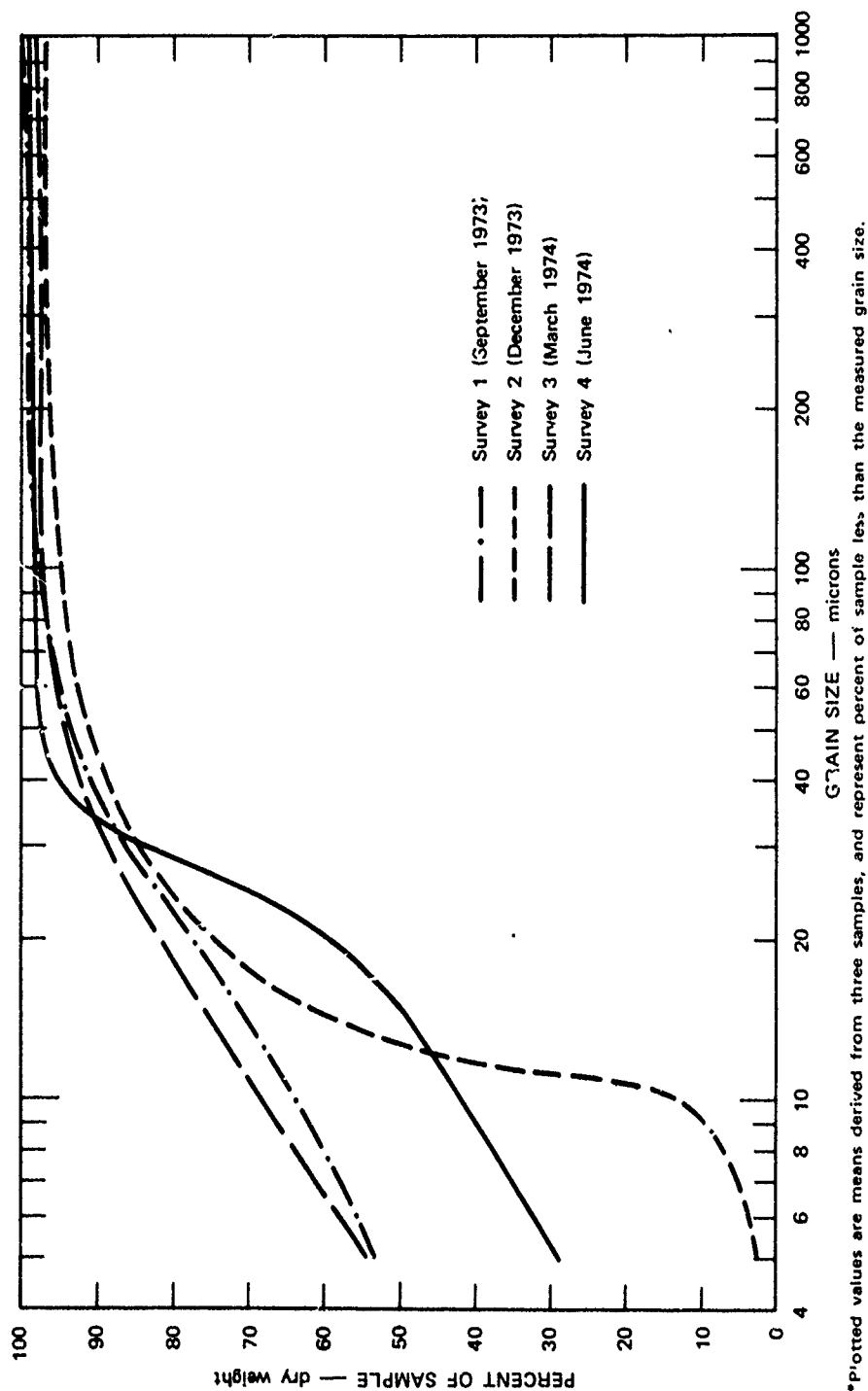


FIGURE 13 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION SB-B*

Results and Discussion
Physical and Chemical Characteristics
Sediment Grain Size

In general, we found only a small amount of sand in the sediment from the entrance channel to Redwood City Harbor. The sediment from RCH-A contained from about 30% to 89% more clay than silt, except in December when the usual reversal occurred. The samples collected in December contained 78.3% silt and only 3.7% clay (Table 45). The sediment particle-size profiles for September 1973 and March 1974 were quite similar, as shown in Figure 14. If enough data had been obtained for March 1973, that profile probably also would have been similar. In general, the sediment collected in June contained somewhat equal proportions of sand, silt, and clay.

As at RCH-A, the sediment at RCH-B contained a small percentage of sand. The average of the mean sand percentages was 4.1%. Comparatively small changes occurred in the sand content from month to month (Table 45). Figure 15 indicates that the sediment was similar in particle-size composition in September 1973, March 1974, and June 1974.

During September 1973 and March and June 1974, the silt-to-clay ratio ranged from 1:1.56 to 1:1.66. In December, the usual reversal in the proportion of silt and clay occurred. A reversal of lesser magnitude occurred in March 1973.

Results and Discussion
Physical and Chemical Characteristics
Sediment Grain Size

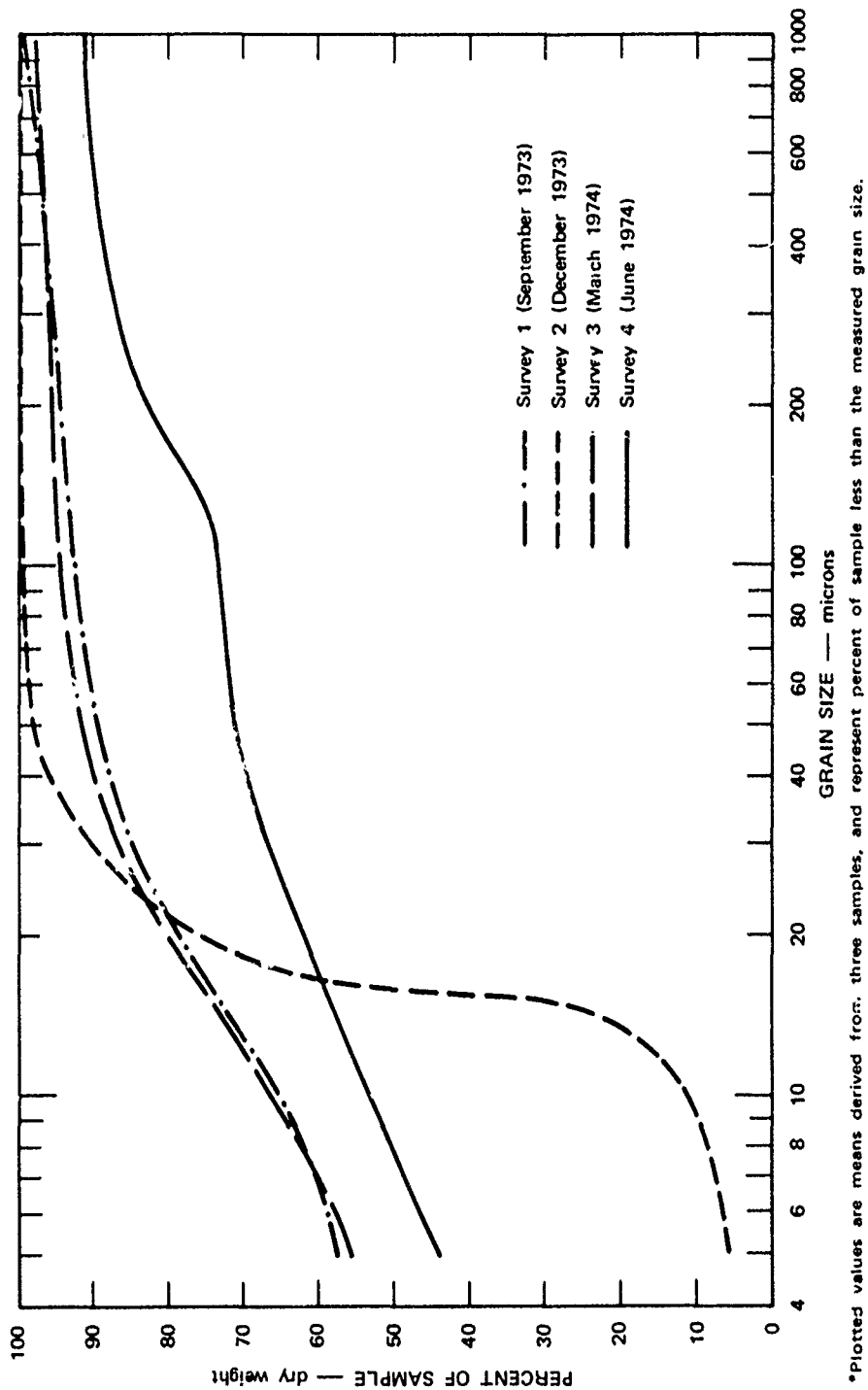


FIGURE 14 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION RCH-A*

Results and Discussion
Physical and Chemical Characteristics
Sediment Grain Size

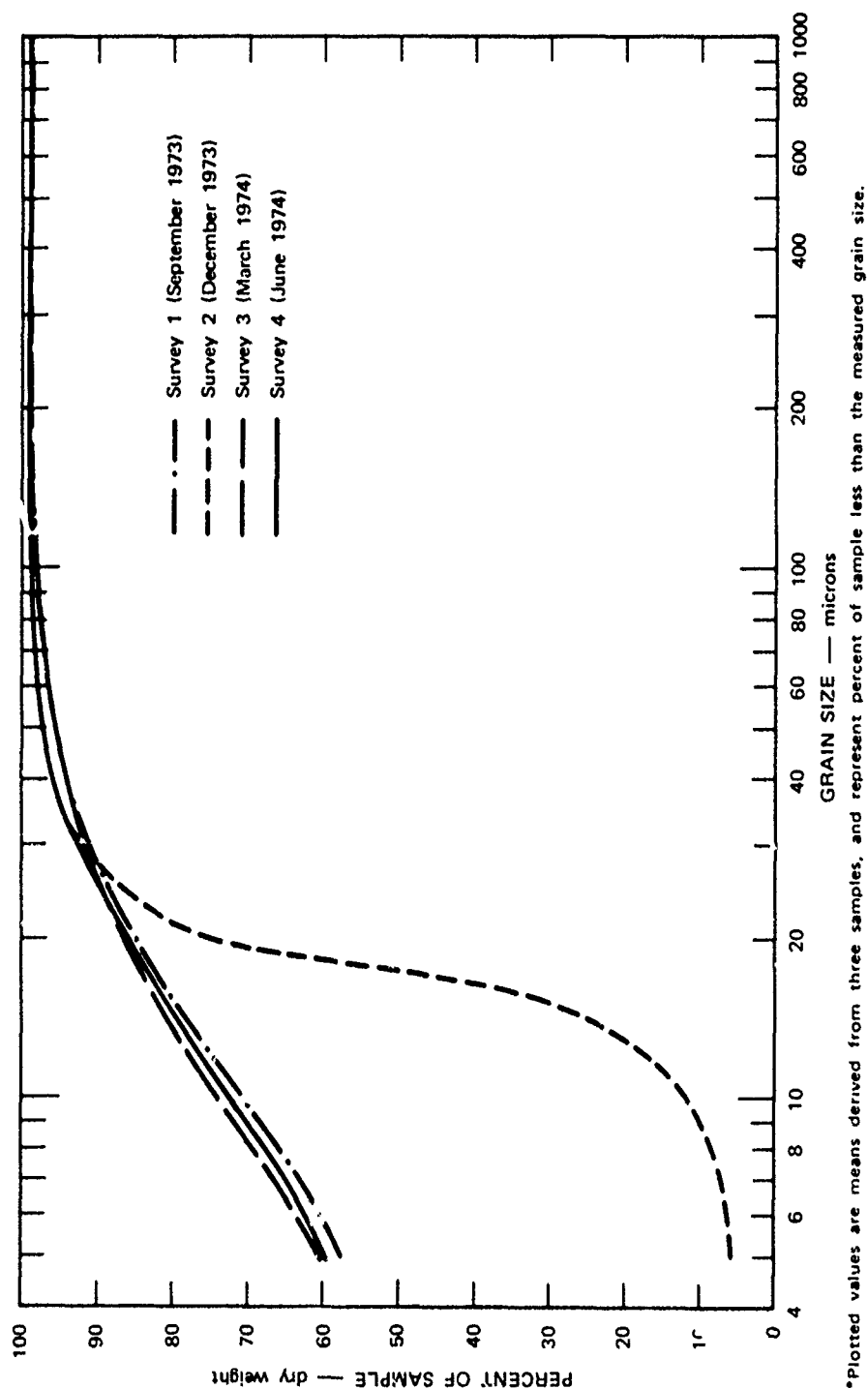


FIGURE 15 SEDIMENT GRAIN-SIZE DISTRIBUTION FOR STATION RCH-B*

ABIOTIC-BIOTIC RELATIONSHIPS

General

Many physical, chemical, and biological factors govern the distribution and abundance of organisms in nature. Because interactions among these factors are often highly complex, identification of the controlling factors can be difficult.

We attempted to identify those physical and chemical parameters measured during this investigation that appeared to influence the kinds and numbers of benthic animals found at each station. We first examined the data without using statistical methods to determine whether any obvious relationships existed. Second, we applied the least-squares method to find out whether more subtle relationships were present. We did not correlate fluctuations in the abundance of individual species with physical or chemical changes in the environment; instead, we sought relationships using the major taxonomic groups (polychaetes, arthropods, and molluscs) as well as the general population data.

Nonstatistical Analyses

Casual inspection of the data revealed few obvious relationships. From the onset, we realized that dissolved oxygen probably would not be a limiting factor, because the observed levels were always at or near saturation and were adequate for all aquatic organisms that we are familiar with. Neither did pH by itself appear limiting, although it could have an effect on sediment chemistry such as the ionic state of sulfides and heavy metals. At none of the stations did changes in sediment grain-size distribution, temperature, turbidity, sulfide levels, or concentrations of any of the heavy metals (one exception) appear to influence the size of the animal populations or the number of taxa present.

Abiotic-Biotic Relationships Nonstatistical Analysis

Table 46 shows that, where fluvial influences were great (as at Mare Island Strait and the Carquinez Strait disposal site), the sediment was inhabited primarily by oligochaetes and by fewer taxa than where the Bay environment was less influenced by fresh water. At Mare Island Strait and the Carquinez disposal site, the salinity was usually lower and the turbidity of the water was usually higher than at any other area investigated. Both salinity and turbidity, as well as sediment sulfide levels, fluctuated more than at other areas.

We also found the largest assemblages of different kinds of animals at locations where salinity was usually high and water and sediment temperature were usually low. These conditions were observed at OIH, ALC, and HP.

Of all areas investigated, OIH had the largest population of benthic animals during all sampling months except June 1974. The majority of the organisms were oligochaete and polychaete worms. The conditions that enabled the sediment to support the large numbers of organisms were not obvious. However, the sediment sulfide levels at OIH usually were higher and much less variable than those at all the other areas investigated, and during at least one sampling month, the sediment contained more lead, zinc, cadmium, and mercury than did the sediment from other areas. We are not certain of the cause of the marked reduction in the number of taxa and specimens collected in June 1974, but, we did observe that the sediment collected during that month contained about 90% more zinc than did the sediment collected in March 1974. Whatever the cause of the decline, the result was a reduction in the size of the population of all major animal groups.

Another observation was that the undredged portion of Mare Island Strait, MIS-B, supported a larger animal population than the dredged portion, MIS-A. However, MIS-A usually was inhabited by a larger number of taxa. The physical and chemical properties of the water and sediment from MIS-A were not much different from those of MIS-B. The population data presented in Table 46 show that the populations in both areas reached their greatest size in September and that, whereas the size of the population at MIS-B remained relatively large in succeeding months, the size of the population at MIS-A declined markedly in December 1973 and March 1974.

Abiotic-Biotic Relationships
Nonstatistical Analysis

Table 46

NUMBER OF BENTHIC SPECIMENS AND TAXA COLLECTED AT VARIOUS DREDGE
AND DISPOSAL AREAS IN SAN FRANCISCO BAY DURING 1973 AND 1974
(Number of Taxa Shown in Parentheses)

Station	Survey					Total*
	P (March 1973)	1 (Sept. 1973)	2 (Dec. 1973)	3 (March 1974)	4 (June 1974)	
MIS-A	132 (11)	8,066 (17)	628 (19)	53 (7)	333 (10)	9,212 (33)
MIS-B	352 (12)	15,773 (12)	15,596 (16)	12,150 (12)	12,307 (10)	56,178 (26)
CS-A	192 (16)	841 (24)	1,419 (20)	300 (18)	5,698 (19)	8,450 (47)
CS-B	34 (15)	4,743 (19)	346 (20)	1,795 (19)	814 (18)	7,732 (48)
ALC	9 (7)	12,764 (58)	888 (82)	7 (9)	1,419 (28)	15,087 (133)
OIH	21,153 (76)	28,784 (66)	41,772 (69)	34,311 (64)	5,236 (44)	131,256 (137)
HP	3,111 (51)	10,514 (50)	1,945 (62)	841 (46)	2,601 (80)	19,012 (138)
SB-A	1,486 (39)	9,680 (48)	8,859 (55)	7,900 (52)	4,721 (52)	32,646 (91)
SB-B	2,765 (43)	6,348 (35)	10,969 (60)	2,456 (43)	10,124 (47)	32,662 (99)
RCH-A	1,425 (42)	19,671 (43)	10,614 (36)	6,921 (44)	21,914 (53)	60,545 (91)
RCH-B	1,965 (48)	2,337 (25)	7,236 (32)	8,526 (31)	14,582 (44)	34,646 (81)

*Taxa totals refer to total number of different taxa.

Abiotic-Biotic Relationships Least-Square Analyses

Although this decline corresponded with a marked lowering of salinity, it also corresponded with times of heavy dredging activity, which occurred in November 1973 and in February through April 1974. We believe the dredged area supports a smaller benthic animal population because the sediment is disturbed to a greater degree by dredging activity at certain times of the year and possibly by a combination of river water flow and tidal action. That salinity changes have little influence is supported by the observation that, although the salinity of the water from MIS-B was lower in December 1973 and March 1974 than at MIS-A, and the change from September to December was greater, the size of the animal population remained relatively stable at MIS-B.

Least-Square Analyses

To analyze the data more completely, we applied the method of least squares. We selected eight dependent variables--the total number of noncolonial specimens per liter, the total number of taxa per liter, the total number of species and specimens of polychaetes per liter, the total number of species and specimens of arthropods per liter, and the total number of species and specimens of molluscs per liter.

The design of the benthic community study is displayed in Table 47, which shows biological and environmental data collected during each of the five surveys.

The pattern of data collection imposes two limitations on the statistical analyses that may be performed. The first limitation is that only one total species and specimen count exists for each combination of station and survey, so the effective number of observations for a combination of variables is the total number of stations times the number of surveys during which that combination of variables was collected. Thus, the number of observations--73--associated with a combination of data, is not large enough for detection of subtle effects on species and specimen counts. The second limitation is that the design of the benthic community study did not allow for the simultaneous estimation of survey effects associated with the time of year and station effects associated with the area surveyed.

Abiotic-Biotic Relationships
Least-Square Analyses

Table 47
DESIGN OF BENTHIC COMMUNITY STUDY

Data Collected	Number of Stations	Number of Determinations				
		P (March 1973)	1 (Sept. 1973)	2 (Dec. 1973)	3 (March 1974)	4 (June 1974)
Number of specimens	11	11	11	11	11	11
Number of species	11	11	11	11	11	11
Water temperature	11	22	22	22	22	22
Sediment temperature	11	73	66	66	44	44
Water salinity	11	22	22	22	22	22
Sediment salinity	11	0	0	0	44	44
Water pH	11	22	22	22	22	22
Sediment pH	11	73	66	66	44	44
Total sulfides in water	11	22	22	22	22	22
Total sulfides in sediment	11	73	66	66	33	32
Water turbidity	11	22	22	22	22	22
Sample volume of sediment	11	73	66	66	44	44
Dissolved oxygen in water	11	22	22	22	22	22
Copper in sediment	11	42	33	33	33	33
Cadmium in sediment	11	42	33	33	33	33
Lead in sediment	11	42	33	33	33	33
Zinc in sediment	9	0	0	27	27	27
Mercury in sediment	9	0	0	27	24	27

Abiotic-Biotic Relationships Least-Square Analyses

Although we cannot compensate for the first limitation, we can address the second by analyzing the data by two approaches--one that accounts for station effects but not survey effects and one that accounts for survey effects but not station effects.

The method of collection also imposes a limitation. These data represent an observational study, instead of a random sampling from a well-defined population, implying that the probability statement obtained by application of commonly used statistical techniques must be interpreted cautiously and that analyses of these data should be considered as a description of the data using least-squares theory rather than as an attempt to create a statistical model.

Briefly, the least-squares theory solves for parameters $b_1, b_2, \dots, b_m$ in a model of the data $y, x_1, x_2, \dots, x_p$ by minimizing

$$\sum_j^n \left[y_j - f(x_{1j}, x_{2j}, \dots, x_{pj}; b_1, b_2, \dots, b_m) \right]^2 \quad (1)$$

where y is the dependent variable, $x_1 \dots x_p$ are independent variables, and summation takes place over all the n observations. The interrelations among the data elements are summarized by the parameter estimates $\hat{b}_1, \hat{b}_2, \dots, \hat{b}_m$, and the fit of the model is summarized by the value of

$$\sum_j^n \left[y_j - f(x_{1j}, x_{2j}, \dots, x_{pj}; \hat{b}_1, \hat{b}_2, \dots, \hat{b}_m) \right]^2 \quad (2)$$

We used a slight extension of this theory for linear f , which allows the possibility that y is a collection of observations instead of a single datum. This theory, developed in Anderson (1958), minimizes the residual sum of squares matrix that corresponds to Equation 1:

$$\sum_j^n \begin{pmatrix} Y_j \\ Y_j \end{pmatrix} - \begin{pmatrix} LX_j \\ BX_j \end{pmatrix} \begin{pmatrix} Y_j - LX_j \\ Y_j - BX_j \end{pmatrix}' \quad (3)$$

Abiotic-Biotic Relationships Least-Square Analyses

where Y is the vector of eight dependent variables, X is the vector of independent variables, and B is the matrix of parameters.

The primary assumption involved in these analyses is that Equation 3 is the same for each observation of the vector Y . According to least-squares theory, there is no assumption of linearity in that the choice of function is a matter of judgment. A linear function was chosen for these analyses because of its ease of interpretation as well as mathematical convenience. All basic computations were performed by BMD 11V (Dixon, 1973) on a CDC 6400 computer.

Table 47 shows that full analysis of these data requires at least six applications of least-squares methodology. The water data and sediment data must be examined from the point of view of stations and surveys, and the data for zinc and mercury--collected in only three surveys--require separate analyses for stations and for surveys.

Before executing these six analyses, we examined the standard deviations of the independent variables for samples within survey and station to determine how well their mean values would summarize the survey results on these variables. Generally, the raw data indicated that the mean summarized the survey results well, because the standard deviations were generally small. Thus, for all subsequent analyses, the average over samples was used as the independent variable in each of the six regression models.

Because the linear least-squares approach structures the data by assuming a constant deviation from the regression plane, there is a tendency to under-represent the variability of the data. To examine the extent to which this is the case here, we calculated the intercorrelations among the variables for each station by pooling across surveys. These correlations were fairly dissimilar, as were the corresponding correlations for the logarithms of the variables. Based on this result, we decided to use the raw frequency counts as the dependent variable, since they are easiest to interpret. In addition, we concluded that the resultant equations smooth the data considerably.

Abiotic-Biotic Relationships Least-Square Analyses

Table 48 shows the independent variables for each of the six linear regression equations, the parameters of which were estimated for each of the eight dependent variables. It also shows the surveys on which parameters were estimated. In Equations 1 through 4, sediment data is used, whereas Equations 5 and 6 enable examination of the relationship between the water data and the eight dependent variables. Equations 1 and 3 allow examination of station effects for the sediment data, whereas Equation 5 provides estimates of station effects for the water data. Similarly, Equations 2, 4, and 6 allow estimation of survey effects.

Table 49 shows the coefficients of determination for each of the regression runs for each of the dependent variables. Overall, the table shows the great variation in the adequacy of these equations. The water equation for estimating survey effects is completely unsuccessful in predicting the total number of species. Except for Equations 1 and 3, the number of arthropod species is not predicted very well by any of these data.

Conversely, except for the number of arthropod species and the total number of species, each of the dependent variables has an equation that accounts for at least 60% of the observed variance. Generally, the equations for the number of arthropods and the number of molluscs are particularly good, sometimes accounting for 80% of the observed variance.

Generally, the water data and the sediment data can be predicted equally well. Sometimes one set is superior for a given dependent variable, and sometimes the other is. However, for both sets of data, the total number of species and the total number of polychaetes are predicted best by the equations that take into account station effects, whereas the counts for the other variables are predicted best by the equations that take into account survey effects (except in the equations that examine the effects of mercury and zinc). For total individual counts, the agreement between sediment data and water data does not exist. For the sediment data, the survey equations are superior, and for the water data, the station equation is superior.

Abiotic-Biotic Relationships Least-Square Analyses

Table 49
INDEPENDENT VARIABLES USED IN THE SIX REGRESSION EQUATIONS

	Equation 1: Surveys 2,3,4 ^a	Equation 2: Surveys 1,2,3,4 ^b	Equation 3: Surveys 2,3,4 ^c	Equation 4: Surveys 1,2,3,4 ^d	Equation 5: Surveys 1,2,3,4 ^e	Equation 6: Surveys 1,2,3,4 ^f
V ₁	Temperature	Sample volume	Temperature	Sample volume	Temperature	Temperature
V ₂	Zinc	Temperature	Zinc	Temperature	Salinity	Salinity
X ₃	Mercury	Total sulfides	Mercury	Total sulfides	D.O.	D.O.
X ₄	North stations	pH	Survey 2	pH	Turbidity	Turbidity
X ₅	Alcatraz	Lead	Survey 3	Lead	pH	Total sulfides
X ₆	Central stations	Cadmium	Constant	Cadmium	Depth	pH
V ₇	Constant	Copper		Copper	WIS-A	Depth
X ₈		Silt		Silt	WIS-B	Survey 1
X ₉		Clay		Clay	CS-A	Survey 2
X ₁₀		WIS-A		Survey 1	CS-B	Survey 3
V ₁₁		WIS-B		Survey 2	ALC	Constant
V ₁₂		CS-A		Survey 3	OH	
X ₁₃		CS-B		Constant	HP	
V ₁₄		Alc			SB-A	
V ₁₅		OD			SB-B	
X ₁₆		HP			RCH-A	
X ₁₇		SB-B			Constant	
V ₁₈		Constant				

$$\begin{aligned}
 & \text{a-} \sum_{i=1}^6 x_i = \text{South stations.} \\
 & \text{b-} \sum_{i=1}^{17} x_i = \text{RCH-B.} \\
 & \text{c-} \sum_{i=1}^5 x_i = \text{Survey 1.} \\
 & \text{d-} \sum_{i=1}^{13} x_i = \text{Survey 1.} \\
 & \text{e-} \sum_{i=7}^{16} x_i = \text{RCH-B.} \\
 & \text{f-} \sum_{i=7}^{12} x_i = \text{Survey 1.}
 \end{aligned}$$

Abiotic-Biotic Relationships
Least-Square Analyses

Table 49

COEFFICIENTS OF DETERMINATION

Dependent Variables	Independent Variables					
	Sediment- Station Effects (Eq. 1)	Sediment- Station Effects (Eq. 2)	Sediment- Survey Effects (Eq. 3)	Sediment- Survey Effects (Eq. 4)	Water- Station Effects (Eq. 5)	Water- Survey Effects (Eq. 6)
1 Total specimens	0.230495	0.493634	0.692746	0.681674	0.809990	0.651279
2 Total species	0.508097	0.675920	0.212475	0.412727	0.383505	0.041197
3 Total polychaetes	0.515535	0.78245	0.429015	0.453688	0.392815	0.182632
4 Total Polychaete spp.	0.808455	0.531338	0.497265	0.694679	0.504883	0.844813
5 Total molluscs	0.919301	0.348910	0.816610	0.892651	0.690219	0.921750
6 Total Mollusc spp.	0.631786	0.520644	0.879124	0.695512	0.743057	0.773438
7 Total arthropods	0.953289	0.544989	0.900416	0.809805	0.732951	0.774313
8 Total Arthropod spp.	0.452586	0.014424	0.411557	0.050125	0.013396	0.930371

Abiotic-Biotic Relationships Least-Square Analyses

This reversal, together with the large variation in the effectiveness of the equations, reveals the complexity of the relations that underlie these data. Table 50 shows the correlation among the dependent variables after removing the variation predicted by the models. The numbers on the main diagonals are the standard errors of the dependent variables. This table confirms that the interrelations are variable and that the picture of the interrelations strongly depends on which equation is being examined.

Comparison of the standard errors for the dependent variables in each of these models shows that, although variation occurs from equation to equation, Equations 1 and 3 are particularly unsuccessful, but Equation 5 is generally good. Equations 1 and 2 are also different from the other sediment equations in that they indicate a preponderance of negative correlations (the others show a preponderance of positive correlations). However, since Equations 1 and 3 are based on fewer observations than the others, the disagreements may not be important.

It is interesting that, for the equation using water variables, the residual correlations are generally negative when stations are considered in the equation; however, the correlations are generally positive when the surveys are considered. The implication is that large errors in long-range predictions may occur because of failure to account for this interaction between station and survey.

Table 51 shows the values of estimated parameters for each of the six models. Tables 52 through 57 show the results of hypothesis tests on the estimated parameters. All hypothesis tests shown are multivariate in the sense that they test whether effects are zero for all dependent variables simultaneously. The F statistics are exact if the dependent variables are multivariate normal and if either A or C, shown in the tables, is either 1 or 2. "C" indicates the number of dependent variables being considered, and "A" refers to the number of covariables or independent variables being considered in the hypothesis tests. Otherwise, the F tests are approximate (see Dixon, 1973). In the following discussion, unless otherwise qualified, "significant" means $p \leq 0.05$ under the assumption that the F test is valid.

Abiotic-Biotic Relationships
Least-Square Analyses

Table 50
RESIDUAL CORRELATIONS AMONG THE EIGHT DEPENDENT VARIABLES

	1	2	3	4	5	6	7	8
	<u>Equation 1</u>							
1	0.076105	-0.466255	-0.416919	-0.008161	-0.072069	0.105982	-0.072248	-0.439308
2		6.560012	0.861569	-0.325127	0.403862	-0.082062	0.324906	0.939118
3			70.737868	-0.208346	0.389872	-0.214847	0.204963	0.861288
4				1.639041	-0.101459	0.061803	0.088881	-0.388558
5					0.446598	0.547134	0.318121	0.423570
6						0.305800	0.402918	-0.075748
7							0.459860	0.323945
8								0.464909
	<u>Equation 2</u>							
1	0.284999	0.269189	0.558504	0.550638	0.718791	0.710473	0.488951	0.004109
2		0.390243	-0.168151	0.160475	0.412646	0.187745	0.295093	0.302605
3			0.391584	0.528941	0.398366	0.376016	0.554118	0.093266
4				0.306769	0.721597	0.384455	0.497155	0.170189
5					0.201443	0.432892	0.538691	-0.176027
6						0.300594	0.087291	0.260483
7							0.314650	-0.070283
8								0.020399

Abiotic-Biotic Relationships
Least-Square Analyses

Table 50 (Continued)

1	2	3	4	5	6	7	8
<u>Equation 3</u>							
1 49.146566	0.302971	-0.015037	-0.323333	0.159937	-0.343662	-0.231773	-0.234003
2	0.077935	-0.448840	-0.473936	0.040781	0.199967	0.070159	-0.477931
3		6.402645	0.82006	-0.32331	-0.510915	-0.133409	0.916461
4			72.951738	-0.246330	-0.243759	0.083411	0.868058
5				1.620401	0.029183	-0.316964	-0.410333
6					0.813911	0.427409	-0.192567
7						0.833623	0.189211
8							0.466661

<u>Equation 4</u>							
1 0.23011	0.41705	-0.237143	0.299675	0.359524	0.135898	0.555255	0.45693
2	8.265371	0.359241	-0.037926	0.19962	0.355155	0.111668	0.431443
3		18.666432	-0.537899	0.02049	0.532463	-0.415726	0.109237
4			21.140766	-0.60502	-0.452108	0.465317	0.132574
5				0.789105	0.790305	0.801905	0.438155
6					0.614229	0.32153	0.51201
7						0.716341	0.325349
8							0.022185

Abiotic-Biotic Relationships
Least-Square Analyses

Table 5C (Concluded)

	1	2	3	4	5	6	7	8
	<u>Equation 5</u>							
1	0.364678	0.232582	0.343813	0.167655	0.123894	0.204749	0.324764	-0.131365
2		0.172664	0.29265	-0.522212	-0.008931	0.252320	0.122779	-0.091046
3			0.176855	-0.115957	-0.143194	0.043095	0.29939	-0.099742
4				0.227311	-0.214849	-0.068181	-0.064603	0.1215
5					0.310754	0.039451	0.043672	-0.215505
6						0.334543	0.04735	-0.083495
7							0.329993	-0.35739
8								0.016333

	<u>Equation 6</u>							
1	2.182329	0.214234	0.19064	0.684496	0.339042	0.439404	0.014407	0.457129
2		0.355936	0.457377	0.153972	-0.375659	-0.296989	-0.095644	0.834752
3			8.471614	0.197512	-0.029094	-0.002005	-0.040365	0.498713
4				0.604277	0.641292	0.489577	0.406353	0.392871
5					0.659304	0.767862	0.724857	-0.025246
6						0.553225	0.268423	0.163739
7							0.540923	-0.101919
8								0.033932

Abiotic-Biotic Relationships
Least-Square Analyses

Table 51

REGRESSION COEFFICIENTS

Independent Variables*	Dependent Variables†							
	1	2	3	4	5	6	7	8
<u>Equation 1</u>								
1	-0.00010	0.02387	0.25533	-0.00087	-0.00024	0.00236	0.00019	0.00164
2	0.50856	13.26398	1.43151	3.67816	0.86886	0.34602	0.26572	0.74711
3	-0.00018	-0.02020	-0.17731	-0.00142	-0.00094	-0.00300	-0.00155	-0.00092
4	-0.44382	-22.44807	-4.65696	-9.94927	-1.45404	-0.24327	-0.18756	-1.46942
5	0.00129	-0.16008	-2.00109	0.03218	0.01042	-0.00962	-0.00674	-0.01224
6	-0.60593	18.72075	453.62615	1.09172	-1.35066	-1.54494	-0.76030	2.70883
7	0.00048	-0.00196	-0.47995	-0.00527	-0.00264	-0.00619	-0.00366	-0.00222
<u>Equation 2</u>								
1	0.00275	-0.00010	-0.00011	-0.00060	0.00097	0.00008	0.00070	-0.00004
2	1.39236	1.39246	0.06741	1.20583	0.23642	1.63658	1.17598	-0.03762
3	-0.00373	-0.00114	-0.00142	-0.00169	-0.00157	-0.00199	-0.00114	-0.00008
4	-1.33120	-0.90073	0.32723	0.90290	0.06289	-0.50136	-0.62394	0.05405
5	-0.01160	0.00261	0.00580	-0.00219	0.00136	0.00151	-0.00728	-0.00014
6	-2.73588	-3.21646	1.50285	-2.85298	-0.58268	-3.12536	-2.46522	-0.11730
7	-0.00266	0.00120	0.00026	-0.00101	-0.00065	0.00120	-0.00006	0.00006
8	-0.61125	-1.45721	-0.95416	-0.73608	0.11639	-2.06984	-0.43263	-0.03247
9	0.09768	0.07236	0.05548	0.02610	0.04754	0.07636	0.17516	0.00147
10	-0.06920	-0.10106	-0.04155	-0.01105	-0.03675	-0.08490	-0.06957	0.00457
11	0.00021	0.00043	0.00022	-0.00009	0.00057	0.00002	0.00102	-0.00001
12	-0.21870	0.03396	0.01177	-0.00533	-0.09788	-0.12234	-0.43963	0.12551
13	-0.01328	-0.04484	-0.03084	-0.01893	-0.00376	-0.00827	-0.2409	-0.00197
14	-0.00303	0.01091	-0.08146	0.62761	0.08707	-0.52005	-0.04245	0.04053
15	0.00615	0.03201	0.02059	-0.00526	0.00261	0.01771	0.00168	0.00074

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Table 51 (Continued)

Independent Variables*	Dependent Variables†							
	1	2	3	4	5	6	7	8
16	-0.01075	-0.01664	-0.01739	-0.00658	-0.01083	-0.01144	-0.01603	-0.00002
17	-0.00795	-0.01448	-0.01502	-0.00909	-0.00950	-0.00457	-0.00976	-0.00028
18	0.38702	0.13567	0.36768	0.31712	0.61260	0.45427	0.70068	-0.00284
Equation 3								
1	0.14119	-0.00004	0.02360	0.18757	-0.00013	-0.00177	-0.00124	0.00133
2	-30.56969	0.49388	13.32386	16.10333	3.51696	-1.25746	-1.42571	0.81504
3	0.16653	-0.00010	-0.02053	-0.25723	0.00229	0.00298	-0.00068	-0.00129
4	58.98127	-0.41549	-22.56361	-32.96481	-9.63825	1.21138	1.68130	-1.60048
5	-2.80012	-0.00005	-0.15459	-0.65718	0.01742	0.00860	0.02509	-0.00602
6	108.24135	-0.55393	18.50871	401.67610	1.66250	5.04851	4.37706	2.46832
Equation 4								
1	-0.00037	0.00546	0.02919	0.00998	-0.00036	-0.00011	-0.00050	-0.00005
2	0.79324	-29.96663	7.14585	-30.16157	0.52358	-0.35005	-0.51460	-0.02208
3	0.00065	-0.00120	-0.01416	-0.00458	0.00096	0.00151	0.00060	0.00011
4	-1.50565	34.75580	-12.03997	41.64118	-0.56426	0.47604	0.70473	0.00958
5	0.00241	0.01644	-0.33567	-0.14767	0.00609	-0.00129	0.00609	-0.00003
6	-1.73654	24.24044	27.64524	-20.52045	0.42974	2.39833	0.74843	0.07820
7	-0.00063	-0.11108	-0.04246	0.00937	-0.00148	-0.00202	0.00021	-0.00005
8	0.43839	46.10967	42.95131	28.99278	-0.73941	0.54097	-0.29637	0.01303
9	0.04241	2.03433	5.83688	0.34231	0.10006	0.11876	0.02927	0.00435
10	-0.00348	2.65157	-3.66549	2.55945	0.04968	-0.10343	-0.10398	0.00573
11	-0.00010	-0.02890	0.00700	-0.01289	-0.00043	-0.00034	-0.00019	-0.00003
12	-0.13066	-10.27911	-10.88071	-0.54064	-0.53589	-0.29148	0.11986	0.11333
13	0.02746	0.94211	-0.66817	0.09624	-0.00192	-0.01053	-0.00086	-0.00016

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Least-Square Analyses

Table 51 (Continued)

Independent Variables*	Dependent Variables†							
	1	2	3	4	5	6	7	8
	Equation 5							
1	-0.00069	-0.00002	-0.00048	-0.00045	-0.00086	-0.00113	0.00011	0.00002
2	-0.84861	0.28676	-0.57733	-0.32280	0.86484	-0.43005	0.25671	-0.04887
3	0.00062	0.00058	0.00068	-0.00040	-0.00166	0.00162	-0.00042	0.00006
4	1.14858	-0.82941	0.89863	1.64999	-0.66870	0.68800	-0.16404	0.04523
5	0.00681	-0.00073	0.00905	-0.00013	0.01787	-0.00017	0.00059	-0.00032
6	1.70561	-0.63141	1.12328	0.48846	-0.58246	0.87220	-0.73921	0.09288
7	0.00093	-0.00015	-0.00007	0.00087	0.00212	0.00128	0.00225	-0.00002
8	-0.03585	0.45356	0.20562	-0.99201	-1.61619	0.14909	-0.23734	0.06042
9	0.04076	-0.02287	-0.00985	-0.01876	0.00798	-0.00295	-0.02867	0.00645
10	0.00047	0.02456	0.01168	-0.00677	0.01132	0.02623	0.00820	0.00238
11	0.12605	0.06410	-0.07155	-0.16358	0.07147	0.08993	0.00040	0.03503
12	0.00001	0.00000	-0.00001	-0.00002	0.00001	0.00000	-0.00001	0.00000
13	0.00166	-0.01137	-0.00580	-0.01193	0.00983	-0.00112	0.01179	0.00450
14	-0.28671	-0.17210	0.06729	0.16097	-0.13646	-0.08818	0.01339	0.07145
15	0.01784	0.01871	-0.00147	0.00885	-0.00065	-0.01109	0.00006	0.00031
16	0.24836	0.37689	0.37653	0.40919	0.25266	0.36223	0.37779	0.00947
17	0.49202	0.48535	0.43278	0.54167	0.44625	0.48145	0.29040	0.00108
18	-0.01510	-0.05843	0.18561	0.01406	0.17881	0.29623	0.25985	0.00032

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Table 51 (Concluded)

Independent Variables*	Dependent Variables†							
	1	2	3	4	5	6	7	8
	Equation 6							
1	-0.00536	-0.00075	-0.02988	-0.00164	-0.00014	0.00024	0.00015	-0.00007
2	-1.87919	-0.04830	36.07179	-0.72118	-0.97524	-1.29867	-1.21410	-0.03824
3	0.01129	0.00056	0.01239	0.00229	0.00162	0.00151	0.00037	0.00015
4	-0.20088	0.15417	-41.32112	0.57110	0.74192	1.12087	1.31324	0.03068
5	0.00569	0.00856	0.10640	0.00957	-0.00321	-0.00726	0.00090	0.00041
6	-2.35081	-0.71299	-62.62781	0.54839	1.80644	2.78630	1.82623	-0.01482
7	0.00386	0.00086	0.00085	0.00144	0.00029	0.00037	0.00058	0.00006
8	7.08730	-0.42270	-31.61539	0.04663	0.46971	1.66646	0.40463	0.04590
9	0.04687	0.09713	-0.17810	-0.03955	0.00851	-0.09444	-0.09936	0.01377
10	-0.07606	0.04495	0.74723	0.00939	0.02470	0.01314	0.02924	0.00519
11	0.48076	0.69815	3.72378	0.10446	-0.04187	0.12384	0.13028	0.08843
12	-0.00008	0.00007	-0.00003	-0.00001	0.00001	0.10001	0.00005	0.00001

* See Table 48.

† See Table 49.

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Table 52

HYPOTHESIS TEST RESULTS FOR EQUATION 1

Hypothesis	A	C	df	F*	Significance	
					0.1	0.05
All variables = 0	6	8	48, 68	5.121		+
Temperature = 0	1	8	8, 13	9.485		+
Zinc = 0	1	8	8, 13	7.447		+
Mercury = 0	1	8	8, 13	1.499		
All stations = 0	3	8	24, 38	2.777		+
North stations = 0	1	8	8, 13	4.826		+
ALC = 0	1	8	8, 13	1.755		
Central stations = 0	1	8	8, 13	1.694		
South stations = 0	1	8	8, 13	2.528	+	
Difference between the coefficients of the covariables:						
3 and 5 = 0	3	1	3, 20	1.918		
3 and 7 = 0	3	1	3, 20	1.907		
5 and 7 = 0	3	1	3, 20	0.391		
4 and 6 = 0	3	1	3, 20	1.482		
4 and 8 = 0	3	1	3, 20	0.806		
6 and 8 = 0	3	1	3, 20	0.524		

* F statistic.

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Table 53

HYPOTHESIS TEST RESULTS FOR EQUATION 2

Hypothesis	A	C	df	F	Significance	
					0.1	0.05
All variables = 0	17	8	136, 93	11.756		+
Sample volume = 0	1	8	8, 11	9.538		+
Temperature = 0	1	8	8, 11	2.085		
Total sulfides = 0	1	8	8, 11	1.688		
pH = 0	1	8	8, 11	1.414		
Lead = 0	1	8	8, 11	2.311		
Cadmium = 0	1	8	8, 11	3.507		+
Copper = 0	1	8	8, 11	2.371		
Silt = 0	1	8	8, 11	1.703		
Clay = 0	1	8	8, 11	2.973	+	
All stations = 0	8	8	64, 70	3.787		+
MIS-A = 0	1	8	8, 11	1.546		
MIS-B = 0	1	8	8, 11	1.894		
CS-A = 0	1	8	8, 11	31.100		+
CS-B = 0	1	8	8, 11	1.986		
ALC = 0	1	8	8, 11	1.577		
OIH = 0	1	8	8, 11	1.908		
HP = 0	1	8	8, 11	2.569	+	
SB-B = 0	1	8	8, 11	2.651	+	
RCH-B = 0	1	8	8, 11	8.134		+
Difference between the coefficients of the covariables for dependent variables:						
3 and 5 = 0	9	1	9, 18	2.260		
3 and 7 = 0	9	1	9, 18	1.943		
5 and 7 = 0	9	1	9, 18	4.380		+
4 and 6 = 0	9	1	9, 18	1.579		
4 and 8 = 0	9	1	9, 18	1.559		
6 and 8 = 0	9	1	9, 18	4.143		+

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Table 54

HYPOTHESIS TEST RESULTS FOR EQUATION 3

Hypothesis	A	C	df	F	Significance	
					0.1	0.05
All variables = 0	6	8	48, 73	4.412		+
Temperature = 0	1	8	8, 14	1.096		
Zinc = 0	1	8	8, 14	9.668		+
Mercury = 0	1	8	8, 14	0.454		
All surveys = 0	2	8	16, 28	2.719		+
Survey 2 = 0	1	8	8, 14	5.316		+
Survey 3 = 0	1	8	8, 14	1.125		
Survey 4 = 0	1	8	8, 14	5.312		+
Difference between the coefficients of the covariables for dependent variables:						
3 and 5 = 0	3	1	3, 21	2.394		
3 and 7 = 0	3	1	3, 21	3.671		
5 and 7 = 0	3	1	3, 21	1.480		
4 and 6 = 0	3	1	3, 21	1.206		
4 and 8 = 0	3	1	3, 21	1.184		
6 and 8 = 0	3	1	3, 21	2.651		

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Table 55

HYPOTHESIS TEST RESULTS FOR EQUATION 4

Hypothesis	A	C	df	F	Significance	
					0.1	0.05
All variables = 0	12	8	96, 118	9.535		
Sample volume = 0	1	8	8, 16	0.529		+
Temperature = 0	1	8	8, 16	3.566		
Total sulfides = 0	1	8	8, 16	0.530		+
pH = 0	1	8	8, 16	3.998		
Lead = 0	1	8	8, 16	0.286		+
Cadmium = 0	1	8	8, 16	2.414		
Copper = 0	1	8	8, 16	2.072		
Silt = 0	1	8	8, 16	0.893		
Clay = 0	1	8	8, 16	2.717	+	
All surveys = 0	3	8	24, 47	20.666		+
Survey 1 = 0	1	8	8, 16	60.777		+
Survey 2 = 0	1	8	8, 16	1.619		
Survey 3 = 0	1	8	8, 16	43.324		+
Survey 4 = 0	1	8	8, 16	43.514		+
Difference between the coefficients of the covariables for dependent variables:						
3 and 5 = 0	9	1	9, 23	3.418		+
3 and 7 = 0	9	1	9, 23	3.324		+
5 and 7 = 0	9	1	9, 23	1.030		
4 and 6 = 0	9	1	9, 23	0.796		
4 and 8 = 0	9	1	9, 23	0.810		
6 and 8 = 0	9	1	9, 23	1.136		

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Table 56

HYPOTHESIS TEST RESULTS FOR EQUATION 5

Hypothesis	A	C	df	F	Significance	
					0.1	0.05
All variables = 0	17	8	136, 232	13.932		+
Temperature = 0	1	8	8, 30	1.539		
Salinity = 0	1	8	8, 30	1.614		
D.O. = 0	1	8	8, 30	0.890		
Turbidity = 0	1	8	8, 30	2.503	+	
Total sulfides = 0	1	8	8, 30	3.707		+
pH = 0	1	8	8, 30	1.628		
Depth = 0	1	8	8, 30	2.029		
All stations = 0	10	8	80, 199	12.752		+
MIS-A = 0	1	8	8, 30	1.513		
MIS-B = 0	1	8	8, 30	5.889		+
CS-A = 0	1	8	8, 30	5.349		+
CS-B = 0	1	8	8, 30	6.987		+
ALC = 0	1	8	8, 30	2.406	+	
OIH = 0	1	8	8, 30	2.204		
HP = 0	1	8	8, 30	9.506		+
SB-A = 0	1	8	8, 30	4.996		+
SB-B = 0	1	8	8, 30	14.139		+
RCH-A = 0	1	8	8, 30	16.728		+
RCH-B = 0	1	8	8, 30	4.655		+
Difference between the coefficients of the covariables for dependent variables:						
3 and 5 = 0	7	1	7, 43	4.995		+
3 and 7 = 0	7	1	7, 43	5.100		+
5 and 7 = 0	7	1	7, 43	0.463		
4 and 6 = 0	7	1	7, 43	1.589		
4 and 8 = 0	7	1	7, 43	0.964		
6 and 8 = 0	7	1	7, 43	0.899		

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Table 57

HYPOTHESIS TEST RESULTS FOR EQUATION 6

Hypothesis	A	C	df	F	Significance	
					0.1	0.05
All variables = 0	11	8	88, 246	16.383		+
Temperature = 0	1	8	8, 36	1.596		
Salinity = 0	1	8	8, 36	3.241		+
D.O. = 0	1	8	8, 36	0.779		
Turbidity = 0	1	8	8, 36	1.933		
Total sulfides = 0	1	8	8, 36	1.003		
pH = 0	1	8	8, 36	2.014		
Depth = 0	1	8	8, 36	0.305		
All surveys = 0	4	8	32, 134	46.924		+
Survey P = 0	1	8	8, 36	3.156		+
Survey 1 = 0	1	8	8, 36	83.276		+
Survey 2 = 0	1	8	8, 36	8.782		+
Survey 3 = 0	1	8	8, 36	286.983		+
Survey 4 = 0	1	8	8, 36	4.219		+
Difference between the coefficients of the covariables for dependent variables:						
3 and 5 = 0	7	1	7, 37	3.059	+	
3 and 7 = 0	7	1	7, 37	6.920		+
5 and 7 = 0	7	1	7, 37	1.842		
4 and 6 = 0	7	1	7, 37	1.134		
4 and 8 = 0	7	1	7, 37	5.950		+
6 and 8 = 0	7	1	7, 37	1.085		

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As shown in Table 48, Equations 1 and 3 were designed to assess the effects of zinc and mercury and were based on the results of Surveys 2 through 4 (December 1973, March 1974, and June 1974). The first equation examines station effects by grouping the stations into three categories:

- (1) North stations: MIS-A, MIS-B, CS-A, CS-B
- (2) ALC
- (3) OIH, HP.

The estimated effects of the southern stations, RCH-B and SB-B, are represented as the negative of the sum of the other station effects. Similarly, Equation 3 examines the effect of zinc and mercury in the presence of survey effects. The effect of temperature was included to help control for station effects in the survey equation and survey effects in the station equation.

Comparison of the regression coefficients in Table 51 shows that the station equations and the survey equations do not agree very well on the effects of zinc and mercury. Still, zinc apparently was associated with increases in the dependent variables in general, and mercury was associated with decreases. In both equations, increased temperature was associated with increase in the dependent variables. Hypothesis tests (Tables 52 and 57) to determine whether these effects might be zero show that, in both equations, the zinc effect was significant but the mercury effect was not. The effect of temperature was significant in the equation for stations but not in the one for surveys, indicating that temperature effects were associated more closely with the survey effects than with the station effects.

Equation 1 shows that large differences exist among stations, even considering the differences in temperature and concentration of metals. The hypothesis tests indicate that both survey and station effects are significant. Southern stations are the sites of more life than northern ones. For most dependent variables, even considering other data, there is a slight increasing trend from Survey 2 (September 1973) through Survey 4 (June 1974), although the total individual count was decreasing. Neither

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equation indicates that the effects for temperature, mercury, and zinc were significantly different for the various group and specimen counts.

Table 51 shows the estimated parameters for Equations 2 and 4. Using these equations, we examined the heavy-metal data, excluding these for zinc and mercury, for Surveys 1 through 4 from all stations except RCH-A and SB-A. For these stations, the effects of sediment grain size, pH, and total sulfides also were examined.

In Equation 2, temperature has a generally positive effect on the dependent variables; whereas, in Equation 4, the effect is mixed, tending to be negative. The impact of total sulfides also is reversed between the two equations; the effect is negative when stations are included in the equation, and it is positive when surveys are considered. However, as can be seen in Table 51, the hypothesis that these effects are zero fails to reject, except in the case of temperature. By this criterion, neither lead, copper, nor the percentage of the sediment between 5 and 43 μ (silt) has any effect. In both equations, the percentage of sediment less than 5 μ (clay) does have an effect at $p < 0.1$, and the coefficients are positive for both equations. Cadmium shows a significant, generally negative, effect in the station equation, and pH shows a significant, generally positive, effect in the survey equations.

We rejected the hypotheses that no station effects existed and that no survey effects existed. In general--even after taking into account the heavy-metal, sediment, and other data--we found that the northern stations were associated with smaller values of the dependent variables than were the southern stations. MIS-A and MIS-B were estimated to have fairly dissimilar effects, MIS-A generally having less life than MIS-B. For CS-A and CS-B, CS-A had a smaller value for the dependent variables. Hypothesis tests that the station effects were zero indicated that CS-A, with a generally negative effect, and RCH-B with a generally positive one, were not zero with $p < 0.05$. The hypothesis that the HP and SB-B effects, also negative, were zero was rejected at $p < 0.1$.

The estimated survey effects showed an irregular pattern. Hypothesis tests that survey effects were zero were rejected for

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all surveys except Survey 2. When this effect is dropped, the survey effects generally follow a U-shaped pattern from Survey 1 to Survey 4.

Both equations indicate that significant differences existed in the way the heavy metals, total sulfides, and sediment grain size affected the dependent variables. Equation 2 indicates such a difference for polychaetes and molluscs as well as for polychaetes and arthropods. The arthropods appeared to be somewhat more sensitive to these variables than the molluscs, and the polychaetes seemed more sensitive than the arthropods. However, the relationships are diverse and difficult to summarize, especially in view of the generally poor fit of the equations to the data.

Equations 5 and 6 are designed to examine station and survey effects, respectively, for the water variables temperature, salinity, dissolved oxygen, turbidity, total sulfides, pH, and depth at which samples were taken. As can be seen in Table 51, salinity had a generally negative effect on the dependent variables in both equations, but dissolved oxygen and turbidity had generally positive effects. In the station equation, total sulfides had a mixed effect on the dependent variables; but, in the survey equation, the effect was generally positive. Depth and pH have mixed effects in both equations.

The hypothesis tests shown in Tables 56 and 57 indicate that only turbidity and total sulfides were significantly different from zero in Equation 5. However, in Equation 6, salinity was the only significant difference among the water variables.

These equations indicate that, given the differences in the other variables, both station and survey effects were significant. The station effects were generally consistent with those noted for the sediment data: MIS-A had less effect than MIS-B; CS-A had less than CS-B; SB-A had less than SB-B. However, the tendency for the effect of the north stations to have had less life was not as pronounced in these equations. The effect of adding the data from the preliminary survey was to change the pattern of estimated survey effects so that they were more generally linear, decreasing from the preliminary survey to Survey 4.

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Both equations indicate that the water variables had different effects on the dependent variables, the primary differences being that effects for polychaetes differ from those for molluscs and arthropods.

Our examination of the effects of data collected on sediment and on water for the number of individuals and the number of species found in the San Francisco Bay support the following conclusions:

- The underlying relations among organisms and the other variables are complex.
- The picture of these relationships changes depending on whether station effects or survey effects are considered. The dependent variables tend to be negatively correlated when stations are considered and positively correlated when surveys are considered.
- These data are consistent with the following hypotheses about the effect of the sediment variables:
 - Mercury is associated with decreased values of the dependent variables.
 - When survey effects are considered, total sulfides are generally associated with decreased values of the dependent variables.
 - Zinc is associated with increased values of the dependent variables.
 - Small sediment size (less than 5 μ) is associated with increased values of the dependent variables.
- The water data support the general conclusions that
 - Increased salinity generally is associated with smaller values of the dependent variables.
 - Increased dissolved oxygen and turbidity are associated with increased values of the dependent variables.

Abiotic-Biotic Relationships
Least-Square Analyses

- Northern stations tend to have less life than the southern stations and, for the disturbed stations to have less life than their undisturbed counterparts.

Many of these relationships are not significant statistically and require careful interpretation, since the effects of unmeasured variables and the interactions among those that were measured do play a role but were not represented in the least-squares equations.

BENTHIC ANIMAL MASTER LIST

PHYLUM PROTOZOA

Subphylum Ciliophora

Class Ciliata

Subclass Euciliata

Order Peritricha

Family Vorticellidae

Vorticella sp.

Subphylum Plasmodroma

Class Sarcodina

Subclass Rhizopoda

Order Foraminifera

Unidentified species

PHYLUM PORIFERA

Unidentified species

Class Demospongiae

Unidentified species

Order Keratosa

Unidentified species

Class Hexactinellida

Unidentified species

PHYLUM CNIDARIA (=COELENTERATA)

Unidentified species

Class Anthozoa

Subclass Alcyonaria (=Octocorallia)

Order Pennatulacea

Unidentified species

Family Stylatulidae

Stylatula elongata (Gabb, 1863)

Subclass Zoantharia (=Hexacorallia)

Order Actinaria

Diadumene sp.

Haliplanella sp.

Benthic Animal Master List

PHYLUM CNIDARIA (=COELENTERATA) (Continued)

Class Hydrozoa

Unidentified species

Order Hydroida

Suborder Calyptoblastea

Unidentified species

Family Campanularidae

Campanularia sp.

Gonothyrea sp.

Family Plumulariidae

Plumularia sp.

Family Sertulariidae

Sertularia sp.

Suborder Gymnoblastea

Family Bimeriidae

Bimeria sp.

Family Syncorynidae

Syncoryne sp.

PHYLUM PLATYHELMINTHES

Unidentified species

Class Turbellaria

Order ?Acoela

Unidentified species

PHYLUM NEMERTEA

Unidentified species

PHYLUM NEMATODA

Unidentified species

PHYLUM SIPUNCULA (=SIPUNCULOIDEA)

Sipunculus sp.

Unidentified species

PHYLUM ANNELIDA

Class Oligochaeta

Unidentified species

PHYLUM ANNELIDA (Continued)

Class Polychaeta

Unidentified species

Family Dorvilleidae

Schistomeringos longicornis Jumars, 1974

Schistomeringos sp.

Unidentified species

Family Eunicidae

Lysidice ninetta Audouin and Milne Edwards, 1833

Marphysa sanguinea (Montagu, 1815)

Unidentified species

Family Hesionidae

Gyptis brevipalpa Hartmann-Schroeder, 1959

Hesionella mccullochae Hartman, 1939

Microphthalmus sp.

Ophiodromus pugettensis (Johnson, 1901)

Unidentified species

Family Glyceridae

Glycera americana Leidy, 1855

Glycera oxycephala Ehlers, 1887

Glycera sp., near robusta Ehlers, 1868

Glycera tenuis Hartman, 1944

Glycera sp.

Family Goniadidae

Glycinde sp.

Family Nereidae

Neanthes succinea (Frey and Leuckart, 1849)

Neanthes sp.

Nereis latenscens Chanberlin, 1919

Unidentified species

Family Nephtyidae

Nephtys caecoides Hartman, 1938

Nephtys cornuta franciscana Clark and Jones, 1955

Nephtys parva Clark and Jones, 1955

Benthic Animal Master List

PHYLUM ANNELIDA (Continued)

Family Phyllodocidae

- Anaitides williamsi Hartman, 1936
- Anaitides sp.
- Eteone dilatata Hartman, 1936
- Eteone lighti Hartman, 1936
- Eteone longa californica Hartman, 1936
- Eulalia aviculiseta Hartman, 1936
- Eumida bifoliata (Moore, 1909)
- near Eumida sanguinea (Oersted, 1843)
- Eumida sp.
- Hesionura sp.
- Promystides sp.
- Unidentified species

Family Polynoidae

- Harmothoe imbricata (Linnaeus, 1767)
- Harmothoe sp.
- Unidentified species

Family Sigalionidae

- Pholoe minuta (Fabricius, 1780)
- Sthenelanelia uniformis Moore, 1910

Family Syllidae

- Autolytus sp.
- Exogone lourei Berkeley and Berkeley, 1938
- Exogone sp.
- Langerhansia sp.
- Odontosyllis parva Berkeley, 1923.
- Sphaerosyllis sp.
- Streptosyllis sp.
- Syllides sp.
- Unidentified species

Family Capitellidae

- Capitella capitata (Fabricius, 1780)
- Capitella sp.
- Capitita ambiseta Hartman, 1947
- Decamastus sp.
- Heteromastus filiformis (Claparède, 1864)
- Heteromastus sp.
- Mediomastus californiensis Hartman, 1944
- Notomastus (Clistomastus) tenuis Moore, 1909
- Unidentified species

Benthic Animal Master List

Family Cirratulidae

- Caulleriella hamata (Hartman, 1948)
- Chaetozone sp.
- Cirratulus cirratus (O. F. Müller, 1776)
- Cirriformia spirabrancha (Moore, 1904)
- Tharyx parvus Berkeley, 1929
- Tharyx sp., cf monilaris Hartman, 1960
- Tharyx sp.
- Unidentified species

Family Cossuridae

- Cossura pygodactylata Jones, 1956

Family Maldanidae

- Asychis sp.

Family Opheliidae

- Armandia brevis (Moore, 1906)

Family Orbinidae

- Haploscoloplos pugettensis (Pettibone, 1957)
- Unidentified species

Family Oweniidae

- Myriochele sp., near gracilis Hartman, 1955

Family Pectinariidae

- Pectinaria californiensis Hartman, 1941

Family Spionidae

- Boccardia truncata Hartman, 1936
- Polydora brachycephala Hartman, 1936 = P. caulleryi (Mesnil, 1897)
- Polydora caeca Oersted, 1843
- Polydora ligni Webster, 1879
- Polydora socialis Schmarda, 1861
- Polydora sp.
- Prionospio cirrifera Wirén, 1883
- Prionospio sp.
- Pseudopolydora kempii californica Light, 1969
- Pseudopolydora paucibranchiata (Okuda, 1937)
- Pseudopolydora sp.
- Pygospio sp.
- Scolecopsis squamata (Mueller, 1806)
- Spiophanes bombyx (Claparède, 1870)
- Spiophanes fimbriata Moore, 1923
- Spiophanes missionensis Hartman, 1941

Benthic Animal Master List

PHYLUM ANNELIDA (Continued)

Spiophanes sp.

Streblospio benedicti Webster, 1879

Unidentified species

Family Trochochaetidae

Disoma multisetosum Oersted, 1844

Trochochaeta multisetosum Oersted, 1843

Family Terebellidae

Polycirrus californicus Moore, 1909

Polycirrus sp., near tenuisetis Langerhans, 1880

Polycirrus sp.

Unidentified species

Family Lumbrineridae

Lumbrineris tetraura (Schmarda, 1861)

Lumbrineris sp.

Family Ampharetidae

Melinnampharete gracilis Hartman, 1969

Unidentified species

Family Sabellidae

Chone gracilis Moore, 1906

Chone mellis (Bush, 1904)

Chone minuta Hartman, 1944

Euchone limnicola Reish, 1959

Unidentified species

Family Chrysopetalidae

Paleanotus bellis (Johnson, 1897)

?Paleanotus sp.

Family Pilargiidae

Pilargis sp.

ARCHIANNELIDA

Unidentified species

PHYLUM ARTHROPODA

Subphylum Mandibulata

Class Crustacea

Subclass Ostracoda

Sarsiella zostericola Cushman, 1906

Sarsiella sp.

Unidentified species

Benthic Animal Master List

PHYLUM ARTHROPODA (Continued)

Subclass Copepoda

Unidentified species

Subclass Cirripedia

Unidentified species

Order Thoracica

Suborder Balanomorpha

Family Balanidae

Balanus cariosus (Pallas, 1788)

Balanus crenatus Bruguière, 1789

Balanus improvisus Darwin, 1854

Balanus sp., cf amphitrite Darwin, 1854

Balanus sp.

Subclass Malacostraca

Division Peracarida

Order Mysidacea

Unidentified species

Order Cumacea

Cumella vulgaris Hart, 1930

Diastylopsis sp.

Eudorella pacifica Hart, 1930

Eudorella sp.

Lamprops sp. cf quadriplicata Smith, 1879

Unidentified species

Order Tanaidacea

Suborder Dikionophora

Family Paratanaidae

Leptochelia dubia (Krøyer, 1842)

Order Isopoda

Unidentified species

Suborder Valvifera

Family Idoteidae

Synidotea bicuspidata (Owen, 1839)

Synidotea harfordi Benedict, 1897

Synidotea laticauda Benedict, 1897

Synidotea sp.

Suborder Anthuridea

Family Anthuridae

Unidentified species

Benthic Animal Master List

PHYLUM ARTHROPODA (Continued)

Suborder Flabellifera

Family Limnoriidae

Limnoria quadripunctata Holthuis, 1949

Suborder Asellota

Unidentified species

Order Amphipoda

Unidentified species

Suborder Gammaridea

Family Ampeliscidae

Ampelisca milleri Barnard, 1954

Family Corophiidae

Corophium acherusicum Costa, 1857

Corophium insidiosum Crawford, 1937

Corophium sp.

Grandidierella japonica Stephensen, 1938

Photis brevipes Shoemaker, 1942

Photis californica Stout, 1913

Photis sp.

Protomedeia zotea Barnard, 1962

Protomedeia sp.

Family Gammaridae

Melita dentata (Krøyer, 1842)

Melita sp., cf sulca (Stout, 1913)

Melita sp.

Unidentified species

Family Ischyroceridae

Ischyrocerus anguipes Krøyer, 1838

Ischyrocerus sp.

Family Phoxocephalidae

Paraphoxus milleri (Thorsteinson, 1941)

Family Pleustidae

Parapleustes pugettensis (Dana, 1853)

Parapleustes sp.

Family Podoceridae

Dulichia sp.

Podocerus sp.

Family Stenothoidae

Stenothoides sp.

Family Synopiidae

Tiron biocellata Barnard, 1962

Benthic Animal Master List

PHYLUM ARTHROPODA (Continued)

Suborder Caprellidea

Unidentified species

Family Aeginellidae

Caprella sp.

Unidentified species

Suborder Hyperiidea

Unidentified species

Order Decapoda

Unidentified species

Suborder Reptantia

Section Brachyura

Unidentified species

Family Majidae

Pyromaia tuberculata (Lockington, 1877)

Family Cancridae

Cancer antennarius Stimpson, 1856

Cancer jordani Rathbun, 1900

Unidentified species

Family Xanthidae

Rithropanopeus harrisi (Gould, 1841)

Family Pinnotheridae

Pinnixa franciscana Rathbun, 1918

Family Grapsidae

Hemigrapsus oregonensis (Dana, 1851)

Section Anomura

Unidentified species

Family Callianassidae

Callianassa californiensis Dana, 1854

Upogebia pugettensis (Dana, 1852)

Upogebia sp.

Section Carides

Family Crangonidae

Crangon sp.

Benthic Animal Master List

PHYLUM ARTHROPODA (Continued)

Subphylum Chelicerate

Class Pycnogonida

Unidentified species

Family Ammotoecidae

Lecythorhynchus marginatus Cole, 1904

Class Arachnida

Unidentified species

Order Acarina

Unidentified species

Hydracarina--Unidentified species

Class Insecta

Unidentified species

Class Acari

Order Trombidiformes

Family Halacaridae

Unidentified species

PHYLUM MOLLUSCA

Class Gastropoda

Subclass Prosobranchia

Order Mesogastropoda

Family Rissoidae

Alvinia californica (Bartsch, 1911)

Alvinia compacta (Carpenter, 1864)

Family Caecidae

Fartulum sp.

Family Epitoniidae

Epitonium tinctum (Carpenter, 1864)

Family Calyptraeidae

Crepidula convexa Say, 1822

Crepidula plana Say, 1822

Order Neogastropoda

Family Muricidae

Urosalpinx cinerea (Say, 1822)

Family Melongenidae

Busycon canaliculatum (Linnaeus, 1758)

Family Nassariidae

Nassarius mendicus (Gould, 1850)

Nassarius obsoletus (Say, 1822)

PHYLUM MOLLUSCA (Continued)

Subclass Opisthobranchia

Order Pyramidellida

Family Pyramidellidae

Iselica ovoidea (Gould, 1853)

Odostomia (Evalea) cf. O. deliciosa Dall & Bartsch, 1907

Odostomia (Evalea) franciscana Bartsch, 1917

Odostomia (Evalea) tenuisculpta Carpenter, 1864

Odostomia (Evalea) valdezi Dall & Bartsch, 1907

Odostomia (Menestho) fetella Dall & Bartsch, 1909

Odostomia (Evalea) sp.

Order Nudibranchia

Unidentified species

Class Bivalvia (Pelecypoda)

Unidentified species

Subclass Pteriomorphia

Order Mytiloida

Family Mytilidae

Adula diegensis (Dall, 1911)

Modiolus sp.

Musculus senhousia (Benson, 1842)

Mytilus edulis Linnaeus, 1758

Order Pterioidea

Family Ostreidae

Ostrea lurida Carpenter, 1864

Family Anomiidae

Pododesmus sp.

Subclass Heterodonta

Order Veneroidea

Family Montacutidae

Mysella ferruginosa (Dall, 1916)

Family Veneridae

Gemma gemma (Totten, 1834)

Protothaca staminea (Conrad, 1837)

Tapes japonica Deshayes, 1853

Transennella tantilla (Gould, 1853)

Family Petricolidae

Petricola cf. P. carditoides (Conrad, 1837)

Results and Discussion
Biological Characteristics
RCH-A

Table 26 (Continued)

TAXA	TOTAL NUMBER OF SPECIMENS PER SURVEY					SPECIMEN TOTAL
	SURVEY					
	P (3/73)	1 (9/73)	2 (12/73)	3 (3/74)	4 (6/74)	
EXIGONE LOUREI	177	1734	589	882	1030	4417
HAPLOSCOLOPUS PUGETTENSIS	2	--	--	2	1	5
MARPHYSA SANGUINEA	1	16	5	--	27	49
GLYCINDE SP.	2	5	1	2	22	33
ASYCHIS SP.	19	4	3	40	10	76
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	4	1	47	220	273
NEPTYS CAECOIDES	1	--	--	--	--	1
SPHAERUSYLLIS SP.	2	104	146	345	257	654
DORVILLEIDAE-UNIDENTIFIED SPP.	1	--	--	--	--	1
THARYX SP.	1	--	--	5	--	6
ETEUNE LUNGA CALIFORNICA	--	7	2	4	170	183
POLYNOIDAE-UNIDENTIFIED JUVENILE	--	1	--	--	--	1
POLYDORA CAULLEKYI	--	4	--	--	--	4
HARMUTHOE IMBRICATA	--	13	--	5	29	47
STREBLOSPIO BENEJICTI	--	30	3	313	2139	2485
POLYDORA LIGNI	--	258	462	175	88	983
POLYCIRRUS SP.	--	2076	4	1	3	2087
DURVILLEA SP.	--	1	--	--	--	1
POLYCHAETA-UNIDENTIFIED SPP.	--	1	--	--	--	1
POLYCIRRUS SP., NEAR TENUISETIS	--	1	--	--	--	1
ETEUNE LIGHTI	--	--	1	2	110	113
PYGUSPIO SP.	--	--	1	--	--	1
POLYNOIDAE-UNIDENTIFIED SPP.	--	--	--	2	--	2
TEREBELLIDAE-UNIDENTIFIED SPP.	--	--	--	4	--	4
HARMUTHOE SP.	--	--	--	3	--	3
CAPITELLA SP.	--	--	--	2	1	3
AUTOLYTUS SP.	--	--	--	1	--	1
STREPTOSYLLIS SP.	--	--	--	--	1	1
SYLLIDAE-UNIDENTIFIED SPP.	--	--	--	--	1	1
ARTHROPODA						
COROPHIUM INSULOSUM	3	10	1	--	--	20
AMPELISCA MILLERI	334	11553	5934	1975	4165	24026
PYRUNAIA TUBERCULATA	1	--	--	--	--	1
OSTRACODA-UNIDENTIFIED SPP.	6	--	--	--	--	6
LEPTOCHELIA DULIA	1	--	3	1	--	5
CUKUPHIUM ACHERUSICUM	1	15	--	13	296	325
SARSIELLA ZOSTERICULA	--	163	183	229	264	842
INSECTA-UNIDENTIFIED SPP.	--	1	--	--	2	3
GRANDIDIERELLA JAPONICA	--	10	31	2	20	69

Benthic Animal Master List

PHYLUM MOLLUSCA (Continued)

Family Tellinidae

Macoma acolasta Dall, 1921

Macoma balthica (Linnaeus, 1758)

Macoma inquinata (Deshayes, 1855)

Macoma nasuta (Conrad, 1837)

Macoma sp.

Tellina modesta (Carpenter, 1864)

Family Solenidae

Siliqua patula (Dixon, 1788)

Siliqua sloati Hertlein, 1961

Order Myoida

Family Myidae

Mya arenaria Linnaeus, 1758

Platyodon cancellatus (Conrad, 1837)

Unidentified species

Family Hiatellidae

Hiatella arctica (Linnaeus, 1767)

Family Pholadidae

Zirfaea pilsbryi Lowe, 1931

Subclass Anomalodesmata

Order Pholadomyoida

Family Lyonsiidae

Lyonsia californica Conrad, 1837

Lyonsia sp.

PHYLUM ECTOPROCTA (=BRYOZOA)

Unidentified species

Order Cheilostomata

Unidentified species

Suborder Anasca

Unidentified species

Family Aeteidae

Aetea anguina (Linnaeus, 1758)

Family Alderinidae

Callopora armata O'Donoghue, 1926

Callopora sp.

Tegella armifera (Hincks, 1880)

PHYLUM ECTOPROCTA (=BRYOZOA) (Continued)

Family Bicellariellidae

Bugula californica Robertson, 1905

Bugula neritina (Linnaeus, 1758)

Bugula sp.

Family Cellariidae

Cellaria mandibulata Hincks, 1882

Cellaria sp.

Family Chapperiidae

Chapperia paluta (Hincks, 1881)

Family Cribrilinidae

Membraniporella sp.

Family Electrinidae

Electra arctica Borg, 1931

Electra crustulenta (Pallas, 1766)

Family Membraniporidae

Conopeum commensale Kirkpatrick and Metzelaar, 1922

Conopeum reticulum (Linnaeus, 1767)

Membranipora membranacea (Linnaeus, 1767)

Membranipora perfragilis (MacGillivray, 1881)

Membranipora villosa Hincks, 1880

Membranipora sp.

Family Scrupocellariidae

Scrupocellaria californica Trask, 1857

Scrupocellaria sp.

Tricellaria occidentalis (Trask, 1857)

Tricellaria ternata (Solander, 1786)

Tricellaria sp.

Suborder Ascophore

Family Cheiloporinidae

Cheilopora praelonga (Hincks, 1883)

Cryptosula pallasiana (Moll, 1803)

Family Hippothoidae

Hippothoa cornuta (Busk, 1852)

Hippothoa hyalina (Linnaeus, 1758)

Family Microporellidae

Microporella californica (Busk, 1856)

Family Phylactellidae

Lagenipora punctulata (Gabb and Horn, 1862)

Benthic Animal Master List

PHYLUM ECTOPROCTA (=BRYOZOA) (Continued)

Family Schizoporellidae

Schizoporella sp.

Family Smittinidae

Parasmittina trispinosa (Johnston, 1838)

Smittidea prolifica Osburn, 1952

Family Schizoporellidae

Schizoporella sp.

Order Ctenostomata

Family Vesiculariidae

Bowerbankia gracilis Leidy, 1855

Family Alcyoniidae

Alcyonidium parasiticum (Fleming, 1828)

Alcyonidium polyomm (Hassall, 1841)

Order Cyclostomata

Unidentified species

Family Crisiidae

Crisia maxima Robertson, 1910

Crisia occidentalis Trask, 1857

Filicrisia geniculata (Milne-Edwards, 1838)

Filicrisia sp.

PHYLUM ENTOPROCTA

Family Pedicellinidae

Barentsia sp.

PHYLUM PHORONIDA

Phoronopsis viridis Hilton, 1930

Phoronis sp.

Unidentified species

PHYLUM ECHINODERMATA

Class Holothuroidea

cf Leptosynapta sp.

Unidentified species

Class Ophiuroidea

Ophionereis sp.

Benthic Animal Master List

PHYLUM CHORDATA

Subphylum Urochordata (=Tunicata)

Unidentified species

Class Ascidiacea

Unidentified species

Order Enterogona

Suborder Aplousobranchia

Amoroucium sp.

Suborder Phlebobranchia

Ciona intestinalis (Linnaeus, 1767)

Order Pleurogona

Suborder Stolidobranchia

Styela sp.

Subphylum Vertebrata

Class Osteichthyes

Unidentified species

LITERATURE REVIEW

Previous Studies of San Francisco Bay

Several benthic surveys have been conducted in San Francisco Bay, most of them within the past 20 years. These studies reflect man's concern about the effects he produces on valuable natural resources (U.S. House Committee on Government Operations, 1969, 1970). Such effects can be economic, the declining fish and shellfish resources being an example (Skinner, 1962). As man becomes more aware of the intricacies of the marine environment, his concern increases about the effects of pollution on marine life (Daniels and Chadwick, 1971). There is also aesthetic concern for the Bay as a valuable recreation area and practical concern for climate and air pollution in the Bay Area (Miller, 1970).

Although pollution undoubtedly affects the marine life of San Francisco Bay, natural environmental variables such as depth, substrate, temperature and salinity, and season also affect marine populations (Emergy and Stevenson, 1957; Carriker, 1967). A significant feature is the inflow of the Sacramento and San Joaquin Rivers into the north San Francisco Bay estuary. These rivers carry fresh water, silt, nutrients, and pesticides into the bay and help to flush pollutants out the Golden Gate. In contrast, currents in the South Bay result largely from tides, and fresh-water inflow is primarily from waste discharges (McCarty et al., 1961).

Comparing the results of previous San Francisco Bay studies is difficult because sampling methods have not been standardized. A number of benthic sampling devices have been employed in benthic studies (e.g., the Petersen, van Veen, Ekman, Smith-McIntyre, and orange peel dredges and the beam and sledge trawls), some of which are available in more than one size. These samplers differ in the amount of area they can sample, in their depth of penetration,

Literature Review

Previous Studies of San Francisco Bay

and in the efficiency of their operation under different conditions of depth, current, and substrate (Gunter, 1957; Thorson, 1957; Hopkins, 1964; American Public Health Association et al., 1971; Holme, 1971; McIntyre, 1971b). Thus, there may be qualitative and quantitative differences in the organisms collected. In addition, the size of the screen through which the sample is washed greatly affects the number of species, the number of individuals and the biovolume recovered (Reish, 1959; Birkett and McIntyre, 1971).

The frequency of sampling and the number of replicates also influence population statistics because of the nonrandom distribution, such as underdispersion or overdispersion, of many benthic invertebrates (Elliott, 1971). The large variances of replicate samples found in our study and other studies (Painter, 1966; McErlean et al., 1972) are evidence for the need for replicate sampling. If the variability in sampling is not estimated, differences in populations attributed to location, time, or environmental factors may well be due to sampling error. A number of authors have employed various statistical procedures to determine the number of samples required to represent adequately the total number of species present (Jones, 1961; Storrs et al., 1966a; McIntyre, 1971a).

Studies conducted in different seasons or years are also difficult to compare because of variations both in physical factors, such as temperature, salinity, turbidity, and in biological factors, such as the life histories of the organisms. Finally, comparison of species lists reported in San Francisco Bay studies is limited by the taxonomic capabilities of the personnel making identifications (Hedgpeth, 1970; Carlton, 1972). A trained taxonomist is required to identify San Francisco Bay organisms, because many organisms have been introduced from other areas of the world with oyster transplants or in bilge water from ships. Nichols (1973) has written a particularly detailed critical review of the methodology and limitations of previous San Francisco Bay surveys.

Despite their limitations, the previous San Francisco Bay benthic surveys did provide some qualitative background information for our study. Accordingly, the previous surveys will be

Literature Review
Previous Studies of San Francisco Bay

discussed with the following areas of emphasis: a comparison of our study areas with those of other studies; the association of locations within these areas with the greatest numbers of species and individuals; the kinds and numbers of the more common animals collected for various seasons; and the relationships of environmental factors such as depth, salinity, temperature, and substrate type to species distribution.

The first extensive benthic study of San Francisco Bay was made during 1912-13 by the Federal Bureau of Fisheries using the steamer Albatross to survey the fisheries resources of San Francisco Bay (Sumner et al., 1914). These investigators studied physical characteristics of the Bay such as tidal range, current velocity, depth, and bottom type. Trawl and dredge samples were taken for counting organisms at 149 dredging stations, whereas water samples were taken for measuring temperature and salinity at 322 hydrographic stations from Suisun Bay to the southern tip of San Francisco Bay, primarily in the tidal channels. The species collected from these studies were reported in several papers by various authors. Packard reported on the molluscs (1918a,b), Schmitt on the crustaceans (1921), and Hartman on the polychaetes (1954).

Packard (1918a), dealing first with only the molluscs collected by the orange peel dredge from Carquinez Strait to south San Francisco Bay, made somewhat quantitative comparisons between areas. He listed 35 species consisting of 23 pelecypods and 12 gastropods. Ten of these species were found at more than one-fourth of the stations. The richest area in numbers of species, individuals, and old shells was the middle division (from an imaginary line from Point San Pedro to Point San Pablo to a line from the Ferry Building to Goat Island Light); the second richest was the lower division (south of that line); and the third richest area was the upper division (San Pablo Bay). Because of the limited number of samples (43), Packard could not specify the species to be expected in those areas. The productive middle division was characterized by the deepest depths (15-20 fathoms), salinities of 28-30‰, lowest annual mean temperature, lowest seasonal temperature range, and largest plankton populations. He considered

Literature Review

Previous Studies of San Francisco Bay

salinity to be the most important factor influencing the distribution of organisms. The importance of temperature was unclear, but Packard suggested that its greatest effect would be on the larvae of the organisms. Whereas most species were found on several substrates, a few species could be described tentatively as characteristically mud- or sand-dwelling organisms. A substrate of sand and shells supported the largest number of species and individuals of molluscs.

Packard's second paper (1918b) dealt qualitatively with all species of molluscs collected in the Albatross survey. Eighty-one species were collected, slightly over half of them pelecypods. For each species, Packard gave a physical description, the range, and the stations of collection. Again, he considered environmental factors in distribution, and his earlier conclusions were confirmed with one exception. A substrate of mud rather than sand and shell was found to support the most molluscs.

In his extensive monograph on decapod crustacea, Schmitt (1921) listed for each Albatross dredging and hydrographic station the date, depth, bottom type, sampling method, and the decapod crustaceans collected; however, he did not discuss the data.

Hartman (1954) later published a species list of polychaetes from San Francisco Bay, many of which were first reported for the Bay from the Albatross expedition. Station numbers from the Albatross expedition, published records for San Francisco Bay, and bibliographic citations were given for each species, but the abundances, distributions, seasonal variations, or relationships to environmental factors were not discussed. Other species from the Albatross expedition have been reported on by other authors, Freadwell (1914) being one.

After the Albatross expedition, the next sampling in San Francisco Bay was not conducted until Filice surveyed the Castro Creek area from April to December 1951 (Filice, 1954a). He worked on the premise, earlier suggested by Patrick (1950) for freshwater environments, that the health of an area can be assessed best by the well-being of its benthic fauna, since the benthos--a valuable food source for other organisms--cannot escape pollution.

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In a preliminary study, Filice compared the fauna of Castro Creek marsh, washed by both industrial and domestic wastes, with relatively unpolluted Galinas Creek marsh across San Pablo Bay; he found several more species in the latter area. He then sampled 85 stations near Castro Creek. One sample was collected with a Petersen dredge in deeper areas, and three pooled samples were collected with an Ekman dredge in shallower areas. Filice found a close correlation between current flow from Castro Creek and lack of bottom invertebrates, which he attributed to the toxicity of the wastes. Other environmental factors were not considered. On either side of this impoverished area, few species were present, but he found a greater-than-normal volume of animals. Filice suggested that the increased volume of animals at the edges of the impoverished area was due to the success of a few tolerant species in an area of enrichment with few competitors.

To test the validity of these conclusions, Filice sampled 375 stations extending from San Pablo Bay to Antioch on the San Joaquin River between September 1951 and April 1952. The most numerous species collected were, in order of decreasing abundance, Gemma gemma, Balanus improvisus, Mya arenaria, Polydora uncata, Nereis succinea, and Macoma inconspicua. However, the most widely distributed species were N. succinea and G. gemma, followed by M. inconspicua, Nassarius obsoletus, and B. improvisus. Filice found only minor differences between his species list and the lists from the Albatross expedition; he attributed these differences to sampling error. In agreement with his earlier findings, Filice found that most stations had low volumes of animals (Filice, 1954b) and few specimens of each species (Filice, 1958). As reported by Packard (1918b), the volume of animals (Filice, 1954b) and the number of species (Filice, 1958) were greater in seaward areas and on mud substrates than on sand. Filice reported a "faunal break" in the eastern half of Carquinez Strait with an average salinity of 9.5‰, the species seaward and riverward being quite different. Filice listed the following pollution categories in order of increasing number of species: industrial outfalls, domestic outfalls, marginal to industrial outfalls, and normal bottom. The densities of organisms paralleled the number of species with the exception of marginal to domestic outfalls, which had a large abundance of a few tolerant species that presumably thrived, in the absence of more sensitive competitors, on the increased organic matter from domestic waste (Filice, 1959).

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Filice also described the distribution and abundance of each of the 53 species collected, especially in relation to salinity, depth, and substrate.

At about the same time, in October 1953, Brown and Caldwell Engineers surveyed 27 stations near Coyote Creek south of the Dumbarton Bridge to study the effects of waste discharges on benthic organisms (Brown and Caldwell Engineers, 1954, in Nichols, 1973). According to Nichols (p. 4), "Although the data on benthic organisms were limited, the scarcity of animals in Coyote Creek above Gray Goose Slough was suggested as evidence of a toxic environment."

In the same year, Jones surveyed the fauna off Point Richmond (California Department of Public Health, 1954, in Nichols, 1973). Jones sampled each of 65 stations once in September with an Ekman dredge and identified and counted subsamples of organisms. Nichols (p. 4) stated, "Because of the lack of replicate sampling ... and the few environmental and pollution parameters measured, the report could conclude only that waste discharges had little noticeable effect on the benthos near Point Richmond."

Jones again studied the benthos near Point Richmond during 1954-55 for his Doctoral thesis research (Jones, 1961). Using a core sampler with an area of 2.5 cm^2 , he first took 50 replicate samples at a station to determine the number of samples needed to estimate the total number of species. He concluded that 30 samples would be sufficient. Jones then collected 30 replicate samples at each of four stations at about six-week intervals between January 1955 and March 1956. Beginning with the fourth collection period, he also took one Ekman dredge sample per station for comparison of techniques. Two of the stations were similar except for coarseness of substrate. The faunas at these two stations were basically similar but differed in the densities of different species. Jones found that the biomass collected at the station with fine substrate was greater than that with coarse substrate, an observation consistent with the findings of Filice (1954b). The species diversities did not differ significantly. The other two stations were similar to one another except for their depth and the compactness of their substrate. The faunas differed somewhat at the

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two--Sphaerosyllis pirifera and Streblospio benedicti predominating at the shallower station, Tharyx parvus and Cossura pygodactylata predominating at the deeper station. Biomass was greater at one station for part of the year and greater at the other station the remainder of the year. From all stations, more than 70 species were collected, most of them found in small numbers and/or on few occasions. The animals found most consistently at all stations were Sphaerosyllis pirifera, Tharyx parvus, Cumella vulgaris, and three species of oligochaetes. Jones followed the fluctuations in dispersion patterns for 19 of the species. Four were generally aggregated, one was never aggregated, and the remaining species generally were dispersed randomly. Comparing the results from the two kinds of sampling devices, Jones concluded that larger samplers are needed to estimate density and that smaller ones are required to study distributional patterns.

South San Francisco Bay was studied again in 1957 when the California Department of Fish and Game conducted a survey in August and September (Pintler, 1958). One sample was collected with an Ekman dredge at each of 24 stations, and three samples each were collected at two stations in Mowry Slough. Pintler reported a total of 22 "kinds" of live organisms, nearly a third of them oligochaetes and over half of them molluscs (predominantly Macoma clams). Like Brown and Caldwell Engineers (1954), he found fewer organisms upstream in Coyote Creek than downstream from a polluted area, with a few species occurring in large numbers.

In 1958, a preliminary study of San Francisco Bay was begun south of Dumbarton Bridge (Harris et al., 1961) by the Sanitary Engineering Research Laboratory (SERL) of the University of California at Berkeley, sponsored by the California State Water Resources Control Board. This study was expanded to investigate the entire San Francisco Bay, with the objective of developing a quantitative description of the biota of San Francisco Bay and of the relationships of organisms to physical and chemical factors, sediment type, and waste discharges (Storrs et al., 1966a,b; Pearson et al., 1970). The Bay was divided into six study areas, three of which were studied in each of four years (McCarty et al., 1961; Storrs et al., 1963a,b, 1964a,b, 1965 a,b). Two samples were collected from 6 to 10 stations in each study area every one

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or two months. Before 1962, the two samples were processed separately, but later they were processed together. To compensate for loss of variability after the samples were combined, 5 to 10 replicates were taken at selected stations. SERL calculated that, with 10 replicates, about 95% of the total number of species at that location had been collected. In addition, with six to seven replicates, 90% of the species collected in 10 replicates would be found.

The total benthic animal biovolume of the Bay consisted of 70% molluscs, 25% annelids, and 5% arthropods. On the basis of biovolume, the dominant molluscs were: Tapes semidecussata south of Hunters Point; Macoma nasuta from Hunters Point to Point San Pablo; Modiolus senhousei and Tapes semidecussata in San Pablo Bay; and Corbicula fluminea and Mya arenaria in Suisun Bay. The dominant arthropods were Corophium insidiosum and Photis californica in the South Bay, Corophium spinicorne and Balanus sp. in Suisun Bay, and Photis californica in the central regions. Finally, the dominant annelids were Neanthes succinea and Polydora uncata in Suisun Bay, Glycinde armigera in San Pablo Bay, and Glycinde armigera and Asychis amphiglypta from Hunters Point to the San Mateo Bridge. In the other areas of the Bay, no one annelid species contributed to more than 50% of the biovolume. Consistent with the findings of Packard (1918a) for molluscs, benthic biovolume and species diversity (based upon number of species and frequency of occurrence) were greatest in the more saline Central Bay. Only in the extreme southern end of the Bay did benthic diversity change with season, being lowest in fall and winter and highest in mid-summer.

Brinkhurst and Simmons (1968) later identified some of the oligochaetes collected during the SERL study. The data were too few to compare stations and seasons. In the highly polluted southern tip of San Francisco Bay, types of organisms and individuals were few, but the proportion of oligochaetes was high. The extremely depressed fauna of Redwood City Creek was suggested to be a result of local pollution, especially since Storrs et al (1963a), found high levels of heavy metals in that creek.

Also in the early 1960s, Dederian (1966) surveyed the benthic fauna of the San Francisco waterfront from the Bay Bridge to

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Previous Studies of San Francisco Bay

Hunters Point. Each of the 147 stations was represented by a single sample taken with a modified Petersen dredge. The most numerous species collected was Transennella tantilla, followed by-- in order of decreasing abundance--Photis brevipes, Pectinaria californiensis, Macome nasuta, and Macoma inquinata. The known ecological distribution of each species was discussed.

At about the same time, the California Department of Fish and Game undertook an ecological study of the Sacramento-San Joaquin Rivers estuary as a part of the Delta Fish and Wildlife Protection study (Kelley, 1966). Painter (1966) reported on the zoobenthos of San Pablo and Suisun Bays collected at 27 stations monthly throughout 1963 with a Petersen dredge. The mesh size of the screen was changed in the second half of the study from 50 to 30 meshes per inch to allow more time for collection of three replicates per station instead of two. More than 40 taxa were reported. The 11 most "important" animals collected were the lamellibranchs Tapes semidecussata, Gemma gemma, Macoma inconspicua, and Mya arenaria; the crustaceans Photis californica, Corophium spp., and Synidotea laticauda; and the polychaetes Neanthes succinea, Glycinde armigera, Streblospio benedicti, and Polydora uncata. Painter discussed the distributions of these species relative to chlorinity, sediment type, depth, and location. The effects of depth and substrate could not be spared. Chlorinity was the major environmental factor affecting distribution. Like Filice (1958), Painter reported a distinct faunal break in eastern Carquinez Strait.

As another part of the Department of Fish and Game study, Hazel and Kelley (1966) described the zoobenthos of the Sacramento-San Joaquin Delta. They sampled 25 stations monthly in 1963 with a Petersen dredge, collecting one sample per station. Although they collected 35 taxa of animals, the only abundant organisms were the clam Corbicula fluminea and the amphipods Corophium spinicorne and C. stimpsoni. Hazel and Kelley discussed the distributions of the common species with respect to substrate type. Like Packard (1918b) and Filice (1954b, 1958), Hazel and Kelley found that sand supported the least life. Seasonal variations in species distributions were not discussed.

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The California Department of Fish and Game also conducted a biological survey of the Bay from the San Rafael Bridge to south of the Dumbarton Bridge (Aplin, 1967). Each month in 1963, one sample was collected with an orange peel dredge from each of six stations. Invertebrates also were collected in the fish trawl nets. Although the data were not quantitative, the polychaete Asychis amphiglypta and the bivalves Musculus senhousi, Tapes semidecussata, and Gemma gemma were common. For each species, the stations and sometimes the substrate type from which it was collected were given.

In 1969, as a part of the San Francisco Bay Delta Water Quality Control Program, commissioned by the State Water Resources Control Board, the Kaiser Engineers reported on surveys performed by them and the California Department of Fish and Game (Kaiser Engineers, 1969). The latter study was a survey of shellfish populations conducted along the entire San Francisco Bay shoreline from June through December 1967. The most abundant clams were Mya arenaria and Tapes semidecussata, the former about three times more numerous than the latter. The life histories and environmental requirements, including salinity, temperature, substrate, and dissolved oxygen, of these two species and of mussels and oysters were reviewed (California Department of Fish and Game, 1968).

To update the SERL study, the Kaiser Engineers sampled 20 of the SERL stations throughout San Francisco Bay in March 1968. Two to four orange peel dredge samples were combined for each station. The dominant groups found were annelids, arthropods, and molluscs. The number of species in the South Bay was about half that of the North Bay, and the species diversity (based on the number of species and their relative abundances) was even less than half. As reported by Packard (1918a) and Storrs et al. (1966b), the Kaiser Engineers found the greatest diversity of species in the more saline Central Bay. Regression analysis was used to derive a formula relating species diversity to chlorosity and percentage of sand.

In 1967, Vassallo studied the intertidal Macoma inconspicua (M. balthica) community on the eastern shoreline of San Francisco Bay just north of the San Mateo Bridge (Vassallo, 1969, 1971).

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He sampled 63 stations in three transects once with a homemade core sampler approximately 0.01 m^2 in area and 21 cm in height. M. inconspicua dominated the higher intertidal, and the amphipod Ampelisca milleri predominated in the lower intertidal. Vassallo discussed the possible ecological relationships of the two. M. inconspicua was distributed uniformly to a depth of 25 cm, and A. milleri (tubes) was distributed to a depth of 2.5 cm.

The U.S. Fish and Wildlife Service conducted a study of the effects of dredging on fish and invertebrates (except polychaetes) from Carquinez Strait to the San Rafael Bridge (U.S. Fish and Wildlife Service, 1970). Seventeen stations were sampled monthly for all or part of the period from September 1967 to August 1969. The sampling device and the number of samples were not specified. No difference was reported in the number of species of benthic organisms between dredged and undredged areas, but abundances were lower in the dredged areas. The exclusion of polychaetes from the study may affect these conclusions. Some relationships between abundances of organisms and season, depth, chlorosity, and sediment were discussed, but no supportive data were presented. Kinds and numbers of organisms increased with depth and salinity.

Brown and Caldwell Engineers, commissioned by the City of San Francisco to study possible locations for waste outfalls, sampled five stations in San Francisco Bay near Alcatraz in June and October of 1970 (Brown and Caldwell Engineers, 1971). A minimum of two samples per station were collected with a Petersen or orange peel dredge. Brown and Caldwell Engineers combined its data with those collected six years earlier on the continental shelf around the mouth of the Bay by the Hydraulic Engineering Laboratory of Berkeley (Yancey and Wilde, 1970), although the data were collected by markedly different methods. Brown and Caldwell Engineers described four communities--shelf, near reef, bar, and Bay--and concluded that sediment type and degree of wave exposure were the most important factors in determining community composition.

South San Francisco Bay was studied again in 1966 by Wilde (1969), who sampled the macrofauna in the mouth of Plummer Creek from March through September. He constructed a hardware mesh fence across the creek with a large net bag in the center. Fish

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and invertebrates were channeled into the net on the outgoing tide. More than 6,000 invertebrate specimens were collected, representing 10 species. These included three molluscs, four arthropods, and no polychaetes. The most abundant organism by far was the bay shrimp Crago franciscorum. Few burrowing animals were collected, as would be expected by the sampling method.

Allen (1971) surveyed the benthic invertebrates in Castro Creek. Three to seven samples were taken with an Ekman dredge at each of 23 stations. Like Pintler (1958) and Brown and Caldwell Engineers (1954), Allen found that biovolume increased toward the mouth of the creek. With one exception, only annelids, arthropods, and molluscs were collected.

Also south of the Dumbarton Bridge, Burton (1972) sampled 45 stations from July through August 1971. He used an Ekman dredge to collect five samples along a transect at each station. Sulfide content of the sediment was determined in the laboratory. A statistically significant correlation existed between high sulfide concentrations of the sediment and low species diversities calculated by the Shannon-Weiner function. Thirty species of invertebrates were identified. The most numerous in decreasing order were Gemma gemma, Ampelisca sp., Macoma inconspicua, and Aorides sp.

The Effects of Heavy Metals on Marine and Estuarine Invertebrates

General Sources of Heavy Metals in Aquatic Systems

A large number of heavy metals are natural constituents of aquatic environments, originating from the weathering of metal-bearing rocks and soils (Leland et al., 1974). The metals can be transported to the aquatic environment by air, surface water, and ground water, and natural levels may be increased by the activities of man (suggested by the observation of Bruland and coworkers, 1974, who found that the rate of accumulation of zinc, copper, cadmium, and lead in coastal sediment deposits is much faster today than a century ago).

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Effects of Heavy Metals
General Sources

Copper, cadmium, lead, zinc, and mercury--the metals of concern in this study--have a large number of agricultural and industrial applications, and effluents from manufacturing plants that use these metals are a prime source of environmental contamination. Other known sources are power plants, mines, nuclear fallout, and smelters (Leland et al., 1974), domestic sewage (Halcrow et al., 1973), water pipes, and the use of agricultural products containing these metals.

Copper may be dissolved from rocks by natural waters (Prytherch, 1934); however, a considerable amount of copper in aquatic systems may come from agricultural and industrial sources. Metallic copper is used in many alloys in the manufacture of cooking utensils, pipes, roofing material, and electrical wires (McKee and Wolfe, 1963). Copper salts are used in the manufacture of textiles, pigments, leather, and pesticides and in photography, engraving, and electroplating.

Cadmium is a natural impurity often found in zinc-lead ores; its many industrial applications include electroplating, photographic processing, and manufacturing of paint and pesticides (McKee and Wolfe, 1963).

Lead also may occur naturally in water, especially in locations having mountain limestone and galena (McKee and Wolfe, 1963). Lead is used commonly as an antiknock agent in gasoline, exiting as automobile exhausts to be washed by rain into the aquatic environment.

Because elemental mercury is relatively inert chemically, it is not likely to occur as a water pollutant. However, its salts are highly soluble in water and, along with organic mercury compounds, are the most likely metals to cause pollution problems. Although mercuric salts occur in nature principally as the sulfide (cinnabar), numerous synthetic organic and inorganic salts are used in industrial processes and in the manufacture of commercial products (McKee and Wolfe, 1963).

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Effects of Heavy Metals
General Sources and Point Sources

Zinc commonly is used in electroplating and in manufacturing printing plates, dyes, and electrical products. Its salts are used in pigments, cosmetics, pharmaceuticals, insecticides, and many other commercial products. Zinc also occurs naturally in rocks and metal ores (Leland et al., 1974).

Point Sources of Heavy Metals in San Francisco Bay

In 1969, Pearson and associates of SERL compiled an inventory of waste dischargers in San Francisco Bay as part of an extensive investigation of the water and sediment quality of the Bay (Pearson et al., 1969). The SERL report listed numerous point sources of heavy metals for Suisun Bay and the lower San Joaquin River. The Sacramento-San Joaquin River System, which enters San Francisco Bay via Suisun Bay, drains much of northern California and undoubtedly carries large amounts of industrial, municipal, and agricultural wastewaters into the Bay.

Pearson and associates also estimated the average daily mass-emission rates of heavy metals for municipal and industrial point sources to the Bay during 1961-64. Table 58 presents these rates.

Surface runoff is another relatively large source of heavy metals for the Bay. According to a study performed by the URS Research Company (1974), the estimated annual amounts of copper, lead, and zinc washed off the streets of the city of Vallejo, located along the eastern shore of Mare Island Strait, are 1,900, 43,000, and 8,700 pounds, respectively. According the URS report, the estimated mean annual concentrations of heavy metals in storm water runoff from a typical city, typical industrial area, and typical marina are, respectively, 0.07, 0.24, and 0.36 mg/liter for copper; 1.2, 4.5, and 6.6 mg/liter for lead; and 0.26, 0.95, and 1.3 mg/liter for zinc.

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Effects of Heavy Metals
Point Sources

Table 58

MASS EMISSION RATES OF HEAVY METALS FOR MUNICIPAL AND
INDUSTRIAL DISCHARGERS IN SAN FRANCISCO BAY AREAS

<u>Area and Type of Discharge</u>	<u>Heavy Metals (pounds/day)</u>
South San Francisco Bay	
Municipal	2,024
Industrial	<u>205</u>
Total	2,229
Suisun-Lower San Joaquin River	
Municipal	1,502
Industrial	<u>10,653</u>
Total	12,155
San Pablo Bay	
Municipal	430
Industrial	<u>5,654</u>
Total	6,084
North San Francisco Bay	
Municipal	719
Industrial	<u>234</u>
Total	953
Central San Francisco Bay	
Municipal	1,163
Lower San Francisco Bay	
Municipal	124
Industrial	<u>26</u>
Total	150

Source: Pearson et al., 1969.

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Effects of Heavy Metals
Toxicity

Toxicity of Heavy Metals to Benthic Organisms

Tables 59 to 63 summarize toxicity data for copper, cadmium, lead, zinc, and mercury. These data were derived from laboratory experiments performed by a number of investigators on genera reported for San Francisco Bay. Experimental conditions and other details of each study are not presented in the tables but may be obtained by consulting the original articles.

The data presented in the tables indicate that, when present in ionic form, the five heavy metals can be highly toxic to marine and estuarine benthos. All the metals can produce toxic effects at concentrations less than 1 ppm, depending on the species and age of the animal tested. With the exception of cadmium and mercury, we found that the concentration of heavy metals in the sediment collected from the seven dredging and disposal areas in San Francisco Bay was much greater than the average ionic concentrations reported to be toxic to benthic animals.

Assessing the potential toxicity of metals contained in the sediments in San Francisco Bay is difficult based only on the concentration of the metals. Largely, toxicity depends on the availability of the metals to the organisms, and availability depends on a diversity of complex factors. Furthermore, toxicity data obtained in the laboratory must be extrapolated cautiously. Most laboratory studies are performed under static test conditions under which changes may occur in the concentration and form of the metal because of adsorption to the test container or because of changes in the quality of the test medium resulting from metabolic activities of the animals. Even so-called long-term studies are short relative to the life span of some benthic species. Laboratory studies provide toxicity data that apply only to the species of animal tested and to the degree conditions of the study.

The degree of toxicity of a given heavy metal may be influenced not only by the availability of that metal but also by the form of the metal, the temperature and salinity of the water, the type of sediment, and the presence of particulate matter.

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Toxicity

Table 59
TOXICITY OF COPPER TO MARINE AND ESTUARINE INVERTEBRATES

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Mollusca				
Oyster (sp. unspecified)	96 hr	1.0	100% survival	Fujiya, 1960
	96 hr	1.9	50% mortality	
	96 hr	3.4	100% mortality	
<u>Crasostrea rigas</u> Embryos	42-48 hr	0.08	100% survival	Calabrese et al., 1973
	42-48 hr	0.103	50% mortality	
	42-48 hr	0.13	100% mortality	
	--	0.01-0.032	No effect	Okubo and Okubo, 1962
	--	0.1	Development inhibited	
<u>Crasostrea virginica</u>	20 wk	25, 50	10-15% mortality	Shuster and Pringle, 1969
<u>Ostrea virginica</u> Presetting larvae	3-5 min	3-20	100% mortality	Prytherch, 1934
Setting larvae	--	<0.5	No effect on setting	
Setting larvae	Few days	0.8-1.5	Lethal after setting	
<u>Mytilus edulis</u> Embryos	--	0.032	No effect on development	Okubo and Okubo, 1962
	--	0.1	Development inhibited	
Adults	--	500	Reduced oxygen uptake	Brown and Newell, 1972 Scott and Major, 1972
	14 days	0.1	5% mortality, 7 days	
	14 days	0.2	Respiration and heart rate unaffected, 55% mortality, 7 days	
	--	22.2	50% mortality, 2 hr	
<u>Mytilus edulis p. mulatus</u> Larvae	60 days	0.10	100% survival	Marks, 1938
	60 days	0.15	Survived 30 days	
	60 days	0.20	Survived less than 2 days	
<u>Mya arenaria</u>	--	> 0.02	Extremely toxic	Pringle et al., 1968 Marks, 1938
<u>Paphia staminea</u>	65 days	1.0	100 alive at 30 days Initial number not given	

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Toxicity

Table 59 (Continued)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
<u>Polychaeta</u>				
<u>Polychaetes (7 spp.)</u>	96 hr	0.15-0.96	50% mortality	Reish, 1974
	28 days	0.03-0.65	50% mortality	
<u>Nereis diversicolor</u>	888 hr	0.1-0.7	41-828 hr mean survival time (from low-Cu area)	Bryan and Hummerstone, 1971
	888 hr	0.1-0.7	247-888 hr mean survival time (from high-Cu area)	
	408 hr	0.25-2.5	18-140 hr mean survival time (from low-Cu area)	
	408 hr	0.25-2.5	16-150 hr mean survival time (from low-Cu area)	
	408 hr	0.25-2.5	50-408 hr mean survival time (from high-Cu area)	
<u>Nereis virens</u>	21 days	<0.1	100% survival	Raymont and Shields, 1963
	21 days	0.1	Toxicity threshold	
	21 days	0.4-0.5	100% mortality, 7 days	
	25 hr	0.18	Respiration rate increased 40%	
	4 days	0.18	Respiration rate increased >100%	
<u>Oligochaeta</u>				
<u>Nais sp.</u>	--	1.0-2.0	Lethal, 24 hr	Learner and Edwards, 1963
<u>Limnodrilus hoffmeisteri</u>	--	0.40	96-hr TLm (hard water)	Wurtz and Bridges, 1961
	--	0.38	24-hr TLm (hard water)	
<u>Ectopoceta</u>				
<u>Bugula neritina (larvae)</u>	--	<0.2	Decreased growth and development	Miller, 1946
	--	0.2-0.3	Decreased growth and development	
	--	>0.3	Decreased growth, larval death	
	--	3.8	50% larval mortality, 2 hr	Wisely and Blick, 1967

Literature Review
Effects of Heavy Metals
Toxicity

Table S9 (Continued)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
<u>Ectoprocta (Continued)</u>				
<u>Bugula sp.</u>	48 hr	0.5	Survived, 3-7 hr	Riley, in Ketchum, 1952
	5 hr	<0.5	100% mortality	
<u>Arthropoda</u>				
<u>Artemia salina</u>				
Adults	94 hr	150-500	50% mortality in 35-94 hr	Corner and Sparrow, 1956
	94 hr	500-1000	50% mortality in 20-35 hr	
	4.5 hr	1.0	Motility and respiration reduced to 95% and 73% of normal	
	24 hr	0.68-1.04	50% mortality	Okubo and Okubo, 1962
	Various	1.0	50% mortality in 168 hr	Brown and Ahsanullah, 1971
	Various	1.0	50% mortality in 110 hr	
<u>Larvae</u>				
<u>Crangon crangon</u>				
Larvae	--	0.33	50% mortality, 54 hr	Connor, 1972
	--	3.3	50% mortality, 2.8 hr	
	--	33.0	50% mortality, 0.22 hr	
Adults	48 hr	32	50% mortality, 48 hr	Fortmann, 1968
<u>Cancer irroratus</u>	48 hr	>5.0	Mortality, % unspecified	Thurberg et al., 1973
	48 hr	0.6	Osmoregulation abolished	
<u>Balanus amphitrite (cyprids)</u>	1 hr	0.5, 1.5	Increased oxygen uptake	Bernard and Lane, 1963
	--	10-500	Progressive decrease in oxygen uptake	
	--	100-200	Survival time reduced	
	--	>50	Activity reduced	
<u>Balanus balanoides</u>	2 hr	10	Almost 100% mortality	Muller, 1940
Nauplii	2 hr	30	Almost 100% mortality	
Cyprids	3 hr	50	Some mortality	
<u>Balanus crenatus</u>	2 hr	10	Almost 100% mortality	Muller, 1940
<u>Balanus amphitrite</u>	--	3.2	No effect	Okubo and Okubo, 1962

Literature Review
Effects of Heavy Metals
Toxicity

Table 59 (Concluded)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Arthropoda (Continued)				
<u>Balanus balanoides</u>				
Nauplii	6 hr	0.41	50% mortality	Pyefinch and Mott, 1948
Cyprids	6 hr	5.9	50% mortality	
Settling cyprids	7-8 days	0.01	Settling prevented	
Metamorphosing cyprids	39 hr	0.01-10.0	Metamorphosis unaffected	
Juveniles	--	0.01-10.0	Calcification prevented	
Adults	24 hr	0.32	50% mortality	
<u>Balanus crenatus</u>				
Nauplii	6 hr	0.26	50% mortality	Pyefinch and Mott, 1948
Cyprids	6 hr	7.0	Less than 50% mortality	
Metamorphosing cyprids	24 hr	0.5-7.5	Metamorphosis unaffected	
Juveniles	--	0.5-7.5	100% mortality	
Adults	24 hr	0.19	50% mortality	

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Table 60
TOXICITY OF CADMIUM TO MARINE AND ESTUARINE INVERTEBRATES

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Mollusca				
<u>Crassostrea gigas</u> Embryos	42-48 hr	1.0 3.8 6.0	100% survival 50% mortality 100% mortality	Calabrese et al., 1973
<u>Crassostrea virginica</u>	20 wks	100, 200	84-100% mortality	Shuster and Pringle, 1968
<u>Ostrea sinuata</u>	--	50	Close to toxic limit	Brooks and Rumsby, 1967
<u>Mya arenaria</u>	96 hr	2.2	50% mortality	Eisler, 1971
<u>Urosalpinx cinerea</u>	96 hr	6.6	50% mortality	Eisler, 1971
<u>Nassarius obsoletus</u>	96 hr	10.5	50% mortality	Eisler, 1971
<u>Mytilus edulis</u>	96 hr	25.0	50% mortality	Eisler, 1971
Polychaeta				
<u>Polychaetes (4 spp.)</u>	96 hr	5.9-21.0	50% mortality	Reish, 1974
<u>Polychaetes (3 spp.)</u>	28 days	0.7-6.4	50% mortality	Reish, 1974
<u>Nereis diversicolor</u>	816 hr	1-100	233-816 hr mean survival time (from low-Zn area)	Brynn and Hummerstone, 1973
	816 hr	1-100	187-816 hr mean survival time (from high-Zn area)	Brynn and Hummerstone, 1973
<u>Nereis virens</u>	96 hr	11.0	50% mortality	Eisler, 1971
Arthropoda				
<u>Artemia salina</u>	Various	1.0	50% mortality, 240 hr	Brown and Ahsanullah, 1971
<u>Cragon septempinosus</u>	96 hr	0.32	50% mortality	Eisler, 1971
<u>Pagurus longicarpus</u>	96 hr	0.32	50% mortality	Eisler, 1971
<u>Cancer irroratus</u>	48 hr	>1.0	Some mortality	Thurberg et al., 1973
		0.12-1.00	Reduced oxygen consumption	

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Table 61
TOXICITY OF LEAD TO MARINE AND ESTUARINE INVERTEBRATES

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Mollusca				
<u>Crassostrea gigas</u> Embryos	42-48 hr	0.5 2.45	100% survival 50% mortality	Calabrese et al., 1973
<u>Mytilus edulis</u>	130 days	0.0 0.5 1.0 5.0	50% mortality, 218 days 50% mortality, 150 days 50% mortality, 129 days 50% mortality, 105 days	Schulz-Baldes, 1972
Polychaeta				
Polychaetes (2 spp.)	96 hr	1.85->10	50% mortality	Reish, 1974
Polychaetes (1 sp.)	28 days	1.45	50% mortality	Reish, 1974
Arthropoda				
<u>Artemia salina</u>	Various	1.0 5.0-10.0	50% mortality Growth inhibition	Brown and Ahsanullah, 1971

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Table 62
TOXICITY OF ZINC TO MARINE AND ESTUARINE INVERTEBRATES

Species	Test Duration	Concentration (mg/liter)	Results	Reference
<u>Mollusca</u>				
<u>Crassostrea gigas</u>				
Embryos	42-48 hr	0.075	100% survival	Calabrese et al., 1973
	42-48 hr	0.31	50% mortality	
	42-48 hr	0.5	100% mortality	
	--	0.32-1.0	No effect	Okubo and Okubo, 1962
	--	3.2	Development inhibited	
Larvae	5 days	0.125-0.5	Reduced growth, increased abnormality	Brereton et al., 1973
	5 days	0.05	Little effect on development	
	5 days	0.2	Growth inhibited	
<u>Crassostrea virginica</u>	20 wks	100-200	7% mortality, similar to controls	Shuster and Pringle, 1969
<u>Ostrea edulis</u> (larvae)	96 hr	0.1-0.5	Growth inhibited	Walne, 1970
	96 hr	2.5-5.0	No growth	
<u>Mytilus edulis</u>				
Embryos	--	0.32	No effect	Okubo and Okubo, 1962
	--	1.0	Development inhibited	
Adults	--	500	No effect on oxygen uptake	Brown and Newell, 1972
<u>Polychaeta</u>				
Polychaetes (5 spp.)	96 hr	0.9-15	50% mortality	Reish, 1974
	28 days	0.9-8.6	50% mortality	
<u>Nereis diversicolor</u>	816 hr	10-250	24-816 hr mean survival time (from low-Zn area)*	Bryan and Hummerstone, 1973
	816 hr	10-250	30-816 hr mean survival time (from high-Zn area)*	
	408 hr	5-25	52-349 hr mean survival time (from low-Zn area)†	
	408 hr	5-25	70-394 hr mean survival time (from high-Zn area)†	

* Salinity 17.5‰.

† Salinity 3.5‰.

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Table 62 (Concluded)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
<u>Ectoprocta</u>				
<u>Bugula neritina</u> (larvae)	--	5.2	50% mortality, 2 hr	Wisely and Blick, 1967
<u>Bugula</u> sp.	48 hr 5 hr	1.0 5.0	Survived, 22.5 hr 100% mortality	Riley, in Ketchum, 1952
<u>Arthropoda</u>				
<u>Artemia salina</u> Adult	Various Various 24 hr	1.0 1.0-10.0 160-275	50% mortality, 312 hr Growth inhibition 50% mortality	Brown and Ahsanullah, 1971 Okubo and Okubo, 1962
Larvae	Various	1.0	50% mortality, 150 hr	Brown and Ahsanullah, 1971
<u>Crangon crangon</u>	48 hr	120	50% mortality	Portmann, 1968
<u>Balanus amphitrite</u>	--	32	No effect	Okubo and Okubo, 1962

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Table 63
TOXICITY OF MERCURY TO MARINE AND ESTUARINE INVERTEBRATES

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Mollusca				
<u>Crassostrea gigas</u> Embryos	42-48 hr 42-48 hr 42-48 hr	0.001 0.0056 0.008	100% survival 50% mortality 100% mortality	Calabrese et al., 1973
<u>Crassostrea virginica</u>	92 days 92 days	0.01 0.10	5% mortality, similar to controls 65% mortality	Cunningham and Tripp, 1973
<u>Crassostrea commercialis</u> Larvae	--	181	50% mortality, 2 hr	Wisely and Blick, 1967
<u>Ostrea edulis</u> Larvae	-- --	0.0033 0.001-0.0033	50% mortality, 4.2 hr 50% mortality, 48 hr	Connor, 1972
<u>Mytilus edulis planulatus</u> Larvae	--	13.0	50% mortality, 2 hr	Wisely and Blick, 1967
<u>Mytilus edulis</u> Embryos	-- --	0.032 0.01	Development inhibited No effect	Okubo and Okubo, 1962
<u>Venus japonica</u>	--	0.3	Survived 6-10 days	Irukayama, in Keckes and Miettinen, 1972
Polychaeta				
Polychaetes (4 spp.)	96 hr	0.027-0.7	50% mortality	Reish, 1974
Polychaetes (3 spp.)	28 days	0.09-0.22	50% mortality	Reish, 1974
Ectoprocta				
<u>Bugula neritina</u> (larvae)	--	0.2	50% mortality, 2 hr	Wisely and Blick, 1967
<u>Bugula sp.</u>	48 hr 5 hr	1.0 0.5	100% mortality, 2 hr 100% mortality	Riley, in Ketchum, 1952

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Table 63 (Concluded)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
Arthropoda				
<u>Artemia salina</u>				
Larvae	57 hr	30-100	50% mortality, 11-57 hr	Corner and Sparrow, 1956
Adult	57 hr	100-750	50% mortality, 3-11 hr	
	24 hr	21-50	50% mortality	Okubo and Okubo, 1962
	Various	1.0	50% mortality, 25 hr	Brown and Ahsanullah, 1971
<u>Crago crangon</u>				
Adult	48 hr	6	50% mortality	Portmann, 1968
Larvae	--	0.033	50% mortality, 20 hr	Connor, 1972
	--	0.33	50% mortality, 5.1 hr	
	--	3.3	50% mortality, 1.5 hr	
	--	0.32	No effect	Okubo and Okubo, 1962
<u>Balanus amphitrite</u>				
<u>Balanus balanoides</u>				
Nauplii	6 hr	0.23	50% mortality	Pyefinch and Mott, 1948
Cyprids	6 hr	3.0	50% mortality	
Settling cyprids	days	0.01	Settling inhibited	
Settling cyprids	days	0.05	Settling prevented	
Adults	hr	0.36	50% mortality	
<u>Balanus crenatus</u>				
Nauplii	6 hr	0.09	50% mortality	Pyefinch and Mott, 1948
Cyprids	6 hr	1.0	>50% mortality	
Metamorphosing cyprids	24 hr	0.5-10.0	Metamorphosis inhibited	
Juveniles	--	0.5-10.0	Lethal	
Adults	24 hr	1.35	50% mortality	
<u>Balanus balanoides</u>				
	--	1.0	Lethal, 2 days	Clarke, 1947
	--	0.5	Lethal, 5 days	
<u>Balanus improvisus</u>				
Cyprids	--	3.3	No effect on metamorphosis	Clarke, 1947

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Also having an influence are the species, size or age, nutritional state, and environmental history of the animal. Bryan (1971) reviewed the influence of a number of these factors on heavy-metal toxicity.

In general, larval forms are less tolerant of the presence of heavy metals than adult forms, large animals tend to be more tolerant than small ones, and starved animals tend to be less tolerant than well-fed ones. The toxicity of heavy metals generally increases with increasing temperature and with decreasing salinity of the water. Several investigators (Corner and Sparrow, 1956; Pyefinch and Mott, 1948; Barnes and Stanbury, 1948; Ketchum, 1952) have reported a synergistic relationship between mercury and copper.

Some benthic organisms can build a resistance to the toxic effects of heavy metals. Laboratory tests performed by Bryan and Hammerstone (1971) on Nereis diversicolor showed that animals collected from areas of high copper pollution were much more resistant to the toxic action of copper sulfate than animals collected from areas with less copper. Mean toxic tissue levels were 220 $\mu\text{g/g}$ for animals from the low-copper area, 320 $\mu\text{g/g}$ for animals from the medium-copper area, and 720 $\mu\text{g/g}$ for animals from the high-upper area.

These investigators found evidence that resistance to the toxic effects of copper may be due to genetic changes rather than to short-term physiological adaptation. Bryan and Hammerstone took N. diversicolor from areas of high copper pollution and placed them in sediment with low copper content. Concurrently, they performed the reverse procedure and found that animals with a low copper history did not acquire tolerance to high copper levels after 45 days of exposure and that animals with a high copper history did not lose their tolerance after 76 days of exposure. The investigators reasoned that time had been sufficient for genetic selection to occur because the highly polluted estuaries had been receiving copper-mine wastes for over 200 years.

Although the adverse effects of heavy metals generally are emphasized, certain metals are essential for life. As yet, the physiological and biochemical necessity of cadmium, lead, and

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mercury has not been established for marine and estuarine invertebrates, but zinc and copper appear to be essential for the proper functioning of certain enzyme systems in certain animals.

Zinc is an essential constituent of many enzymes, including carbonic anhydrase, alkaline phosphatase, carboxypeptidase, and alcohol dehydrogenase (Williams, 1953). Wolfe (1970a) reported the presence of carbonic anhydrase, alkaline phosphatase, and malic dehydrogenase in oyster tissues. He also discovered that all the zinc in oyster tissues is bound, either to soluble high-molecular-weight proteins or to structural components of the cell. However, in dialysis experiments, Wolfe found that up to 96% of the zinc bound to alkaline phosphatase could be removed without affecting the activity of the enzyme. He concluded that most of the zinc found in oysters serves no useful function. Pequegnat and associates (1969) reached a similar conclusion. These researchers calculated that 2.7 mg/kg of tissue is the maximum essential concentration of zinc in tissues of marine organisms.

The cupric form of copper is considered one of the best catalysts for oxidation-reduction processes (Williams, 1971). It is associated with several enzymes such as lactase, the phenol and polyphenol oxidases, and ascorbic acid oxidase (Lehninger, 1950). Prytherch (1931, 1934) found that traces of copper are essential for the initiation of setting and metamorphosis of oyster larvae. Prytherch observed in laboratory experiments that copper was the only factor that would induce setting of oysters and reported observing larvae setting in maximum numbers in the field when copper concentrations in the water ranged from 0.05 to 0.6 mg/liter. He also found that setting coincided with low tide and maximum river outflow. Mixing of fresh and saline water usually results in the formation of copper colloids, and Prytherch concluded that this was the form of copper that probably was taken up by oyster larvae.

Copper also has been found to be essential in the setting of barnacles, the formation of melanin in the ink of the octopus, the hardening of the exoskeleton and egg encasements of marine invertebrates, and the blackening of blood in some invertebrates after injury (Corcoran and Alexander, 1964).

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Uptake and Accumulation of Heavy Metals

Heavy metals may affect aquatic organisms adversely by interfering with some vital process on their external surfaces. Particularly prone to damage are the gills and other soft membranes through which respiration and/or excretion occur.

Metals that are taken up also may have adverse effects on aquatic organisms by inhibiting internal metabolic processes. Uptake may occur via ingestion of sediment, water, or other organisms or by diffusion through semipermeable membranes. Benthic organisms also may acquire metals by ingesting suspended particles to which metals have been adsorbed (Brooks and Rumsby, 1965). Membrane absorption may occur either by simple diffusion or active transport, simple diffusion having been shown to occur in algae and protozoa as well as in multicellular organisms that possess external semipermeable membranes (Pringle et al., 1968). Many benthic forms do not appear to be able to regulate the ionic concentration of their internal fluids, becoming isotonic with their environments. In some animals, uptake of heavy metals across semipermeable membranes may occur to some extent by active transport. According to the carrier hypothesis, certain ions may be transported across membranes as chelates with metabolically produced organic molecules at the expense of energy (Pringle et al., 1968).

A number of field studies have been performed to determine the concentration of a variety of heavy metals in whole benthic animals. Table 64 summarizes data pertaining to whole-body levels of copper, cadmium, lead, zinc, and mercury. Many of the studies reviewed lacked information on the concentration of the metal in question in the sediment or water from which the animals were collected for analysis.

Benthic organisms tend to accumulate certain heavy metals more than others. Of the five metals studied in this investigation, zinc and copper were observed to be accumulated to a greater degree than the other metals.

We found only one study in which heavy metal uptake and accumulation was investigated using animals from San Francisco Bay. This

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Table 64
CONCENTRATION OF SELECTED HEAVY METALS IN MARINE AND ESTUARINE INVERTEBRATES

Species	Body Burden ($\mu\text{g/g wet weight}$)				Environmental Level		Location	Reference
	Copper	Cadmium	Lead	Mercury	Zinc	Water ($\mu\text{g/liter}$)	Sediment ($\mu\text{g/g}$)	
Mollusca								
<u>Crassostrea virginica</u>								
--	--	--	--	--	2040	--	--	Alexander and Rowland, 1966
--	--	--	--	--	85-245	0.55-0.75	--	Wolfe, 1970b
--	--	--	--	--	313-3174	0.8-24	--	Chipman et al., 1958
--	--	--	--	--	1500-2800	--	--	Fitzgerald et al., 1962
48-261*	--	--	--	--	1200-5700*	--	--	Windom and Smith, 1972
400-3000*	--	--	--	--	3500-13,500*	--	--	Galtsoff, 1964
92	3	0.5	--	--	1428	--	--	Pringle et al., 1968
0-200	0.6-2.5	--	--	--	0-6000	--	--	Huggett et al., 1973
--	--	--	--	0.20†	--	--	--	Delaware River Basin Commission, 1970
--	--	--	--	0.28	--	--	--	Cunningham and Tripp, 1973
--	--	--	--	--	0.06	0.005	0.001	U.S. Dept. Interior, 1966
72-85	--	--	--	--	--	--	--	N. Atlantic Coast
16-17	--	--	--	--	--	--	--	Coulson et al., 1932
16-27	--	--	--	--	--	--	--	Coulson et al., 1932
9-520†	--	--	--	--	310-4000†	--	--	Gulf Coast
13-26	0.8-1.4	<0.2	--	--	199-275	--	--	Atlantic Coast
9-192	0-35	--	--	--	333-10,019	--	--	McFarren et al., 1962
--	--	--	--	--	255	--	--	Shuster and Pringle, 1968
--	--	--	--	--	203	--	--	Ratkowsky et al., 1974
--	--	--	--	--	318	--	--	Sastry and Bhatt, 1965
<u>Crassostrea cucullata</u>								
--	--	--	--	--	--	--	--	Sastry and Bhatt, 1965
<u>Crassostrea madresensis</u>								
19	0	--	--	--	--	--	--	Ratkowsky et al., 1974
<u>Crassostrea commercialis</u>								

Table 64 (Continued)

Species	Body Burden ($\mu\text{g/g}$ wet weight)				Environmental Level		Location	Reference	
	Copper	Cadmium	Lead	Mercury	Zinc	Water ($\mu\text{g/liter}$)			Sediment ($\mu\text{g/g}$)
Mollusca (continued)									
<u>Ostrea sinuata</u>	-- 41*	23* 35*	1* 10*	-- --	172* 1103*	-- --	-- --	Unknown New Zealand	Brooks and Rumsby, 1967 Brooks and Rumsby, 1965
<u>Ostrea edulis</u>	1060-1491	--	--	--	717-27,808	--	--	N. Wales	Coombs, 1972
<u>Ostrea angasi</u>	4-81	0.2-19	--	--	371-8865	--	--	Tasmania	Ratkowsky et al., 1974
<u>Ostrea[†] gigas</u>	13-268	--	--	--	109-953	Cu 0.9-2.9 Zn 17-49	--	Japan	Ikuta, 1968
<u>Mytilus edulis</u>	9	<10	12	--	91	--	Cu 102 Cd <20 Pb <5 Zn 100	New Zealand	Brooks and Rumsby, 1965
--	--	--	--	--	81	--	--	New Zealand	Macchi, 1965
--	--	--	--	--	253-779*	40-88	--	Wales	Ireland, 1973
--	--	--	--	1.0*	40*	--	--	Nieuport, Belgium	Bertine and Goldberg, 1972
--	--	--	10-20*	--	--	--	--	England	Chapman and Linden, 1927
--	--	--	5-6*	--	--	--	--	Ilse Glenan, France	Cheftel et al., 1949
--	--	--	0.15-0.36*	--	--	--	--	Vigo, Spain	Costa and Molina, 1957
--	--	--	1-30*	--	--	--	--	Bristol, England	Nickless et al., 1972
--	--	--	1.9-6.4*	--	--	--	--	Weser Estuary and German Bight	Schulz-Baldes, 1973
2-4	--	--	--	--	--	1.0	--	S. California	Marks, 1938
12-24*	--	--	--	--	--	1.0	--	S. California	Marks, 1938
10*	5*	31*	9*	--	91*	--	--	Irish Sea	Segar et al., 1971
--	--	--	--	--	--	0.113	--	Irish Sea	Mullin and Riley, 1956
--	--	--	8.4*	--	--	--	--	Germany	Schulz-Baldes, 1972
5-11*	3-7*	--	<4-8*	--	204-341*	--	--	N. California (Incl. S.F. Bay)	Graham, 1972

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Species	Body Burden ($\mu\text{g/g}$ wet weight)				Environmental Level		Location	Reference
	Copper	Cadmium	Lead	Mercury	Zinc	Water ($\mu\text{g/liter}$)		
Mollusca (continued)								
<u>Mytilus californianus</u>	9-30*	2-5*	<2-23*	--	164-310*	--	--	N. California (incl. S.F. Bay) Graham, 1972
<u>Mytilus viridis</u>	1-3	--	--	--	--	1.0	--	S. California Marks, 1938
<u>Tapes philippinarum</u>	--	--	--	--	11	28	--	Bombay, India Sastry and Bhattacharya, 1965
<u>Tapes semidecussata</u>	--	--	--	--	19	--	--	Japan Ichikawa and Ohno, 1974
<u>Protothaca staminea</u>	19*	10*	<2*	--	11*	--	--	San Francisco Bay Graham, 1972
<u>Paphia staminea</u>	8*	6*	5*	--	68*	--	--	San Francisco Bay Graham, 1972
<u>Modiolus modiolus</u>	2	--	--	--	--	1.0	--	S. California Marks, 1938
<u>Busycon canaliculatum</u>	27*	6*	33*	--	425*	--	--	Irish Sea Segar et al., 1971
<u>Crepidula fornicata</u>	76	--	--	--	--	--	--	Narragansett Bay Betzner and Pilson, 1974
<u>Mya arenaria</u>	270*	4*	41*	--	940*	--	--	Irish Sea Segar et al., 1971
Polychaeta	5.8	0.27	0.70	--	17	--	--	Atlantic Coast Shuster and Pringle, 1968
<u>Armandia</u> sp.	3-80	--	--	--	48-250	--	--	Puerto Rico Phelps et al., 1969
<u>Armandia maculata</u>	--	--	--	--	0	--	--	Puerto Rico Phelps, 1967
<u>Capitella</u> sp.	--	--	--	--	0	--	--	Puerto Rico Phelps, 1967
<u>Mageiona</u> sp.	--	--	--	--	0	--	--	Puerto Rico Phelps, 1967
<u>Nephtys incisa</u>	--	--	--	--	99*	--	--	Massachusetts Phelps, 1967
<u>Prionospio</u> sp.	--	--	--	--	42*	--	--	Rhode Island Phelps, 1967
<u>Nereis</u> sp.	--	--	--	--	0	--	--	Massachusetts Phelps, 1967
<u>Pectinaria</u> sp.	--	--	--	--	25*	--	--	Massachusetts Phelps, 1967
	--	--	--	--	0	--	--	Rhode Island Phelps, 1967

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Table 64 (continued)

Species	Body Burden (-g/g wet weight)				Environmental Level		Location	Reference
	Copper	Cadmium	Lead	Mercury	Zinc	Water (-g/liter)		
Polychaeta (continued)								
<u>Nereis diversicolor</u>	22-1152*	--	1-6*	--	155-199*	--	S.W. England	Bryan and Hummerstone, 1971
	662-2573*	--	--	--	--	3-5530 Zn 99-2237*	Restronguet Creek, England	Bryan and Hummerstone, 1971
	56-167*	--	--	--	--	1-6 210-407*	Tamar, England	Bryan and Hummerstone, 1971
	21*	--	--	--	--	.1 38*	Dart, England	Bryan and Hummerstone, 1971
	--	0.08-3.6*	--	--	130-250*	Zn 10-1150 Cd 0.2-9.3*	S.W. England	Bryan and Hummerstone, 1973
<u>Nereis</u> sp.	--	--	--	--	75-95*	--	N. Carolina	Cross et al., 1970
<u>Glycera americana</u>	--	--	--	--	140-195*	--	N. Carolina	Cross et al., 1970
Arthropoda								
<u>Cragon crangon</u>	--	--	--	1.3*	39*	Zn 0.01 Hg 0.00003	Newport, Belgium	Bertine and Goldberg, 1972
<u>Cragon allmani</u>	56-112*	1.2-3.5*	16-23*	--	121-166*	--	Firth of Clyde	Halcrow et al., 1973
<u>Balanus amphitrite</u> <u>communis</u>	--	--	--	--	72	28	Bombay, India	Sastry and Bhatt, 1965
<u>Balanus eburneus</u>	--	--	--	--	3.6	6.8	Texas	Parker, 1962
<u>Balanus balanoides</u>	--	0.1*	--	--	4500-23,100*	40-88	Wales	Ireland, 1973
	29	--	--	--	--	0.113	Irish Sea	Mullin and Riley, 1956
		--	--	--	--	--	Unknown	Culkin and Riley, 1958
<u>Cancer pagurus</u>	35	--	--	--	--	--	Unknown	Culkin and Riley, 1958
	--	0.1*	--	--	--	0.113	Irish Sea	Mullin and Riley, 1956
<u>Cancer magister</u>	--	--	--	--	566	--	Unknown	Carey, in Pequegnat et al., 1969

* Dry weight.

* Wet or dry weight not specified.

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study was conducted by Anderlini and coworkers (1974) in Mare Island Strait. The concentrations of heavy metals in the sediment, water, and animals at several stations were monitored over six-months, which included two periods of major dredging activity by the Corps of Engineers. These investigators found no relationship among the levels of copper, cadmium, lead, zinc, or mercury in the sediment, water, or animals and the station or time, except for a slight decrease in lead concentrations with time. The effect of dredging on heavy-metal concentrations was difficult to evaluate because the two periods of heavy dredging activity coincided with the two heaviest rainfalls of the study period.

Ninety-five percent or more of the lead in the water column was associated with suspended particles. The concentrations of the metals associated with suspended particles were similar to those observed in the bottom sediments. Concentrations of copper, lead, and mercury were higher in the sediment than in the invertebrates, whereas the reverse was true for cadmium and zinc. Cadmium concentrations were six times higher in Ischadium demissum and Mytilus edulis than in sediments. Zinc concentrations were up to 2.8 times higher in Neanthes succinea, Macoma balthica, and native and transplanted Mytilus edulis than in sediments. The fluctuations in levels of metals in the invertebrates did not correlate with fluctuations of metals in the sediments or with copper or lead in suspended particles.

The accumulation from water of mercury, lead, and copper by Macoma balthica was studied in a nine-day laboratory experiment. One to three concentrations (2.5, 5, and 10 µg/liter above ambient) and three salinities (5, 12.5, and 25‰) were used.

The amount accumulated increased with time and with increasing concentration and decreasing salinity. Anderlini and his associates (1974) suggested that, if this were true for other invertebrates and metals, the low salinity recorded during the second dredging period could have been the cause of the few gradual increases in concentrations of metals in the animals at that time.

Mytilus edulis from Mare Island Strait had up to four times the metal content of M. edulis from Tomales Bay. When M. edulis

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was transplanted to Mare Island Strait, metal concentrations increased, but M. edulis transferred from Mare Island Strait to Tomales Bay had metal levels lower than the baseline sample by a factor of two to three in 27 days.

The magnitude of heavy-metal accumulation appears to be governed by several factors, one being the manner by which an organism feeds. According to Phelps and his coworkers (1969), nonselective deposit feeders tend to accumulate more zinc than selective deposit feeders, and filter feeders tend to accumulate the least. Phelps (1967) also found that metal partitioning occurred between nonselective and selective feeders, iron being taken up preferentially by selective feeders and zinc being accumulated preferentially by nonselective feeders. Phelps attributed this difference to where and on what these two types of animals feed. Since selective types feed mostly at the sediment-water interface and mostly on freshly settled particulate matter, Phelps (1967) reasoned that they are most apt to ingest particulate or colloidal iron; nonselective types as well as omnivores and carnivores feed primarily on surface and subsurface sediment and/or other organisms. He hypothesized that zinc would be more available to subsurface feeders because of the tendency of zinc to be released from the sediment under anaerobic conditions.

That zinc or other metals are released more readily from sediment under anaerobic conditions is not accepted by all investigators. Bachmann (1963) and Phelps (1967) have agreed this is true; but Bryan and Hummerstone (1971) and Anderline and coworkers (1974) presented evidence that heavy-metal desorption occurs most readily under aerobic conditions.

Although Phelps (1967) reported finding selective accumulation of zinc and iron by animals having different feeding mechanisms, Cross and coworkers (1970) could not substantiate this phenomenon. In their investigation of the accumulation of metals by polychaetes, they found that Nereis sp., which they classified as a subsurface feeder, accumulated zinc and iron to the same degree as surface feeding polychaetes. Evidence exists, however, that Nereis sp. does not feed exclusively on subsurface particles but also can feed by filtration and will feed on surface particles (Harley, 1953;

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Goerke, 1971); if this polychaete does, in fact, feed by several mechanisms, it is not likely that evidence that selective metal accumulation would appear.

Several investigators have reported that some benthic organisms tend to regulate the amount of metal retained. Bryan and Hummerstone (1971), who have performed relatively comprehensive studies on the relationship of environmental heavy metal levels and the toxicity and accumulation of metals by Nereis diversicolor, compared the amount of copper, zinc, lead, manganese, and iron in this polychaete with that in the sediment. Their study was conducted in seven estuaries in southwest England. Although the average concentration of copper in the sediment ranged from 20 to more than 9,000 µg/g dry weight, depending on the estuary, the animal-to-sediment ratio for copper ranged from 0.24 to 0.68. Sediment concentrations for zinc ranged from 99 to 2,237 µg/g dry weight; however, the concentration of the metal in N. diversicolor, which inhabited the sediment, ranged from 155 to 199 µg/g dry weight. Bryan and Hummerstone suggested that either these metals were not available to the animals or the animals were capable of regulating the degree to which the metals accumulated internally.

Bryan and Hummerstone (1973) reported strong evidence that zinc is regulated by N. diversicolor but no evidence that cadmium is. They found that the concentration of zinc in the sediment varied by a factor of 30, but the concentration of zinc in specimens of N. diversicolor removed from the same sediment varied by a factor of only 2.7. On the other hand, the sediment and whole body concentrations of cadmium varied by about the same factor.

Cross and coworkers (1970) reported that, at two stations where the median sediment metal content differed by a factor of 4 for manganese, 10 for iron, and 8 for zinc, no differences were observed in the whole-body metal content of three of the six polychaete species analyzed. These investigators concluded that either the three species were able to regulate internal metal levels or much of the metal associated with the sediment was unavailable to them. Cross et al. also reported that the levels of the respective metals found in the animals supported another theory on metal accumulation by aquatic organisms: The accumulation or enrichment

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of divalent metal ions follows the order of stability of metal ligand complexes (Goldberg, 1957).

Bryan and Hummerstone (1971) suggested possible sites of regulatory activity for N. diversicolor. Analysis of the distribution of copper in various body parts of this worm showed that the parapodia, body wall, and parts of the nephridia associated with the body wall contained the highest amount of copper. Raymont and Shields (1964) reported a similar phenomenon for Nereis virens. However, the parapodia and body wall might be major sites of entry for copper rather than regulatory sites.

Unpublished work cited by Bryan and Hummerstone (1971) showed that the toxicity of copper increases with decreasing salinity. This suggested to them that salinity may influence copper uptake and retention in benthic organisms. Their own work on the relationship between copper uptake and salinity was inconclusive, but Cronin and associates (1974) found that the rate of uptake of zinc and copper by hatchery-reared oysters (C. virginica) increased with decreasing salinity and that oysters placed in areas of low salinity had much higher levels of cadmium than those transferred from the hatchery to areas of high salinity.

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Many investigators have demonstrated that heavy metals can be highly toxic to benthic animals in the ionic form; yet, as we and others have discovered, benthic organisms can occur in relatively great abundance in areas where the sediment contains very high levels of heavy metals. The apparent tolerance is not limited to a few species. At Oakland Inner Harbor, where the sediment was more highly contaminated with heavy metals than at any other area we investigated, we found a great diversity of benthic macrofauna. This apparent paradox can be explained to a large extent by availability.

Metals can exist in seawater in at least four different forms: (1) as part of living organisms, (2) as colloidal particles, (3) adsorbed to other colloidal particles, and (4) in true solution (Leland et al., 1974). Trace metals in true solution generally form

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complexes with a number of other ions normally found in seawater. These complexes include CuCl^+ , Cu(OH)^+ , CdCl^+ , CdCl_2 , Cd(OH)^+ , PbCl^+ , HgCl_4^{2-} , and ZnCl^+ (Krauskopf, 1956). Several factors may affect the conversion of these forms. Zirino and Yamamoto (1972) discussed the pH-dependent reactions of copper zinc, cadmium, and lead with the anions, OH^- , Cl^- , SO_4^{2-} , HCO_3^- , and CO_3^{2-} in seawater between pH 7 and 9. They formulated a model based on available and estimated individual ion activity coefficients and stability constants, assuming the metals were in the divalent state, and developed a different set of ionic species than that formulated by Krauskopf. Their results showed that, at different pH values, the dominant ionic species were different.

In the pH range studies by Zirino and Yamamoto, all four metals occurred primarily as complexes, with only a few species predominating for each metal. Copper was associated primarily with hydroxide and carbonate ions. The dominant species were CuCO_3 and Cu^{2+} at pH 7.0 and Cu(OH)_2^0 at pH 7.5 and 8.1. Cadmium complexed strongly only with chloride ions throughout the entire pH range studied. The dominant species was CdCl_2^0 , followed in decreasing order by CdCl^+ , CdCl_3^- , and Cd^{2+} . Lead reacted mainly with carbonate and to a lesser extent with chloride ions. PbCl^+ dominated at pH 7.0, and PbCO_3^0 dominated at pH 7.5 and 8.1. Zinc did not complex as readily as did the other metal ions at pH 7.0 and 7.5, but it complexed strongly with the hydroxide ion at pH 8.0. Zinc complexes were formed with sulfate, but the amount was insignificant. Goldberg and Arrhenius (1958) determined, however, that approximately 10% of the amount of zinc in seawater is present as sulfates.

Several investigators have found organic complexes of metals in sea water. Rona and coworkers (1962) and Slowey and Hood (1966) reported that zinc and copper in seawater were not dialyzable, suggesting the existence of a complexed form they believed to be organic. Corcoran and Alexander (1964) found that copper in seawater from Florida existed primarily in the soluble, nonionic state, probably as an organic molecule. Little of this metal was found in the particulate or ionic form. Williams (1969) also presented evidence supporting the presence of organically bound copper in seawater.

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Complexed copper, as well as copper associated with suspended solids, has been found analytically in fresh water (Stiff, 1971). Morel et al. (1973) reviewed the speciation of metallic ions in fresh water and the roles of acid-base components, oxidation-reduction status, solubility, and complexation. Lerman and Childs (1973) discussed complexation of metals in fresh water by the organic compounds nitrilotriacetate (NTA) and citrate, which may appear in waters affected by industrial societies.

The concentration of heavy metals in solution in the ocean is orders of magnitude less than that calculated to have accumulated in the ocean from weathering of land during geologic time (Krauskopf, 1956). Sonnen (1965) reported that a number of investigators have found that zinc in freshwater streams rapidly associates with suspended sediment. The settling of sediment particles effectively removes metals from solution. Many other studies (Duursma and Gross, 1971; Cross et al., 1970; Duke et al., 1966; Pomeroy et al., 1966; Jennings and Osterberg, 1969) have shown that many of the trace metals present in estuarine systems are associated with sediments.

Heavy metals may be removed from solution by several possible mechanisms--precipitation, adsorption to sediment particles or to particulates in the water, and absorption by marine organisms. Krauskopf (1956) calculated that an increase of one pH unit would reduce the solubility of simple, divalent metal carbonates by a factor of 10 and that of divalent metal hydroxides by a factor of 100. By surveying tabulated solubilities, he concluded that the solubility of only a very few unusual metal salts would change by a factor of 100 for a temperature change of 100°C. Neither of these factors nor changes in pressure would alter equilibria sufficiently to account for the observed concentrations of metals in sediment and water. Krauskopf also found that the measured equilibrium concentrations of metals in aerated seawater were of the same order of magnitude as the calculated concentrations, although they exceeded the observed seawater levels considerably.

In local areas of abundant organic matter, anaerobic conditions under which sulfides are produced often prevail. Most metal sulfides are highly insoluble compounds. In addition, strong

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reducing agents can change the valence state of metals, resulting in other precipitation reactions. Calculations and experimental determinations of the solubilities of sulfide precipitates in seawater were made under conditions approximating those of a very stagnant Norwegian fjord (pH about 7 and hydrogen sulfide about 0.005 M). Under these conditions, Krauskopf (1956) found that zinc decreased to a concentration comparable to that in nature, but copper, lead, and mercury became undetectable. He suggested that, if cadmium were present, it also would have become undetectable. Krauskopf did not conclude, however, that the formation of insoluble sulfides was a major factor controlling the amount of metals in water because the concentration of the metals studied was not related to the solubilities of their sulfides. Presley and coworkers (1972) found that waters abundant in dissolved sulfides often were laden also with dissolved metal ions, thus supporting Krauskopf's hypothesis.

In studies on metal adsorbents, Krauskopf (1956) found that excess copper, lead, and zinc strongly adsorbed to all adsorbents tested, except plankton, within a few hours, thereby reducing the concentration of these metals to levels normally found in seawater. Mercury showed a strong affinity to clay and organic matter; however, it reached equilibrium slowly. He concluded that adsorption processes are probably the most important controls of metal concentrations.

In a study of the adsorption of mercury (II), MacNaughton (1973) concluded that adsorption was often a major process controlling mercury concentrations in fresh and salt water. The mechanism of zinc adsorption depends primarily on the size of suspended particles. Sand and silt particles generally adsorb zinc physically; clay particles have a large capacity for cation exchange, although some secondary adsorption also may occur on clay surfaces (Robinson, 1962). According to Andelman (1973), the sorption of trace elements onto surfaces can occur without ion exchange as a result of coulombic interactions with the surface in its electric double layer. Most particles of water are negatively charged, and trace cations can be held at the negatively charged surface of colloidal or particulate mineral or other material.

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Horne (1969) considered ion exchange at the sediment-water interface to be the most important mechanism for chemical control. Many other investigators (Cress et al., 1970; Halcrow et al., 1973; Smith et al., 1973; McCulloch et al., 1971; Peterson et al., 1972) found greater levels of metals associated with finer-grained sediments than with coarser sediments, which suggests a mechanism of ion exchange. However, Turekian and Scott (1967) found no significant differences in the trace elements associated with sediments of different size fractions. In a review, Battelle Laboratories (1974) cite several studies in which ion exchange appeared insignificant. However, the Battelle report suggested that, although ion exchange might be responsible for binding only a small fraction of the total amount of metal present, the amount may be important because of its relative ease of removal.

Factors that have been shown to affect the extent of heavy-metal adsorption are pH, salinity, temperature, pressure, sediment type, the presence or absence of organic compounds, time, and the concentration of metal cations relative to the concentration of nonmetallic anions.

Preliminary studies by the Battelle Laboratories (1974) indicated that only a small fraction of copper and cadmium are desorbed from sediments, and lead and mercury do not undergo desorption. Copper desorption was greatest at high Eh, high temperature, and low salinity. Cadmium desorption was greatest at high Eh, high temperature, and (unlike copper) at high salinity. The Battelle study suggested that the factors of greatest probable effect on adsorption and desorption of heavy metals are salinity, Eh, time, sediment-to-solution ratio, and sediment metal content. Factors of least importance would include water and sediment pH, bottom water and sediment temperature, and initial heavy metal concentrations in solution. Battelle currently is conducting studies on the effects of the five important factors on sorption and desorption of heavy metals.

MacNaughton (1973) considered the factors most affecting mercury adsorption to be pH, chloride concentration, organic content of the solid adsorbent, and--to a lesser extent--the solid substrate and contact time. Robinson (in Sonnen, 1965) calculated

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that exchange capacity would vary logarithmically with hydrogen ion concentration, the concentration of the cation to be exchanged, and the valence of the cation. Robinson's results indicated that, between pH 5.0 and 8.0, increased acidity would cause a corresponding decrease in exchange capacity. Backmann (1963) predicted that a decrease in pH would result in a decrease in adsorption of zinc by ion exchange. Below pH 2.5, mercury (II) is weakly adsorbed, but adsorption abruptly increases above this pH and reaches a maximum at pH 4 to 6 (MacNaughton, 1973). MacNaughton also found chloride to be the only anion common to natural waters that interferes significantly with the adsorption of mercury (II). Sonnen (1965) conducted laboratory studies that demonstrated that a saline environment favors the desorption of zinc from suspended sediment. He concluded that zinc, adsorbed to sediments washed into the estuary from freshwater areas, would be released into solution if sufficient mixing of fresh and salt water occurred in an estuary. Such releases would become significant when the concentration of salts in the mixture reached 5% of the salinity of pure seawater. Sonnen also concluded that significant amounts of zinc would be released even if the two types of water remained stratified because of differences in density.

Trace metals tend to interact with organic compounds, especially through the mechanisms of complex and chelate formation (Andelman, 1973). MacNaughton (1973) reported that suspended or deposited sediments composed primarily of organic detritus or containing adsorbed organics strongly adsorb mercury. The degree of adsorption was unaffected by chloride, and desorption occurred only when the organic material was destroyed or desorbed. MacNaughton used relatively high amounts of organic materials in his experiments--more than is usually present in fresh or salt water--and he cautioned that his results may have been somewhat exaggerated. Nevertheless, the results do indicate that bound mercury and, probably, other metals might be incorporated into the estuarine sediments if suspended material carried by a river were deposited in an estuary. Duke and Rice (1967) reported that EDTA reduced the availability of radiozinc to an experimental biological community in laboratory experiments. In contrast to the findings of Andelman, MacNaughton, and Duke and Rice, several studies cited in the Battelle report (1974) indicated that organic binding is an insignificant binding

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mechanism. Stumm and Balinski (in Battelle Northwest Laboratories, 1974) found many organic ligands to which heavy metals might bind in natural waters, the functional groups of these ligands showing little specificity toward individual metal ions; in the presence of magnesium and calcium ions, which are much more abundant in natural water than trace metals, the ligands tended to bind with the more abundant divalent ions.

The degree of heavy-metal adsorption to the sediment also has been shown to be related to sediment type. MacNaughton (1973) found that freshly precipitated ferric hydroxide had the strongest affinity for mercury (II), whereas manganese oxide, goethite, and kaolinite displayed slightly weaker bonding. Quartz, alumina, and montmorillonite adsorbed mercury by almost an order of magnitude less than other solids per unit area and with the same equilibrium metal ion concentration.

Robinson (1962) reported that the composition of clay was one of the major factors influencing cation exchange equilibria. The attraction of a cation in solution to the ionic constituents of clay was apparently strongest in those ions in corner positions of the lattice structure, next strongest in the ions on the edges, then in those on the plane surfaces. He stated that the accessibility of these three sites can affect the exchange capacity of a single clay or can be an important factor in accounting for differences in the exchange capacities of different clays.

Certain substances may obstruct or clog the exchange sites. Dion (1944) found that ferric oxide, in both the hydrated and non-hydrated forms, exhibits a clogging effect on clay minerals. Hendricks (1941) proposed that some organic ions adsorbed on the basal surfaces of montmorillonite may obstruct the exchange positions.

Most investigators have found that increasing the concentration of a particular cation in the solution increases its replacing power in relation to the exchange equilibrium (Sonnen, 1965). Krauskopf (1956) reported observing a lower percentage of mercury adsorbed to iron oxide or apatite at higher initial mercury concentrations, and Sonnen found that the release of adsorbed zinc

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from suspended sediment was greatest when the initial amount of ionic zinc was highest.

Investigators disagree about the effects of different anions on cation exchange capacity. Nezyaka reported in a personal communication to Grim (1953) that he found a difference in the replaceability of sodium and calcium ions in montmorillonite that depended on whether calcium hydroxide or sulfate was used. Elgabaly and Jenny (1943) suggested, however, that the formation of basic salts with the clay and a soluble anion, such as clay-Zn(OH)^+ , complicates the question of whether a portion of the effect is the result of a pH shift. Other investigators have found anions to have little, if any, influence on cation exchange.

Not all heavy metals in sediments are exchanged rapidly in water. Some may occupy a position within the crystalline lattice. By using different extraction procedures, several investigators found large amounts of metals in the lattice structure of clay. Chester and Hughes (1969) found that most of the copper (72%) and lead (86%) in sediments analyzed were of lithogenous origin (derived from weathering of land). Hirst (1962) also arrived at similar results. Elgabaly and Jenny (1943) reported that zinc also may occupy spaces in the lattice structure of clays, and Presley and associates (1972) found 61% of the zinc and 43% of the copper in their sediment samples to be of lithogenous origin.

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APPENDIX A
DISTRIBUTION AND ABUNDANCE OF TAXA

CONTENTS

A	DISTRIBUTION AND ABUNDANCE OF TAXA	
B	PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER	
C	PHYSICAL AND CHEMICAL CHARACTERISTICS OF SEDIMENT	
	Temperature, Sulfides, Salinity, pH, and	
	Sample Volume	C-1
	Cumulated Sediment Grain-Size Characterization	C-29
	Categorical Sediment Grain-Size Characterization . . .	C-53
	Heavy-Metal Concentration	C-77

STATION MIS-A

PRELIMINARY SURVEY

TAXA	SAMPLE NO.			NO. OF SPECIES	SPECIMENS TAXA
	1	2	3		
NEMATODA				7	7
NEMATODA-UNIDENTIFIED SPP.	6	--	1	--	
ANNELIDA-OLIGOCHAETA				9	9
OLIGOCHAETA-UNIDENTIFIED SPP.	9	--	--	--	
ARTHROPODA				130	95
COPEPODA-UNIDENTIFIED SPP.	92	--	3	--	1
OSTRACODA-UNIDENTIFIED SPP.	--	1	--	--	1
BALANUS CREMATUS	--	1	--	--	1
MYSIDACEA-UNIDENTIFIED SPP.	3	--	--	--	3
MOLLUSCA				14	11
MACOMA BALTHICA	2	--	--	9	1
MACOMA SP. CF NASUTA	--	--	1	--	1
MYA ARENARIA	--	--	4	--	4
ECTOPROCTA				0	0
CHEILOSTOMATA-UNIDENTIFIED SPP.	P	P	--	--	P
MEMBRANIPORA PERFRACILIS	--	P	P	--	P

MIS-A
Survey P

GRAND TOTALS	11	112	2	9	3	132	132

MIS-B
Survey P

STATION MIS-B
PRELIMINARY SURVEY

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3	4		
NEMATODA					7	7
NEMATODA-UNIDENTIFIED SPP.	4	--	--	3		
ANNELIDA-OLIGOCHAETA					232	232
OLIGOCHAETA-UNIDENTIFIED SPP.	51	24	23	134		
ANNELIDA-POLYCHAETA					5	5
STREBLOSPIO BENEDICTI	--	--	1	4		
ARTHROPODA					19	13
COPEPODA-UNIDENTIFIED SPP.	7	1	1	4		
HYSIDACEA-UNIDENTIFIED SPP.	--	1	--	--		1
AMPELISCA MILLERI	--	--	--	3		3
AMPHIPODA-UNIDENTIFIED SPP.	--	--	--	1		1
INSECTA-UNIDENTIFIED SPP.	1	--	--	--		1
MOLLUSCA					89	20
MYA ARENARIA	3	1	1	15		63
MACOMA BALTHICA	3	4	2	54		6
NASSARIUS OBSOLETUS	--	--	2	4		
ECTOPROCTA					P	P
MEMBRANIPORA PERFRAGILIS	--	--	--	P		
GRAND TOTALS	12	69	31	30	222	352

CS-A
Survey P

STATION CS-A

PRELIMINARY SURVEY

TAXA	SAMPLE NO.					NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3	4	5		
CNIDARIA HYDROA-UNIDENTIFIED SPP.	--	P	--	--	--	P	P
NEMATODA NEMATODA-UNIDENTIFIED SPP.	--	9	--	--	--	9	9
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	--	44	--	1	9	53	53
ANNELIDA-POLYCHAETA HETEROMASTUS FILIFORMIS STREBLOSPIO BENEDICTI ETEONE LIGHTI	--	1 5 1	-- 1 --	-- -- --	-- 1 --	9	1 7 1
ARTHROPODA MYSIDACEA-UNIDENTIFIED SPP. SYNDUTEA LATICAUDA	--	1 --	-- --	-- --	-- 1	2	1 1
MOLLUSCA NASSARIUS OBSOLETUS MYA ARENARIA MACOMA BALTHICA MYTILUS EDULIS - JUVENILE TAPES JAPONICA	6 12 8 1 --	6 21 12 -- 2	7 1 3 -- --	3 -- 6 -- --	19 5 7 -- --	119	41 30 36 1 2
ECTOPROCTA MEMBRANIPURA PERFRAGILIS CHEILOSTOMATA-UNIDENTIFIED SP. A CHEILOSTOMATA-UNIDENTIFIED SP. B	P -- --	P -- --	-- P P	-- -- --	-- -- --	9	P P P
GRAND TOTALS	27	102	12	10	41	192	192

CS-B
Survey P

STATION CS-B		PRELIMINARY SURVEY					NUMBER OF GROUP	SPECIMENS TAXA
TAXA		1	2	3	4	5		
PORIFERA PORIFERA-UNIDENTIFIED SPP.	--	P	--	--	--	--	P	P
NEMERTEZ NEMERTEA-UNIDENTIFIED SPP.	1	--	--	--	--	--	1	1
NEMATODA NEMATODA-UNIDENTIFIED SPP.	1	--	--	--	1	--	2	2
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	--	2	--	--	--	--	2	2
ANNELIDA-POLYCHAETA ASYCHIS SP. STREBLOSPIID BENEDICTI HETEROMASTUS FILIFORMIS NEANTHES SACCINEA - JUVENILE	5 4 -- --	-- 2 -- --	-- -- -- --	-- -- -- --	-- -- -- --	-- 2 1 1	15	5 8 1 1 1
ARTHROPODA COPEPODA-UNIDENTIFIED SPP. CAMBRIDAE-UNIDENTIFIED JUVENILE	2 --	-- --	-- --	-- --	-- --	-- 1	3	2 1 1
MOLLUSCA MYA ARENARIA MUSCULUS SENHOUZIA MYTILUS EDULIS	1 5 --	-- 1 3	1 -- --	-- -- --	-- -- --	-- -- --	11	2 6 3
ECTOPROCTA MEMBRANIPORA PERFRAGILIS CHEILOSTOMATA-UNIDENTIFIED SPP.	P --	P P	-- --	-- --	P P	P --	P	P P
GRAND TOTALS	15	19	8	1	1	1	34	34

ALC
Survey P

STATION ALC
PRELIMINARY SURVEY

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
ANNELIDA-POLYCHAETA					
GLYCERA OXYCEPHALA	1	2	--	6	3
GLYCINDE SP.	--	--	3		3
MOLLUSCA					
MACOMA NASUTA	--	--	3	3	3
ECTOPROCTA					
CHEILOSTOMATA-UNIDENTIFIED SPP.	P	--	--	P	P
CELLARIA-MANDIBULATA	--	P	--		P
SCRUPOCCELLARIA SP.	--	--	P		P
TRICELLARIA SP., ? OCCIDENTALIS	--	--	P		P
GRAND TOTALS	7	2	6	7	9

OIH
Survey P

STATION OIH
PRELIMINARY SURVEY

TAXA	SAMPLE NO.						NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3	4	5	6		
PORIFERA								
KERATOSA-UNIDENTIFIED SPP.	--	--	--	P	P		P	P
Cnidaria							3	2
PENNATULACEA-UNIDENTIFIED SPP.	--	--	--	1	1			1
CF DIADUMENE SP.	--	--	--	--	1			P
CALYPTORHASTEA-UNIDENTIFIED SPP.	--	--	--	P	--			P
CNIDARIA-UNIDENTIFIED SPP.	--	--	--	--	P			
NEMERTEA							24	24
NEMERTEA-UNIDENTIFIED SPP.	--	2	5	11	6			
NEMATODA							306	306
NEMATODA-UNIDENTIFIED SPP.	73	148	6	23	56			
ANNELIDA-OLIGOCHAETA							4886	4886
OLIGOCHAETA-UNIDENTIFIED SPP.	645	806	1370	1376	689			
ANNELIDA-POLYCHAETA							13323	3
HETEROMASTUS FILIFORMIS	1	--	2	--	--			12
MEDIOASTUS CALIFORNIENSIS	7	--	4	--	1			35
HAPLOSCOPLOS PUGETIENSIS	1	2	14	10	8			34
PECTINARIA CALIFORNIENSIS	7	5	5	8	9			4
POLYDORA LIGNI	1	2	1	--	--			64
PSEUDOPOLYDORA PAUCIBRANCHIATA	8	6	23	24	3			36
SCOLELEPSIS SQUAMATA	1	1	6	5	23			10715
STREBLOSPIO BENEDICTI	675	1886	2994	3101	2059			2
GLYCERA AMERICANA	1	--	--	--	1			50
GLYCINDE SP.	11	6	16	9	8			53
NEPHTYS CAECIOIDES	10	3	10	16	14			23
PHOLOE MINUTA	3	2	1	12	5			1971
EXOGONE LOUREI	293	325	653	440	260			102
SPHAEROSYLLIS SP.	33	17	80	42	20			30
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	4	5	17	4			30
NEPHTYS CORNUTA FRANCISCANA	--	1	1	2	26			30

OIH
Survey P

STATION OIM PRELIMINARY SURVEY (CONT.)

TAXA	SAMPLE NO.			SPECIMENS		
	1	2	3	4	5	TAXA
NEPHYS PARVA	---	1	---	---	---	1
ETEONE LONGA CALIFORNICA	---	5	---	---	---	16
CAPITELLA CAPITATA	---	---	4	1	1	12
THARYX SP.	---	---	6	6	---	2
MYRIOCHELE SP., NEAR GRACILIS	---	---	2	---	---	2
TROCHOCHELE SP., NEAR GRACILIS	---	---	3	1	1	5
CIRRAFULUS CIRRAFUS	---	---	---	5	---	5
THARYX SP., CF. PARVUS	---	---	---	4	---	5
SCHISTOMERINGOS LONGICORNIS	---	---	---	3	2	5
SCHISTOMERINGOS SP., CF. LONGICORNIS	---	---	---	1	---	1
GLYCERA SP., NEAR RUBUSTA	---	---	---	1	---	1
ETEONE DILATAE	---	---	---	1	---	1
HARMOTHOE IMBRICATA	---	---	---	1	---	1
CHAETZONE SP.	---	---	---	1	---	1
ASYCHIS SP.	---	---	---	1	---	1
HARMOTHOE SP., CF. IMBRICATA	---	---	---	1	---	1
NEPHYS SP., CF. CURNUTA FRANCISCANA	---	1	---	---	---	1
PHYLLUDOCIDAE-UNIDENTIFIED SPP.	---	---	---	1	---	1
POLYDORA SOCIALIS	---	---	---	3	---	3
MEDIONASTUS CALIFORNIENSIS - JUVENILE	---	---	---	---	1	1
ETEONE LONGA CALIFORNICA - JUVENILE	---	---	---	---	1	1
GLYCINUS SP. - JUVENILE	---	---	---	---	1	1
NEPHYS CAECIDIUS - JUVENILE	---	---	---	---	1	1
ARTHROPODA						
OSTRACODA-UNIDENTIFIED SPP.	19	7	136	70	---	234
CUMACEA-UNIDENTIFIED SP. A	2	---	3	5	3	13
CUMACEA-UNIDENTIFIED SP. B	2	---	1	5	---	8
AMPELISCA MILLERI	3	6	10	12	1	12
LEPTOCHELIA DUBIA	1	---	7	---	---	9
CRANGON SP.	---	---	1	1	---	1
AMPHIPODA-UNIDENTIFIED SPP.	---	---	---	1	---	1
PHOTIS CALIFORNICA	---	---	---	1	---	1
PINNIXA FRANCISCANA	---	---	---	2	1	2
LECTYORHYNCHUS MARGINATUS	---	---	---	---	3	3
CUMACEA-UNIDENTIFIED SPP.	---	---	---	---	1	1
PYROMAIA TUBERCULATA	---	---	---	---	---	1
LUDORELLA PACIFICA	1	---	1	---	---	2
BRACHYURUS-UNIDENTIFIED LARVA	---	---	1	---	---	1
MOLLUSCA						
MACOMA ACULASTA	1	---	---	---	---	1
MACOMA INGUINATA	1	---	---	2	---	1
MACOMA NASUTA	25	22	24	34	22	110

OIH
Survey P

STATION OIH PRELIMINARY SURVEY (CONT.)

TAXA	SAMPLE NO.					NUMBER OF GROUP	SPECIMENS
	1	2	3	4	5		TAXA
TELLINA MODESTA	1	1	1	1	1		2
TAPEA JAPONICA	1	1	1	1	1		2
GEMMA GEMMA	512	322	562	369	312		2075
TRANSENNELLA TANTILLA	2	3	5	5	2		12
MYSELLA FERRUGINOSA	1	2	2	4	2		11
MUSCULUS SENHOSIA	16	3	17	5	4		45
SILICUA PATULA	1	1	1	1	1		1
MACOMA BALTHICA - JUVENILE	1	1	1	2	1		2
SILICUA SLUATI	1	1	1	1	1		2
ADULA DIEGENSIS	1	1	1	1	1		1
MYTILUS EDULIS	1	1	1	1	1		3
PELECYPUDA-UNIDENTIFIED SPP.	1	1	1	1	1		1
ODOSTOMIA (EVALEA) SP. CF TENUSCULPTA	1	1	1	1	1		1
ECTOPROCTA						P	P
HIPPOTHOA HYALINA				P			P
MEMBRANIPORA PEXFRAGILIS				P			P
FILICRISIA OFICULATA				P			P
ENIGMATIC						2	2
GRAND TOTALS	81	230	291	565	3564	21153	21153

HP
Survey P

STATION HP

PRELIMINARY SURVEY

TAXA	SAMPLE NO.					NUMBER OF SPP.	SPECIMENS TAXA
	1	2	3	4	5		
CNIDARIA							
CF DIADUMENE SP.	5	--	22	--	5	64	32
CF HALIPLANELLA SP.	3	2	1	12	14		32
HYDROZOA-UNIDENTIFIED SPP.	--	P	P	--	--		P
GONOTHYRAEA SP.	--	P	--	--	--		P
CALYPTOBALASTEA-UNIDENTIFIED SPP.	--	--	P	--	--		P
NEMERTEA							
NEMERTEA-UNIDENTIFIED SPP.	7	4	13	16	7	47	47
NEMATODA							
NEMATODA-UNIDENTIFIED SPP.	3	8	2	--	--	13	13
ANNELIDA-OLIGOCHAETA							
OLIGOCHAETA-UNIDENTIFIED SPP.	1	8	4	--	1	14	14
ANNELIDA-POLYCHAETA							
CAPITELLIDAE-UNIDENTIFIED SPP.	1	--	--	--	--	1773	1
MEDIOMASTUS CALIFURNIENSIS	29	80	91	2	55		247
THARYX SP., CF. PARVUS	1	4	--	--	--		5
ASYCHIS SP.	4	4	3	--	4		15
POLYDORA SOCIALIS	1	--	2	2	--		6
STREBLUSPIO BENEICTI	1	9	3	--	--		13
SCHISTONEKINGOS LONGICORNIS	2	--	--	--	--		2
NEPHIYS CORNUA FRANCISCANA	1	--	1	--	1		3
EXOGONE LOUREI	65	291	489	--	153		1414
POLYCHAETA-UNIDENTIFIED JUVENILE	--	3	--	--	--		3
CAPITELLA CAPITATA	--	10	1	--	7		15
CIRRATULUS CIRRIATUS	--	2	5	--	2		6
THARYX PARVUS	--	2	--	--	1		3
COSSURA PYGODACTYLATA	--	2	3	--	--		5
LANGERHANIA SP.	--	1	--	--	--		1
MEDIOMASTUS SP., CF. CALIFURNIENSIS	--	32	--	--	--		32
THARYX SP.	--	--	1	--	--		1
SPHAGROSYLLIS SP.	--	--	2	--	--		2
GLYCERA AMERICANA	--	--	--	1	--		1

HP
Survey P

STATION HP PRELIMINARY SURVEY (CONT.)

TAXA

		SAMPLE NO.					NUMBER OF GROUP	SPECIMENS TAXA
		1	2	3	4	5		
ANATIDES SP., CF WILLIAMS - JUVENILE								
METEROMASTUS FILIFORMIS		--	--	--	1	--		1
ARMANDIA BREVIS		--	--	--	--	2		2
CYPTIS BREVIPALPA		--	--	--	--	1		1
CIRATULUS CIRATUS - JUVENILE		--	1	--	--	1		1
SCHISTOMERINOS LONGICORNIS - JUVENILE		--	1	--	--	--		1
METEROMASTUS FILIFORMIS - JUVENILE		--	--	--	--	1		1
? THARYX SP. - JUVENILE		--	--	--	--	1		1
STIPUNCULA								
STIPUNCULA-UNIDENTIFIED SPP.		--	--	--	1	--	1	1
ARTHROPODA								
COEPLIUM SP. - JUVENILE		1	--	--	--	--	1165	1
AMPELISCA MILLERI		130	180	412	248	124		1094
LEPTOMELIA DUBIA		5	6	20	13	7		51
PYROMATA TUBERCULATA		6	1	8	--	--		15
OSTRACODA-UNIDENTIFIED SPP.		--	1	--	--	--		1
UPOGEBIA SP.		--	1	--	--	--		1
CUMACEA-UNIDENTIFIED S. B		--	--	1	--	--		1
EUODONELLA PACIFICA		--	--	1	--	--		1
MOLLUSCA								
GENNA GENNA		--	1	3	--	--	26	4
TRANSMELLA TANTILLA		--	5	1	5	1		12
MUSCULUS SENHOUTIA		--	2	--	--	3		5
MACOMA ACON/STA		--	--	1	--	--		1
ADULA DIEGENEYS		--	--	1	--	--		1
MYA ARENARIA		--	--	--	2	--		1
MYSELLA FERRUGINOSA		--	--	--	--	1		1
ECTOPROCTA								
BOMERBANKIA GRACILIS		--	P	--	--	--	P	P
CYCLOSTOMATA-UNIDENTIFIED SPP.		--	--	P	--	--		P
SCRUPOCELLARIA SP.		--	--	--	--	P		P
BUGULA SP.		--	--	--	--	P		P
ECHINODERMATA								
HOLOTHURIDEA-UNIDENTIFIED SPP.		1	2	--	--	1	4	4
PHORONIDA								
PHORONIS SP.		1	--	--	--	--	1	1
GRAND TOTALS								
	57	268	631	1513	303	396	3111	3111

STATION SB-A

PRELIMINARY SURVEY

TAXA	1	2	3	4	NUMBER OF SPECIMENS	TAXA
CNIDARIA						
GONUTHYRAEA SP.	--	P	P	--	5	P
CF DIADUMENE SP.	--	--	3	--		3
CF HALIPLANELLA SP.	--	--	2	1		3
CALYPTOBLASTEIA-UNIDENTIFIED SPP.	P	--	--	P		P
CNIDARIA-UNIDENTIFIED SPP.	--	P	P	--		P
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	2	1	2	17	22	22
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	--	164	94	12	275	275
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	--	60	31	35	132	132
ANNELIDA-POLYCHAETA						
PSEUDOPOLYDORA PAUCIBRANCHIATA	--	--	1	1	504	2
POLYDORIDAE-UNIDENTIFIED JUVENILE	1	--	--	--		1
HETEROMASTUS FILIFORMIS	17	60	67	15		150
HETEROMASTUS CALIFORNIENSIS	11	--	--	--		11
COSSURA PYGODACTYLATA	3	9	14	4		30
ASYCHIS SP.	3	4	6	7		20
POLYDORA BRACHYCEPHALA	9	--	--	11		20
POLYDORA SP. NEAR SOCIALIS	1	--	--	--		1
EXOGONE LOUREI	54	31	43	60		274
SPHAERUSYLLIS SP.	1	--	--	--		1
CIARRATULUS CIARRATUS	--	6	3	--		3
HAPLJSCULOPUS PUGETTENSIS	--	4	3	--		7
GLYCINDE SP.	--	1	--	--		1
CIRRIFORMIA SPIKABRANCHIA	--	--	1	--		1
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	--	2	4		1
SCHISTOMERINGUS LONGICORNIS	--	--	6	--		7
STREBLUSPIO BENEDICTI	--	--	--	4		6

SB-A
Survey P

STATION SB-A ELIMINARY SURVEY (CONT.)

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3	4		
ARTHROPODA					219	154
AMELISCA MILLERI	37	--	2	115		2
LEPTOCHELIA DUBIA	--	1	1	--		50
OSTRACODA-UNIDENTIFIED SPP.	--	--	6	44		13
CURONPIUM ACHERUSICUM	--	--	--	13		
MOLLUSCA					318	113
TAPES JAPONICA	14	52	30	17		200
MUSCULUS SEMHOUSIA	22	104	49	25		2
UROSAIPINK CINEREA	--	2	--	--		1
ISELICA OVOIDEA	--	1	--	--		1
ADULA DIEGENSIS	--	1	1	--		1
MACOMA NASUTA	--	--	--	--		1
ECTOPROCTA					P	P
MEMBRANIPORA PERFRAGILIS	--	--	P	--		
CHORDATA					5	4
ASCIDIACEA-UNIDENTIFIED SPP.	--	1	3	--		1
STYELA SP.	--	--	1	--		
ENIGHATICA					1	1
ENIGHATICA	1	--	--	--		
GRAND TOTALS	177	513	411	385	1486	1486

PRELIMINARY SURVEY

A-13

SB-B
Survey P

STATION SB-B PRELIMINARY SURVEY (CONT.)

TAXA	SAMPLE NO.					NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3	4	5		
ARTHROPODA						448	
OSTRACODA-UNIDENTIFIED SPP.	11	--	11	--	--		22
COROPHIUM ACHERUSICUM	39	1	75	39	4		158
GRANDIERELLA JAPONICA	1	3	1	1	1		7
AMPELISCA MILLERI	35	22	55	24	116		252
SYNDOTEA LATICAUDA	--	1	--	--	--		1
CUMACEA-UNIDENTIFIED SPP. A	--	--	1	--	--		1
COROPHIUM INSIDIOSUM	--	--	5	--	--		5
INSECTA-UNIDENTIFIED LARVA	--	--	--	1	--		1
SYNDOTEA LATICAUDA - JUVENILE	--	--	--	1	--		1
MOLLUSCA						142	
MUSCULUS SENHOUZIA	34	32	14	13	6		99
TAPES JAPONICA	1	1	--	2	2		6
GEMMA GEMMA	2	1	1	8	2		14
CREPIDULA CONVEXA - JUVENILE	--	--	2	--	--		2
MACOMA NASUTA	--	--	--	1	--		1
ODOSTOMIA (EVALEA) SP.	9	--	--	--	--		9
ODOSTOMIA (EVALEA) FRANKISCANA	1	--	--	--	--		1
ODOSTOMIA (MENESTHO) FETELLA	1	--	--	--	--		1
UROSALEPINX CINEREA	1	--	--	--	--		1
MASSARIUS ORSOLETUS	7	--	--	--	--		7
? OSTREA LURIDA - JUVENILE	--	--	--	--	1		1
ECTOPROCTA						P	P
SMITTOIDEA PROLIFICA	--	--	--	P	--		
CHORDATA						1	1
ASCIDIACEA-UNIDENTIFIED SPP.	--	1	--	--	--		
ENIGMATICA						1	1
ENIGMATICA	--	--	1	--	--		
GRAND TOTALS	165	608	728	478	786	2765	2765

RCH-A
Survey P

STATION RCH-A									
PRELIMINARY SURVEY									
TAXA	SAMPLE NO.						NUMBER OF COUP	SPECIMENS OF	TAXA
	1	2	3	4	5	6			
CNIDARIA							24		15
CF DIANUMENE SP.	1	3	4	7	--				3
CF HALIPLANELLA SP.	1	2	--	6	--				p
GONOTHYRAEA SP.	p	p	--	p	p				
PLATYHELMINTHES							1		1
? ACOELA-UNIDENTIFIED SPP.	--	--	--	--	1				
NEMERTEA							21		21
NEMERTEA-UNIDENTIFIED SPP.	--	7	4	3	2				
NEMATODA							53		53
NEMATODA-UNIDENTIFIED SPP.	12	11	1	13	21				
ANNELIDA-OLIGOCHAETA							79		79
OLIGOCHAETA-UNIDENTIFIED SPP.	21	20	--	23	14				
ANNELIDA-POLYCHAETA							394		p
CAPITELLA CAPITATA	7	--	--	--	1				23
HETEROMASTUS FILIFORMIS	5	6	7	5	--				1
HETEROMASTUS SP. - JUVENILE	1	--	--	--	--				52
COSSURA PYGODACTYLATA	1	10	3	21	11				92
PSEUDOPOLYDORA PAUCIBRANCHIATA	15	19	--	48	13				1
SCHISTOMERINUS LONGICORNIS	1	--	--	--	--				177
EXOGRONE LOUREI	46	13	5	96	17				2
HAPLOSCOLOPLUS PUGETTENSIS	--	1	--	1	--				1
MARPHISA SANGUINEA	--	1	1	--	1				2
GLYCINDE SP.	--	--	--	12	5				14
ASYCHIS SP.	--	2	--	--	--				1
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	--	--	1	--				1
NEPHTYS CAECIOIDES	--	--	--	1	--				1
SPHAEROSYLLIS SP.	--	--	--	--	2				2
ODORVILLELLIDAE-UNIDENTIFIED SPP.	--	1	--	--	--				1
CF THARYX	--	--	1	--	--				1

RCH-A
Survey P

STATION RCH-A PRELIMINARY SURVEY (CONT.)

TAXA	SAMPLE NO.					NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3	4	5		
ARTHROPODA						351	
COROPHEUM INSIDIOSUM	1	1	--	1	--		3
ARPELISCA MILLERI	45	49	50	181	14		339
PYROMAIA TUBERCULATA	1	--	--	--	--		1
OSTRACODA-UNIDENTIFIED SPP.	--	4	--	2	--		6
LEPTOCHELIA DUBIA	--	--	1	--	--		1
COROPHEUM ACHERUSICUM	--	--	--	1	--		1
MOLLUSCA						35	
EPITONIUM TINCTUM	1	--	--	--	--		1
UKOSALPINX CINEREA	5	--	--	--	--		5
NASSARIUS OBSOLETUS	2	--	--	--	--		2
ODOSTOMIA (NEMESTHO) FETELLA	2	--	--	--	--		2
MYA ARENARIA	1	--	--	--	--		1
TAPES JAPONICA	12	7	21	18	15		73
GEMMA GEMMA	1	--	--	--	--		1
MUSCULUS SENHOSIA	80	52	125	122	35		414
MACOMA NASUTA	--	1	1	2	--		4
MACOMA BALTHICA	--	--	1	--	--		1
ODOSTOMIA (EVALEA) SP. CF VALDEZI	1	--	--	--	--		1
CHORDATA						2	
ASCIDIACEA-UNIDENTIFIED SPP.	1	1	--	--	--		2
ENIGMATICA						1	
ENIGMATICA	--	1	--	--	--		1
GRAND TOTALS	42	270	212	225	149	1425	1425

STATION RCH-B

PRELIMINARY SURVEY

TAXA	SAMPLE NO.					NUMBER OF SPECIMENS	SPECIMENS TAXA
	1	2	3	4	5		
CNIDARIA							
HYDROZUA-UNIDENTIFIED SPP.	P	--	--	--	--	37	P
CF DIADUMENE SP.	24	--	--	32	0		02
CF HALIPLANELLA SP.	8	1	--	1	10		PC
GUNOTHYRAEA SP.	--	P	--	P	P		P
CALYPTOBLASTEIA-UNIDENTIFIED SPP.	P	--	P	P	--		P
NEMERTEA							
NEMERTEA-UNIDENTIFIED SPP.	14	6	--	5	6	32	32
NEMATODA							
NEMATODA-UNIDENTIFIED SPP.	98	1	--	4	21	114	114
ANNELIDA-OLIGOCHAETA							
OLIGOCHAETA-UNIDENTIFIED SPP.	135	26	--	54	47	322	322
ANNELIDA-POLYCHAETA							
HETEROMASTUS FILIFORMIS	80	57	74	52	70	350	334
COSSURA PYGODACTYLATA	11	7	--	--	5		29
COSSURA SP., CF PYGODACTYLATA	1	--	--	--	--		1
ASYCHIS SP.	2	30	--	4	12		52
HAPLOSCULOPUS PUGETENSIS	3	--	2	--	--		5
POLYDORA SOCIALIS	1	--	--	--	--		1
PSEUDOPOLYDORA KEMPI CALIFORNICA	4	5	1	3	1		14
? PSEUDOPOLYDORA SP.	1	--	--	--	--		1
STREBLOSPID BENEDICTI	2	1	--	--	--		3
SCISTODERINUS LONGICORNIS	4	--	4	--	--		4
GLYCINDE SP.	1	--	--	1	--		2
HARMUTHUE IMBRICATA	1	--	1	--	--		2
EXOGENE LUJUEI	192	34	--	32	64		350
SPHAEROSYLIS SP.	1	--	--	--	5		7
POLYDORA BRACHYCEPHALA	--	9	--	1	--		9
POLYDORA SOCIALIS	--	3	--	--	3		6
PSEUDOPOLYDORA PAULIBRANCHIATA	--	1	1	7	3		12
CIRPATULUS CIRRATUS	--	--	1	--	--		2
CIRPATULUS SPIRABRANCHIA	--	--	1	--	--		1

RCH-B
Survey P

STATION RCN-8 PRELIMINARY SURVEY (CONT.)

RCH-B
Survey P

TAXA	SAMPLE NO.					NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3	4	5		
POLYDORA SP., NEAR SOCIALIS	--	--	1	--	--		1
CHAETOLONE SP.	--	--	--	--	--		1
SCHISTOMERINGS LONGICORNIS - JUVENILE	--	--	--	--	2		2
HETERONASTUS FILIFORMIS - JUVENILE	1	--	--	--	--		1
CIPRATIUS CIRRATUS - JUVENILE	--	1	--	--	1		2
SCHISTOMERINGS SP., NEAR LONGICORNIS	--	--	--	7	--		7
NEPHYS SP., NEAR CAECIDIES	--	--	--	1	--		1
SIFUNCULA						1	1
SIFUNCULA-UNIDENTIFIED SPP.	1	--	--	--	--		
ARTHROPODA						104	
COPEPODA-UNIDENTIFIED SPP.	2	--	--	--	--		2
LEPTOCHELIA OUBIA	1	--	--	1	--		2
PYRROIA TUBERCULATA	4	--	--	--	--		4
OSTRACODA-UNIDENTIFIED SPP.	--	9	--	1	--		10
AMPELISCIA MILLERI	--	50	--	5	1		65
COROPHIUM ACHERUSICUM	--	--	--	1	--		1
COMPHIUM SP.	--	--	--	1	1		2
PHYCNOGONIDA-UNIDENTIFIED SPP.	--	--	--	3	--		3
HYDRACARINA-UNIDENTIFIED SPP.	15	--	--	--	--		15
MOLLUSCA						455	
TAPES JAPONICA	22	14	9	24	22		91
MUSCULUS SENHOUZIA	146	7	11	89	107		360
ODOSTOMIA (EVALEA) VALDEZI	--	1	--	--	--		1
NASSARIUS OBSOLETUS	--	--	2	--	--		2
ISELICA OVOIDEA	--	--	--	--	1		1
CHORDATA						17	
UROCHORDATA-UNIDENTIFIED SPP.	6	--	--	7	--		13
STYELA SP.	--	--	--	1	--		1
ASCIIDIACEA-UNIDENTIFIED SPP.	--	--	--	--	3		3
TUNICATA-UNIDENTIFIED SPP.	--	--	p	--	--		p
ENIGMATICA						2	
ENIGMATICA	1	--	--	--	1		2
GRAND TOTALS	54	772	269	108	377	1965	1965

MIS-A
Survey 1

TAXA	SAMPLE NO.			SPECIMENS 30 JHP	TAXA
	1	2	3		
CNIDARIA HYDROZOA-UNIDENTIFIED SPP.	P	--	--	P	P
NEMATODA NEMATODA-UNIDENTIFIED SPP.	197	62	10	269	269
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	4086	2255	1227	7568	7568
ANNELIDA-POLYCHAETA SYMBIOSIS BENEDICTII HAPLOSCOPUS PUGETENSIS ETHEONE LIGHTI NEANTHES SUCCINEA PSEUDOPOLYDORA KEMPI CALIFORNICA	25 1 7 -- --	1 -- 1 1 --	7 -- 5 -- 1	49	33 1 13 1 1
ARTHROPODA COPEPODA-UNIDENTIFIED SPP. AMPELISCA MILLERI GRANDIDIERELLA JAPONICA INSECTA-UNIDENTIFIED SPP.	33 6 1 1	80 5 -- --	1 3 -- --	130	114 14 1 1
MOLLUSCA MYA ARENARIA MACOMA BALTHICA NASSARIUS OBSOLEIUS ODUSTOMIA (EVALEA) SP. A	1 14 2 0	-- 9 6 --	2 10 -- --	50	3 33 8 6
ECTOPROCTA MEMBRANIPORA PERFRAGILIS	P	--	--	P	P
GRAND TOTALS	4380	2420	1266	9066	9066

MIS-B
Survey 1

STATION MIS-B

SURVEY NO. 1

TAXA	SAMPLE NO.					NUMBER OF GROUP	SPECIMENS TAXA
	3	4	5	4	5		
NEMATODA						243	243
NEMATODA--UNIDENTIFIED SPP.	159	83	1				
ANNELIDA-OLIGOCHAETA						15122	15122
OLIGOCHAETA--UNIDENTIFIED SPP.	6580	6951	1591				
ANNELIDA--POLYCHAETA						317	317
NEANTHES SUCCINEA	1	1	1				3
ETEONE LIGHTI	15	9	--				24
STREBLOSPIRO BENEDICTI	101	164	17				282
PSEUDOPOLYDORA KEMPI CALIFORNICA	2	1	2				5
HETEROMASTUS FILIFORMIS	--	1	--				1
ETEONE SP., CF LIGHTI	--	--	2				2
ARTHROPODA						28	19
COPEPODA--UNIDENTIFIED SPP.	3	15	1				9
AMPELISCA MILLERI	3	6	--				
MOLLUSCA						63	41
MACOMA BALTHICA	30	11	--				22
MYA ARENARIA	7	10	5				
ECTOPROCTA						P	P
MEMBRANIPORA PERFRAGILIS	P	P	--				
GRAND TOTALS	6901	7252	1620			15773	15773

CS-A
Survey 1

STATION CS-A

SURVEY NO. 1

TAXA	SAMPLE NO.				NUMBER OF SPECIMENS	SPECIMENS TAXA
	1	3	4			
CNIDARIA						
CF GONOTHYRAEA SP.	--	P	--		0	P
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	--	12	43		45	45
ANNELIDA-ULIGOCHAETA						
ULIGOCHAETA-UNIDENTIFIED SPP.	137	92	158		337	337
ANNELIDA-POLYCHAETA						
GLYCINDE SP.	1	11	6		114	19
NEANTHES SUCCINEA	2	--	--			2
STREBLOSPIO BENEDICTI	63	13	4			43
POLYDORA LIGNI	4	--	--			4
EIEONE LIGHTI	1	1	--			2
THARYX PARVUS	--	1	1			2
CAULLERIELLA HAMATA	--	1	--			1
POLYDORA BRACHYCEPHALA	--	--	1			1
EXOGONE LUNEI	--	--	1			1
ARTHROPODA						
PARAPHOXUS MILLERI	5	3	1		251	1
HYPERIDEA-UNIDENTIFIED SPP.	1	--	--			1
COPEPODA-UNIDENTIFIED SPP.	1	--	--			1
AMPELISCA MILLERI	1	--	--			2
BALANUS IMPROVISUS	159	1	40			240
LEPTOCHELIA DUBIA	--	1	--			1
GRANDIOERELLA JAPONICA	--	--	1			1
MOLLUSCA						
MAGOMA BALTHICA	4	2	4		30	10
MYA ARENARIA	12	--	10			22
MUSCULUS SENHOUZIA	--	1	--			1

CS-A
Survey 1

STATION CS-A SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	1	3	4	4		
ECTOPROCTA MEMBRANIPORA PERFRAGILIS	--	--	P		P	P
ENIGMATICA ENIGMATICA	1	--	--		1	1
GRAND TOTALS	24	395	139	307	841	841

CS-B
Survey 1

STATION CS-8

SURVEY NO. 1

TAXA	SAMPLE NO.			SPECIMENS IN GROUP	TAXA
	1	2	3		
NEMATODA					
NEMATODA-UNIDENTIFIED SPP.	75	--	41	116	116
ANNELIDA-ULIGOCHAETA					
ULIGOCHAETA-UNIDENTIFIED SPP.	1592	351	1492	3435	3435
ANNELIDA-POLYCHAETA					
EXUGONE LOUREI	1	--	1	1005	2
POLYDORA LIGNI	1	--	--		1
THARYX PARVUS	124	75	165		364
GLYCINDE SP.	24	26	14		64
STREBLUSPIO BENEDICTI	184	255	222		261
MEDIOASTUS CALIFORNIENSIS	1	--	--		1
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	1	--		1
HETEROMASTUS FILIFORMIS	--	1	--		1
ARTHROPODA					
PARAPHOXUS MILLEKI	2	--	--	5	2
CAPRELLIDEA-UNIDENTIFIED SPP.	--	--	1		1
COROPHIUM SP. 'CF' INSIDIUM	--	1	--		1
CUPEPODA-UNIDENTIFIED SPP.	1	--	--		1
MOLLUSCA					
MACOMA BALTHICA	3	--	2	92	5
MYA ARENARIA	10	60	15		85
TAPFS JAPONICA	--	1	--		1
UDOSTOMIA (MENESTHO) FFIELLA	--	1	--		1
ECTOPROCTA					
MEMBRANIPURA PERFRAGILIS	--	p	--	p	p
GRAND TOTALS	2013	272	1753	4743	4743

ALC
Survey 1

STATION ALC

SURVEY NO. 1

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	2	4	5		
PORIFERA					
KERATOSA-UNIDENTIFIED SPP.	--	P	--	P	P
CNIDARIA					
CF HALIPLANELLA SP.	1	--	--	1	1
CALYPTOBLASTEA-UNIDENTIFIED SP. A	--	P	--		P
CALYPTOBLASTEA-UNIDENTIFIED SP. B	--	P	--		P
HYDROZOA-UNIDENTIFIED SPP.	--	--	P		P
PLATYHELMINTHES					
PLATYHELMINTHES-UNIDENTIFIED SPP.	--	--	2	2	2
NEMERTEA					
NEMERTEA-UNIDENTIFIED SPP.	25	60	137	222	222
NEMATODA					
NEMATODA-UNIDENTIFIED SPP.	36	51	409	496	496
ANNELIDA-OLIGOCHAETA					
OLIGOCHAETA-UNIDENTIFIED SPP.	9	71	61	141	141
ANNELIDA-POLYCHAETA					
MICROPHthalmus SP.	--	--	29	11713	29
SPIOPHANES BONDYX	--	--	1		1
POLYCHAETA-UNIDENTIFIED SPP.	--	--	2		2
POLYDORA SOCIALIS	1	--	--		1
GLYCERA TENUIS	5	20	20		45
HAPLOSCLOPLOS PUGETTENSIS	1	--	--		1
SCOLELEPSIS SP. NEAR SQUAMATA	1	--	--		1
GLYCINDE SP.	2	3	--		5
ARMANDIA BREVIS	5	7	19		31
ETEONE DILATAE	1	--	--		1
HESIONURA SP.	572	2387	7340		10299
SYLLIDES SP.	20	599	646		1265

Literature Review
Effects of Heavy Metals
Toxicity

Table 59 (Continued)

Species	Test Duration	Concentration (mg/liter)	Results	Reference
<u>Polychaeta</u>				
<u>Polychaetes (7 spp.)</u>	96 hr	0.15-0.96	50% mortality	Reish, 1974
	28 days	0.03-0.65	50% mortality	
<u>Nereis diversicolor</u>	888 hr	0.1-0.7	41-828 hr mean survival time (from low-Cu area)	Bryan and Hummerstone, 1971
	888 hr	0.1-0.7	247-888 hr mean survival time (from high-Cu area)	
	408 hr	0.25-2.5	18-140 hr mean survival time (from low-Cu area)	
	408 hr	0.25-2.5	16-150 hr mean survival time (from low-Cu area)	
	408 hr	0.25-2.5	50-408 hr mean survival time (from high-Cu area)	
<u>Nereis virens</u>	21 days	< 0.1	100% survival	Raymont and Shields, 1963
	21 days	0.1	Toxicity threshold	
	21 days	0.4-0.5	100% mortality, 7 days	
	25 hr	0.18	Respiration rate increased 40%	
	4 days	0.18	Respiration rate increased >100%	
<u>Oligochaeta</u>				
<u>Nais sp.</u>	--	1.0-2.0	Lethal, 24 hr	Learner and Edwards, 1963
<u>Limnodrilus hoffmeisteri</u>	--	0.40	96-hr TLm (hard water)	Wurtz and Bridges, 1961
	--	0.38	24-hr TLm (hard water)	
<u>Ectopoceta</u>				
<u>Eugula neritina (larvae)</u>	--	< 0.2	Decreased growth and development	Miller, 1946
	--	0.2-0.3	Decreased growth and development	
	--	> 0.3	Decreased growth, larval death	
	--	3.8	50% larval mortality, 2 hr	Wisely and Blick, 1967

ALC
Survey 1

STATION ALC SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO.		SPECIMENS	
	2	4	5	TAXA
ARCHIANNELLIDA-UNIDENTIFIED SPP.				
MEDIOMASTUS CALIFURNIENSIS	--	1	--	1
PRIONOSPID SP.	--	19	8	27
THARYX SP., CF. MONILARIS	--	1	--	1
POLYDORA BRACHYCEPHALA	--	1	--	1
EXOCHNE LOUREI	--	--	1	1
	--	--	1	1
ARTHROPODA				
PHOTIS BREVIPEDES	--	--	1	1
COPEPODA-UNIDENTIFIED SPP.	--	--	1	1
MOLLUSCA				
MACOMA NASUTA	--	1	--	1
TELLINA MODESTA	--	5	2	3
TRANSENELLA TANTILLA	--	--	113	118
MYTILUS EDULIS	--	--	1	1
ADULA DIEGENSIS	--	--	31	31
TAPES JAPONICA	--	--	1	1
MYSELLA FERRUGINOSA	--	--	17	17
HIATELLA ARCTICA	--	--	3	3
MACOMA BALTHICA	--	--	3	3
FARTULUM SP.	--	--	7	6
ECTOPROCTIA				
CHAPPERIA PALUTA	--	--	P	P
CRISIA MAXIMA	P	--	P	P
TRICELLARIA TERNATA	--	--	P	P
SCRUPOCELLARIA CALIFORNICA	--	P	P	P
HIPPOTHOA HYALINA	--	--	P	P
CALLOPORA S.	--	--	P	P
TRICELLARIA OCCIDENTALIS	--	--	P	P
SCRUPOCELLARIA SP.	--	--	P	P
CHEILOPORA PRAELONGA	--	--	P	P
SMITTUIDEA PROLIFICA	--	--	P	P
MICROPORELLA CALIFORNICA	--	--	P	P
ELECTRA ARCTICA	--	--	P	P
CELLARIA SP.	--	--	P	P
PARASMITTINA TRISPINOUSA	--	--	P	P

ALC
Survey 1

STATION ALC SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO.					NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3	4	5		
HIPPOTHOA CORNUA	—	—	P			—	P
LAGENIPORA PUNCTULATA	—	—	P				P
TEGELLA ANATIFERA	—	—	P				P
MENIDIPORA PERFRAGILIS	—	—	P				P
CRISIA OCCIDENTALIS	—	—	P				P
GRAND TOTALS	679	3227	8858			12764	12764

OIH
Survey 1

STATION C1H

SURVEY NO. 1

TAXA	SAMPLE NO.					NUMBER OF SPECIMENS
	2	3	4	5	6	TAXA
PORIFERA						
KERATOSA-UNIDENTIFIED SPP.	--	--	--	P	P	P
CNIDARIA						
PENNAULACEA-UNIDENTIFIED SPP.	--	2	2			4
CNIDARIA-UNIDENTIFIED SPP.	--	--	--	P	P	P
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	6	3	1		12	12
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	64	226	403		690	690
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	4381	2978	2037		5396	5396
ANNELIDA-POLYCHAETA						
PECTINARIA CALIFORNIENSIS	17	1	2		13549	20
GLYCINDE SP.	55		5			65
ETEMNE LONGA CALIFORNICA	26	18	18			62
CF. HARMOTHOE SP.	1	--	--			1
NEPHYS CAECIOIDES	3	5	16			24
ETEMNE LIGHTI	3	5	2			10
NEPHYS CONNATA FRANCISCANA	11	2	1			14
EXOGONE LOUREI	379	60	57			496
ASYCNIS SP.	5	--	1			6
SCHISTOMELIGUS LONGICORNIS	2	2	3			7
THARYX PARVUS	1	--	1			2
POLYDORA LIGNI	30	40	29			67
HARMOTHOE SP.	3	3	1			4
HAPLOSCULOPLOS PUGETTENSIS	3	4	11			23
EUCHONE LIGNICOLA	14	2	--			16
STREBLOSPIO BEMEDICTI	383	4749	3985			12617
PSEUDOPOLYDORA PAUCIBRANCHIATA	339	43	5			376
PHOLUE MINUTA	2	5	6			13

OIH
Survey 1

STATION OIH SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO.		NUMBER OF SPECIMENS	
	2	3	GROUP	TAXA
SCOLEPSIS SQUAMATA	1	---	---	1
ETEMNE DILATAE	1	---	---	1
SPHAEROSTYLIS SP.	99	---	---	99
MEPHYS PARVA	4	10	---	14
ARMADIA BREVIS	1	---	---	1
PSEUDOPOLYDORA KEMPT CALIFORNICA	4	3	---	10
SCOLEPSIS SP., CF SQUAMATA	1	---	---	1
CASSIDIA PYGMAEOLATA	1	---	---	7
CAPITELLA CAPITATA	1	2	---	2
7 PRIONOSTIDES SP.	1	1	---	1
7 PRIONOSPIO SP.	---	1	---	1
HAIRIOTHOE IMBRICATA	---	---	---	3
TRACHOMAETA MULTISETOSUM	---	---	---	1
PRIONOSPIO SP.	1	---	---	2
ARTHROPODA	207	72	1212	310
OSTRACODA-UNIDENTIFIED SPP.	1	---	---	1
SARSIELLA ZOSTERICOLA	11	---	---	11
LEPTOCHELLA DUBIA	3	3	---	6
EUDORELLA SP.	237	50	---	302
CUMELLA VULGARIS	---	2	---	2
ANTHURIDAE-UNIDENTIFIED SPP.	---	1	---	6
COPEPODA-UNIDENTIFIED SPP.	---	2	---	15
PINNIXIA FRANCISCANA	7	2	---	8
PHOTIS BREVIPE	3	5	---	4
CORDIPHILUM ACHERUSICUM	4	---	---	9
GRANDIDIERELLA JAPONICA	8	1	---	532
AMPELISCA MILLERI	510	17	---	1
GAMMARIDAE-UNIDENTIFIED SPP.	---	1	---	3
AMPHIRODA-UNIDENTIFIED SPP.	---	3	---	1
SARSIELLA SP.	---	1	---	1
DECAPODA-UNIDENTIFIED LARVA	---	---	---	1
MOLLUSCA	2608	239	3129	2908
GEMMA GEMMA	1	---	---	1
TRANSENNELLA TANTILLA	1	---	---	1
MUSCULUS SEMMOUSIA	105	59	---	201
MACOMA NASUTA	4	2	---	6
MACOMA INQUIINATA	7	---	---	7
MACOMA ACOLASTA	1	---	---	2
HYSELLA FERRUGINOSA	1	1	---	2
LYONSIA CALIFORNICA	---	---	---	1
TAPES JAPONICA	---	---	---	1

OIH
Survey 1

STATION OIH SURVEY NO. 1 (CONT.)						
TAXA	SAMPLE NO.			NUMBER OF SPECIES	SPECIMENS TAXA	
	2	3	6			
ECTOPROCTA						
BUGULA MERITIMA	P	P	P	P	P	
BUGULA CALIFORNICA	P				P	
TRICELLARIA TERNATA		P			P	
BUGULA SP.			P		P	
ECHINODERMATA						
HOLOTHUROIDEA-UNIDENTIFIED SPP.	206	98	47	342	341	
CF. LEPTOSTYMPIA SP.			1		1	
GRAND TOTALS	69	13273	8705	6906	29794	28784

HP
Survey 1

STATION HP
SURVEY NO. 1

TAXA	SAMPLE NO.						NUMBER OF GROUP	SPECIMENS TAXA
	3	5	6	5	6	6		
Cnidaria							26	P
NEAR COMOTRYAEA SP.								4
CF DIADUMENE SP.	4							22
CF HALTPLANELLA SP.	9	2	11					
Nemertea							40	40
NEMERTEA-UNIDENTIFIED SPP.	10	16	14					
Nematoda							109	109
NEMATODA-UNIDENTIFIED SPP.	36	46	27					
Annelida-Oligochaeta							61	61
OLIGCHAETA-UNIDENTIFIED SPP.	49	5	7					
Annelida-Polychaeta							1166	
TARAX PARVUS	13	9	8					30
CAPITELLA CAPITATA	6	4	4					14
ASYCHIS SP.	8	7	4					19
GLYCERA AMERICANA	1	2						3
MEDIDASTUS CALIFORNIENSIS	124	45	52					241
ARANDIA BREVIS	2	2	2					6
BOCCARDIA TRUNCATA	1							1
POLYDORA SP.	4							4
SCHISTONERINOS LONGICORNIS	2							2
ETERME LONGA CALIFORNICA	1							1
CIRRATULUS CIRRATUS	5	1						6
SPHAEROSYLIS SP.	4							8
STRENDSPID BENEDICTI	42							51
GLYCERA SP.	1							1
NEPHYS CAECOIDES	1							1
EXOGONE LOUREI	411	183	160					754
COSSURA PYGODACTYLATA	1	1						2
NEPHYS PARVA	1							1
NEPHYS CORNUTA FRANCISCANA	2							2
PHOLDE MINUTA	1							1
HARMOTHOE IMBRICATA	1	1						2

HP
Survey 1

STATION HP SURVEY NO. 1 (CONT.)							
TAXA		SAMPLE NO.			NUMBER OF		SPECIMENS
		3	5	6	GROUP	TAXA	
POLYDORA SOCIALIS		1	2	1		3	
GLYCIDAE SP.		---	6	1		7	
SPIOPHANES FIMBRIATA		---	1	1		1	
HETEROMASTUS FILIFORMIS		---	---	4		4	
POLYDORA SP. CF SOCIALIS		---	---	1		1	
SIPUNCULA		---	1	---	1	1	
SIPUNCULA-UNIDENTIFIED SPP.		---	---	---			
ARTHROPODA		1952	2382	4501	9103	8335	
AMPELISCA MILLERI		77	97	65		239	
LEPTOCHELIA DUBIA		---	1	4		5	
SAKSIELLA ZOSTERICOLA		---	1	2		10	
COROPHIUM ACHERUSICUM		---	6	---		1	
PYROMATA TUBERCULATA		1	---	---		1	
OSTRACODA-UNIDENTIFIED SPP.		4	---	---		4	
COROPHIUM INSIDIOSUM		7	---	---		7	
COROPHIUM SP.		2	---	---		2	
MOLLUSCA		---	---	---	6	1	
PETRICOLA SP. CF CARDITOIDES		---	---	1		1	
LYONSIA SP. CF CALIFORNICA		---	---	1		1	
ADALA DIEGENSI		1	---	---		1	
MUSCULUS SEMHOUSIA		1	---	---		1	
TRANSENNELLA TANTILLA		---	---	---		1	
MACOMA NASUTA		---	1	---		1	
ECHINODERMATA		---	---	---	1	1	
MOLOTHURIDEA-UNIDENTIFIED SPP.		---	---	1		1	
PHORONIDA		---	---	---	1	1	
PHORONIS SP.		1	---	---		1	
CHORDATA		---	---	---	2	2	
TUNICATA-UNIDENTIFIED SPP.		---	---	---			
GRAND TOTALS	50	2791	2842	4831	10514	10514	

SB-A
Survey 1

STATION SB-A		SURVEY NO. 1				NUMBER OF SPECIMENS	
TAXA		SAMPLE NO.				GROUP	TAXA
		2	3	4			
CNIDARIA						2	
CNIDARIA-UNIDENTIFIED SPP.		--	1	--			1
CF GOMUTHYRAEA SP.		P	--	--			P
CALYPTOMLASTEIA-UNIDENTIFIED SPP.		--	P	--			P
CF MALIPLANELLA SP.		1	--	--			1
NEMATODA						22	
NEMATODA-UNIDENTIFIED SPP.		18	4	--			22
ANNELIDA-OLIGOCHAETA						357	
OLIGOCHAETA-UNIDENTIFIED SPP.		246	49	62			357
ANNELIDA-POLYCHAETA						2161	
POLYNOIDA-UNIDENTIFIED JUVENILE		2	--	--			2
SPHAEROSYLLIS SP.		55	13	--			68
GLYCINDE SP.		3	1	3			7
HARMOTHOE IMBRICATA		2	1	--			3
CAPITELLA CAPITATA		3	3	9			15
ASYCHIS SP.		4	5	26			33
HAPLOSCOLOPLOS PUGETTENSIS		2	--	--			2
PSEUDOPOLYDORA KEMPI CALIFORNICA		10	5	2			17
COSSURA PYGODACTYLATA		2	3	--			5
STREMBLOSPIO BENEDICTI		38	47	50			135
POLYDORA LIGNI		4	--	--			4
HETEROMASTUS FILIFORMIS		46	11	1			58
ETEONE LONGA CALIFORNICA		1	--	--			1
EXOGONE LOUREI		697	372	320			1389
AUTOLYTUS SP.		1	--	--			1
POLYDORA BRACHYCEPHALA		167	95	135			397
PSEUDOPOLYDORA PAUCIBRANCHIATA		1	--	--			1
POLYDORA SP.		1	--	--			1
CIRRATULUS CIRRATUS		--	1	--			1
SCHISTOMERINGOS LONGICORNIS		--	4	2			6
CF HARMOTHUE SP.		--	--	2			2
MEDIONASTUS CALIFORNIENSIS		--	--	9			9
ETEONE DILATAE		--	--	2			2

SB-A
Survey 1

STATION SB-A SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	2	3	4	5		
ARTHROPODA					5876	
COPEPODA-UNIDENTIFIED SPP.	4					4
SARIELLA ZOSTERICOLA	132			90		222
PHYCNOGONIDA-UNIDENTIFIED SPP.	1	3				4
COROPHIUM ACHERUSICUM	3	7		4		14
AMPELISCA MILLERI	1140	2634	2757			6531
GRANODIERELLA JAPONICA	1			1		2
PARAPLEUSTES PUGETTENSIS	1			4		5
PYROMAIA TUBERCULATA	1					1
SYNDOTEA LATICAUDA	1	14	12			31
LEPTOCHELIA DUBIA	1	1	3			5
CUMELLA VULGARIS	1	2				2
DECAPODA-UNIDENTIFIED SPP.		54				54
OSTRACODA-UNIDENTIFIED SPP.						
MOLLUSCA					167	
MUSCULUS SEMMOUSIA	3	3	2			8
TAPES JAPONICA	41	45	69			155
MACOMA NASUTA	1					1
ISELICA OVOIDEA	3					3
CHORDATA					95	
TUNICATA-UNIDENTIFIED SPP.	43	28				71
ASCIDIACEA-UNIDENTIFIED SPP.			24			24
GRAND TOTALS	2685	3406	3589		9680	9680

SB-B
Survey 1

STATION SB-8

SURVEY NO. 1

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	2	3	4			
CNIDARIA CF DIADUMENE SP. CF COMOTHYRAEA SP.	--	--	1	p	1	1 p
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	3	1	--	--	4	4
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	42	1	22	--	65	65
ANNELIDA-POLYCHAETA CIRRATULUS CIRRATUS COSSURA PYGODACTYLATA EXOCHORDA LOUREI STREBLOSPION BENEDICTI ASYCHIS SP. HETERONASTUS FILIFORMIS POLYDORA BRACHYCEPHALA PSEUDOPOLYDORA KEMP CALIFORNICA SCHISTONERINUS LONGICORNIS HARMOHAE INBRIGATA GLYCIDAE SP. CAPITELLA CAPITATA	3 3 57 35 2 57 65 -- -- -- -- -- --	2 5 92 23 3 26 79 5 3 1 1 2	3 1 75 13 14 40 85 -- -- -- -- -- --	--	697	8 a 224 71 19 123 229 5 5 1 1 2
ARTHROPODA SARISTELLA ZOSTERICOLA LEPTOCNELIA JUBIA PYCNOGONIDA-UNIDENTIFIED SPP. GRANODIERELLA JAPONICA OSTRACODA-UNIDENTIFIED SPP. ANPELISCA MILLERI PARAPLEUSTES PUGETENSIS COROPHIUM INSIDIOSUM ARACHNIDA-UNIDENTIFIED SPP. SYNDOTEA LATICAUDA COROPHIUM ACHERUSICUM	-- 7 1 2 22 2055 4 1 1 1 2 2	9 1 1 1 -- 2434 -- -- -- -- -- --	-- 1 2 1 14 1074 1 -- -- -- -- -- --	--	5401	9 9 4 4 36 5223 5 3 1 3 4

SB-B
Survey 1

STATION SB-B SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	2	3	4			
MOLLUSCA					111	12
MUSCULUS SENHOUZIA	9	3	--			1
ISELICA OVOIDEA	1	--	--			4
TAPES JAPONICA	30	24	40			1
GENNA GENNA	1	--	--			2
HYA ARENARIA	--	1	1			1
MACOMA NASUTA	--	--	1			
CHORDATA					59	29
ASCIDIACEA-UNIDENTIFIED SPP.	--	25	--			40
TUNICATA-UNIDENTIFIED SPP.	26	--	14			
GRAND TOTALS	2430	2511	1407		6348	6348

SURVEY NO. 1

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	2	3	4			
PROTOZOA						
FORANINIFERA-UNIDENTIFIED SPP.	--	--	4		4	4
CNIDARIA						
CF GONOTHYRAEA SP.	--	--	4		6	P
CF HALIPLANELLA SP.	1	--	5			6
NEMERTEA						
NEMERTEA-UNIDENTIFIED SPP.	--	2	1		3	3
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	159	154	428		741	741
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	889	508	1052		2449	2449
ANNELIDA-POLYCHAETA						
ETEONE LONGA CALIFORNICA	4	1	2		6472	7
POLYNOIDAE-UNIDENTIFIED JUVENILE	1	--	--			1
NARPHYSA SANGUINEA	7	6	3			16
GLYCINDE SP.	2	2	2			6
POLYDORA BRACHYCEPHALA	2	2	--			4
HARMOTHOE IMBRICATA	3	4	6			4
METERMASTUS FILIFORMIS	83	33	69			13
STREBLOSPIO-BENEDICTI	27	--	3			185
SPHAEROSYLIS SP.	42	3	59			30
EXOOME LOUREI	722	330	687			104
PSEUDOPOLYDORA PAUCIBRANCHIATA	13	4	1			1739
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	3	--			18
POLYDORA LIGI I	116	44	98			4
POLYCIRRUS SP.	1123	630	326			258
ASYCHIS SP.	--	1	3			2079
CAPITELLA CAPITATA	--	--	1			4
SCHISTOMERINGOS SP.	--	--	1			1
POLYCHAETA-UNIDENTIFIED SPP.	--	--	1			1

STATION RCH-A SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	2	3	4			
POLYCIARUS SP., NEAR TENUISETIS	--	--	1			1
ARTHROPODA					11900	
SARSIELLA ZOSTERICOLA	93	--	73			166
INSECTA-UNIDENTIFIED SPP.	--	--	1			1
AMPELISCA MILLERI	7008	3318	1227			11553
GRANDIDIERELLA JAPONICA	4	8	4			16
COROPHIUM SP.	--	--	2			2
PARAPLEUSTES PUGETTENSIS	--	--	1			1
SYNDOTEA SP., CF LATICAUDA	--	5	--			5
PYCNOGONIDA-UNIDENTIFIED SPP.	--	1	--			1
COROPHIUM ACHERUSICUM	15	--	--			15
COPEPODA-UNIDENTIFIED SPP.	1	2	1			4
CUMELLA VULGARIS	1	--	--			1
SYNDOTEA LATICAUDA	7	--	12			19
COROPHIUM INSIDIOSUM	--	--	16			16
MOLLUSCA					196	
TAPES JAPONICA	12	7	28			47
MUSCULUS SENHOUZIA	--	6	135			141
UROSALPINX CINEREA	--	--	1			1
GEMMA GEMMA	--	--	1			1
CREPIDOULA CONVEXA	--	--	6			6
ECTOPROCTA					P	
MEMBRANIPORA MEMBRANACEA	--	--	P			P
GRAND TOTALS	44	10336	5074	4261	19671	19671

RCH-A
Survey 1

RGH-B
Survey 1

STATION RGH-B SURVEY NO. 1 (CONT.)

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	2	3	4	5		
PHOMCNIDA CF PHOMONOPSIS SP.	--	1	--		1	1
GRAND TOTALS	25	1531	652	154	2337	2337

STATION RCH-B

SURVEY NO. 1

RCH-B
Survey 1

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	2	3	4			
NEMERTEA					9	9
NEMERTEA-UNIDENTIFIED SPP.	4	4	1			
NEMATODA					47	47
NEMATODA-UNIDENTIFIED SPP.	43	--	4			
ANNELIDA-OLIGOCHAETA					129	129
OLIGOCHAETA-UNIDENTIFIED SPP.	83	44	2			
ANNELIDA-POLYCHAETA					895	895
STREBLOSPID BENEDICII	537	142	14			693
HETEROMASTUS FILIFORMIS	33	13	16			62
PSEUDOPOLYDORA KEMPI CALIFORNICA	18	4	2			24
ASYCHIS SP.	1	1	--			2
COSSURA PYGODACTYLATA	42	4	--			46
PSEUDOPOLYDORA PAUCIBRANCHIATA	20	3	--			23
CAPITELLA CAPITATA	1	1	--			2
EXOGONE LOUREI	22	16	3			41
HAPLOSCOLOPLOS PUGETTENSIS	--	1	--			1
NEPHTYS CAECOIDES	--	--	1			1
ARTHROPODA					1225	
SYNIDOTEA BICUSPIDA	1	--	--			1
SARIELLA ZOSTERICOLA	14	--	--			14
AMPELISCA MILLERI	698	393	104			1195
GRANDIDIERELLA JAPONICA	3	3	--			6
OSTRACODA-UNIDENTIFIED SPP.	--	6	1			7
SYNIDOTEA LATICAUDA	--	1	1			2
MOLLUSCA					31	
MUSCULUS SENHOUZIA	10	12	3			25
TAPES JAPONICA	1	1	1			3
MYA ARENARIA	--	1	--			1
MACOMA NASUTA	--	1	--			1
MACOMA BALTHICA	--	--	1			1

MIS-A
Survey 2

STATION MIS-A						
TAXA	SURVEY NO. 2			NUMBER OF SPECIMENS		
	SAMPLE NO.			GROUP	TAXA	
	1	2	3			
LNIDARIA						
CAMPANULARIA SP.	P	P	P	P		P
HYDROIDA-UNIDENTIFIED SPP.						
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	14	22	25	61		61
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	215	23	21	259		259
ANNELIDA-POLYCHAETA						
ETEDNE LIGHTI	1			4		1
ETEDNE LOUREI	1					1
STREBLDSPID BENEDICTI			1			1
ETEDNE LONGA CALIFORNICA			1			1
ARTHROPODA						
SYNIO: IEA LATICAUDA		1		282		1
INSECTA-UNIDENTIFIED SPP.		1				1
COPEPODA-UNIDENTIFIED SPP.	56	131	92			279
BALANUS SP.			1			1
MOLLUSCA						
MYA ARENARIA	2			22		2
MACOMA BALTHICA	6	3	1			10
MUSCULUS SEMMOUSIA	1	2	2			5
GEMMA GEMMA	1					1
NASSARIUS OBSOLETUS	2	1				3
ODOSTOMIA (MENESTHO) FETELLA		1				1
ECTOPROCTA						
MEMBRANIPORA PERFRAGILIS	P	P	P	P		P
GRAND TOTALS	19	299	185	144	629	628

MIS-B
Survey 2

STATION MIS-0

SURVEY NO. 2

AJ4454 JF0 SPECIMENS
580JP TAXA

SAMPLE NO. 3
1 2

	P	P	P	P
Cnidaria				
Hydrozoa-UNIDENTIFIED SPP.				
Nematoda				
Nematoda-UNIDENTIFIED SPP.	10	--	15	25
Annelida-ULIGOCHAETA				
ULIGOCHAETA-UNIDENTIFIED SPP.	4472	4565	5838	14875
Annelida-POLYCHAETA				
STRELOSPIO BENEDICTI	155	185	181	521
NEANTHES SUCCINEA	1	1	--	2
EXOGONE SP.	--	1	--	1
PSEUDOPOLYDORA KEMPI CALIFORNICA	--	4	1	5
ARTHROPODA				
PYCNOGONIDA-UNIDENTIFIED SPP.		1	--	1
GRANDIDIERELLA JAPONICA	--	1	--	1
MELITA SP.	--	2	--	2
COPEPODA-UNIDENTIFIED SPP.	--	--	35	35
MOLLUSCA				
MACOMA BALTHICA	7	9	7	23
MYA ARENARIA	5	24	2	31
NASSARIUS OBSOLETUS	3	69	1	73
GEMMA GEMMA	--	1	--	1
ECTOPROCTA				
MEMBRANIPORA PERFRAGILIS	--	--	P	P

15396 15596

GRAND TOTALS 16 4653 4863 6090

CS-A
Survey 2

STATION CS-A			SURVEY NO. 2			NUMBER OF SPECIMENS GROUP TAXA
TAXA	1	2	3			
CNIDARIA						
CAMPANULARIA SP.	P	--	P		P	
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	5	4	18		27	27
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	191	338	317		946	946
ANNELIDA-POLYCHAETA						
ETEONE LONGA CALIFORNICA	2	1	--		511	3
ETEONE LIGHTI	1	2	7			10
STREBLOSPIO BENEDICTI	111	173	185			469
METERONASTUS FILIFORMIS	1	--	--			1
PLEUROPOLYDORA KEMPI CALIFORNICA	1	2	--			3
THARYX PARVUS	1	--	--			1
POLYDORA LIGHTI	1	3	1			5
GLYCINDE SP.	2	4	1			7
CHAETOZONE SP.	--	4	2			6
THARYX SP.	--	--	6			6
ARTHROPODA						
AMPHISCIA MILLERI	--	1	--		9	1
GRANDIDIERELLA JAPONICA	8	--	--			8
MOLLUSCA						
MYA ARENARIA						
MACGNA BALTHICA	2	6	2		26	10
NASSARIUS OBSOLETUS	2	2	2			6
ODOSTOMIA (MENESTHOI) FETELLA	6	--	2			8
TAPES JAPONICA	--	--	1			1
	--	--	1			1
GRAND TOTALS	334	540	545	20	1419	1419

CS-B
Survey 2

STATION CS-B

SURVEY NO. 2

TAXA	SAMPLE NO.			NUMBER OF SPECIMENS TOTAL	SPECIMENS TAXA
	1	2	3		
CNIDARIA CAMPAULARIA SP.	--	P	P	P	P
NEMATODA NEMATODA-UNIDENTIFIED SPP.	1	--	2	3	3
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	30	11	151	192	192
ANNELIDA-POLYCHAETA NEANTHES SUCCINEA STREBLOSPLO BENEDICTI STREMOE LIGHTI METEOMASTUS FILIFORMIS CHAETIZONE SP. GLYCINDE SP.	1 9 5 1 -- --	-- 8 4 -- 2 --	1 13 1 -- -- 6	49	2 30 10 1 2 4
ARTHROPODA AMPELISCA MILLERI BALANUS SP. OF AMPHITRITE	1 --	1 --	-- 2	4	2 2
MOLLUSCA GENNA GENNA MACOMA BALTHICA MYA ARENARIA MYTILUS EDULIS MASSARIUS OBSOLETUS ODOSTOMIA (EVALEA) SP. A ODOSTOMIA (MENESTHO) PETELLA MUSCULUS SEMMOUSIA	1 1 10 2 3 3 --	-- -- 15 1 4 2 5 1	4 1 14 -- 1 4 6 --	98	5 2 59 3 8 4 11 1
ECTOPROCTA MEMBRANIPORA PENTRAGILIS	--	P	--	P	P
GRAND TOTALS	68	54	224	146	146

STATION ALC
SURVEY NO. 2

A-44

ALC
Survey 2

STATION ALC SURVEY NO. 2 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF SPECIMENS GROUP	SPECIMENS DATA
	1	2	3		
GYRTIS BREVIPALPA	---	1	10	---	1
MESONURA SP.	---	2	---	---	12
MESONASTUS CALIFORNIENSIS	---	7	4	---	11
MESONASTUS FILIFORMIS	---	1	---	---	1
LUMBRINERIS SP.	---	---	1	---	1
PHYLLODOCIDA--UNIDENTIFIED--JUVENILE	---	---	1	---	1
NEAR EUMIDA--SANGUINEA	---	---	1	---	1
SPIOPHANES SP.	---	---	1	---	1
NEREIS LATESCENS	---	---	1	---	1
ANATIDES SP., NEAR WILLIAMS	---	---	60	---	60
EULALIA AVICULISETA	---	1	---	---	1
POLYGIROSUS CALIFURNICUS	---	1	---	---	1
PRIONOSPID. CIRRIFERA	---	3	---	---	3
CHONE MINUTA	---	1	---	---	1
THARYX SP.	---	2	1	---	2
PALCANOTUS BELLIS	---	1	---	---	1
POLYDORA CAULLERYI	24	7	31	---	64
STREPTOSYLLIS SP.	---	1	3	---	4
CHONE MOLLIS	1	---	---	---	1
LUMBRINERIS TETRAURA - JUVENILE	---	---	1	---	1
LUMBRINERIS TETRAURA	---	1	2	---	2
SYLLIDES SP.	---	1	---	---	1
NEANTHES SUCCINEA	---	3	---	---	3
ARTHROPODA					
PHOTIS BREVIPES	11	95	35	---	141
MELITA DENTATA	1	---	---	---	1
ISCHYROCERUS ANGUIPES	1	---	---	---	1
CURDIPHIUM ACHERUSICUM	6	16	2	---	26
PARAPLEUSTES PUGETTENSIS	2	---	---	---	2
MELITA SP.	1	---	---	---	1
CANCER SP., CF. ANTEMNARIUS	---	1	4	---	5
LEPTOCHELIA DUBIA	---	6	2	---	8
CUREPQUA--UNIDENTIFIED SPP.	---	19	7	---	26
AM. ELISCA MILLERI	---	---	1	---	1
BR. CHYURA--UNIDENTIFIED SPP.	---	---	1	---	1
GR. MOIDIERELLA JAPONICA	---	---	1	---	1
SYNDOTEA--GIGUSPIDA	---	3	---	---	3
PROTOMEDEIA ZOTEA	---	2	---	---	2
STENOTHAIDES SP.	---	3	---	---	3
AMPHIPODA--UNIDENTIFIED SPP.	---	1	---	---	1
AEGINELLIDAE--UNIDENTIFIED SPP.	---	3	---	---	3
MELITA SP., CF. SULCA	---	2	---	---	2
ASELLOTA--UNIDENTIFIED SPP.	---	1	---	---	1
TIRON BIUCCELLATA	---	5	---	---	5

STATION ALC SURVEY NO. 2 (CONT.)

GRAND TOTALS	87	134	390	364	998	888

OIH
Survey 2

STATION UIH

SURVEY NO. 2

TAXA	SAMPLE NO.		NUMBER OF SPECIMENS GROUP	SPECIMENS TAXA
	1	2		
PROTOZOA				
FORAMINIFERA-UNIDENTIFIED SPP.	8	2	4	14
CNIDARIA				
STYLATULA ELUMGATA	17	10	13	40
HYDROZOA-UNIDENTIFIED SPP.	P	P	--	P
NEMERTEA				
NEMERTEA-UNIDENTIFIED SPP.	12	8	6	26
NEMATODA				
NEMATODA-UNIDENTIFIED SPP.	813	211	323	1347
ANNELIDA-OLIGOCHAETA				
OLIGOCHAETA-UNIDENTIFIED SPP.	4989	4438	2817	12244
ANNELIDA-POLYCHAETA				
GLYCINOE SP.	12	32	23	67
ETHEONE LIGHTI	2	--	5	7
NEPHTYS CAECOIDES	15	13	8	36
NEPHTYS CORMUTA FRANCISCANA	13	9	13	35
PSEUDOPOLYDORA KEMPI CALIFORNICA	3	6	1	10
STREBLOSPID BENEDICTI	8247	5539	7510	21298
PSEUDOPOLYDORA PAUCIBRANCHIATA	249	259	217	785
POLYDORA LIGNI	8	5	11	24
POLYDORA MINUTA	5	2	8	15
NEPHTYS PARVA	1	2	1	4
ETHEONE SP. 1 CF LONGA CALIFORNICA	3	--	--	3
HAPLOSOCOLOPLOS PUGETTENSIS	6	6	5	17
ANATIDES SP.	1	--	--	1
SPHAEROSYLLIS SP.	142	79	177	398
HETERONASTUS FILIFORMIS	3	--	--	3
CAPITELLA CAPITATA	2	--	3	5
MEDIONASTUS CALIFORNIENSIS	1	1	1	5
PECTINARIA CALIFORNIENSIS	9	16	7	32

OIH
Survey 2

STATION OIH SURVEY NO. 2 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
CHETOZONE SP.	1	1	1		3
ERYCONE LONGI	395	309	398		1102
NEPHTYS CAECOIDES - JUVENILE	16	2	13		31
ANNANOTA BREVIS	--	1	--		1
COSSURA PYGODACTYLATA	--	1	--		1
THARYX PARVUS	--	1	--		1
THARYX SP.	--	2	--		2
EUCHONE LINNICOLA	5	11	7		23
THARYX IMBRICATA	--	--	3		3
CIRRATULUS CIRRATUS	--	--	2		2
CHONE GRACILIS	1	--	1		2
THARYX SP.	2	--	--		2
MELIMNAMPARETE GRACILIS	1	--	--		1
EUMIDA BIFOLIATA	--	--	1		1
SCHISTONERINGS SP. - JUVENILE	2	--	--		2
SCOLEPSIS SQUAMATA	2	1	2		5
ASYCHIS SP.	2	--	--		2
SCHISTONERINGS LONGICORNIS	--	1	1		2
ARTHROPODA				863	
GRANDIDIERELLA JAPONICA	--	9	6		15
PHOTIS SP.	56	--	2		58
LEPTOCHELIA DUBIA	--	1	2		3
CUMELLA VULGARIS	--	41	87		128
PINNIXIA FRANCISCANA	--	--	4		4
DECAPODA-UNIDENTIFIED LARVA	--	--	5		5
SARSIELLA ZOSTERICOLA	176	142	246		564
AMPELISCA MILLERI	--	42	36		78
SYNDOTEA LATICAUDA	--	1	2		3
COPEPODA-UNIDENTIFIED SPP.	2	--	--		2
BALANUS CRENATUS	1	1	--		2
PYGOCONIDA-UNIDENTIFIED SPP.	--	1	--		1
MOLLUSCA				3079	
GEMMA GEMMA	1046	703	1201		2947
MACOMA NASUTA	49	31	32		112
MACOMA ACULASTA	1	--	1		2
TELLINA MODESTA	4	--	3		7
MYSELLA FERRUGINOSA	1	--	2		3
MUSCULUS SEMIHOUSIA	--	2	1		3
MYTILUS EDULIS	--	--	3		3
MACOMA INQUINATA	--	--	--		--

OIH
Survey 2

STATION OIH SURVEY NO. 2 (CONT.)						
TAXA	SAMPLE NO.			NUMBER OF SPECIMENS	TAXA	
	1	2	3			
ECTOPROCTA						
BYGULA MERITIMA	P	P	--		P	
TRICELLARIA SP.	--	P	--		P	
CRYPTOSULA PALLASIANA	--	P	--		P	
CRISIA MAXIMA	--	P	--		P	
FILICRISIA SP.	P	--	--		P	
ECHINODERMATA						
HOLOTHURIDEA-UNIDENTIFIED SPP.	116	68	39	223		223
CHORDATA						
CIDNA INTESTINALIS	2	--	--	2		2
ENIGMATIC						
ENIGMATIC	--	--	4	4		4
GRAND TOTALS	71	1643	12008	13321	13772	13772

HP
Survey 2

STATION HP

SURVEY NO. 2

TAXA	SAMPLE NO.			NUMBER OF SPECIMENS GROUP	SPECIMENS TAXA
	1	2	3		
PROTOZOA FORAMINIFERA-UNIDENTIFIED SPP.	1	--	--	1	1
CNIDARIA HALIPLANELLA SP. CANPULARIA SP. DIADUMENE SP.	13 P 1	6 P 73	4 P --	97	23 P 74
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	12	19	17	48	48
NEMATODA NEMATODA-UNIDENTIFIED SPP.	38	26	16	80	80
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	53	38	50	141	141
ANNELIDA-POLYCHAETA CIRRATULUS CIRRATUS ASYCHIS SP. MEDIOMASTUS CALIFORNIENSIS EACOGONE LOUREI GLYCINDE SP. CAPITITA AMBIESETA POLYDORA SOCIALIS EACOGONE SP. SPHAEROSYLLIS SP. AUTOLYTUS SP. COSSURA PYGODACTYLATA ARANDIA BREVIS STREBLOSPIO BENEDICTI NEMPTYS CURNUTA FRANCISCANA THARYX PARVUS ETEONE SP. - CF LONGA CALIFORNICA GLYCINDE SP. - JUVENILE	2 11 232 283 1 1 5 1 1 1 2 1 1 4 14 --	2 13 258 192 -- -- 6 -- 8 -- 1 9 8 5 30 1 2	3 7 172 12 -- -- -- -- -- -- 1 3 -- -- 11 -- --	1391	7 31 682 547 1 1 1 1 1 1 4 19 8 10 55 1 2

STATION HP SURVEY NO. 2 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
PSEUDOPOLYDORA PAUCIBRANCHIATA	---	1	---	---	1
POLYDORAE-UNIDENTIFIED JUVENILE	---	1	---	---	1
DISOMA MULTISETOSUM	---	1	1	---	2
CHAETODOME SP.	---	---	1	---	1
HAPLOSCHODOPLOS PUGETTENSIS	---	---	1	---	1
LAPITELLA CAPITATA	---	---	2	---	2
PHOLOE MINUTA	---	---	1	---	1
POLYDORA SP.	---	---	3	---	3
SPID. VINES FIMBRIATA	---	---	1	---	1
PRIMOSPPIO CIRRIFERA	---	2	---	---	2
ETEONE DILATAE	2	1	---	---	2
SCHISTOMERINGOS LONGICORNIS	1	1	1	---	3
ARTHROPODA				168	
AMPELISCA MILLERI	21	17	4	---	42
LEPTOCHELIA DUBIA	18	25	20	---	63
SARSIELLA ZOSTERICOLA	17	28	7	---	52
BALANUS CRENATUS	6	---	1	---	7
PTARMATA TUBERCULATA	1	1	---	---	1
PHOTIS SP.	---	1	---	---	1
COROPHIUM ACHERUSICUM	---	---	1	---	1
ACARINA-UNIDENTIFIED SPP.	---	---	1	---	1
MOLLUSCA				13	
MACOMA BALTHICA	1	---	---	---	1
POGODESMUS SP. - JUVENILE	1	---	---	---	1
MYTILUS EDULIS	1	---	---	---	1
ALVINIA COMPACTA	3	---	---	---	3
PROTHACA STAMINEA	---	1	---	---	1
TAPEA JAPONICA	---	1	---	---	1
GEMMA GERMA	---	1	---	---	1
MYSELLA FERRUGINOSA	---	1	1	---	2
MUSCULUS SEMMOUSTA	---	---	1	---	1
MACOMA INQUINATA	---	---	1	---	1
ECTOPROCTA				?	
HIPPOTHOA HYALINA	P	P	P	---	P
SMITTOIDEA PROLIFICA	P	---	---	---	P
ELECTRA ARCTICA	---	---	---	---	P
ALCIONIDION PARASITICUM	---	---	---	---	P
ANASCA-UNIDENTIFIED SPP.	P	---	---	---	P

HP
Survey 2

HP
Survey 2

STATION HP	SURVEY NO. 2 (CONT.)	TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
			1	2	3		
		PHORONIDA					
		PHORONIS SP.	2	--	--	5	2
		PHORONOPSIS VIRIDIS	--	3	--		3
		ENIGMATA					
		ENIGMATICA	1	--	--	1	1
GRAND TOTALS			62	759	781	405	1945

SB-A
Survey 2

STATION SB-A

SURVEY NO. 2

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3	4		
PROTOZOA FORAMINIFERA-UNIDENTIFIED SPP.	1	3	4		13	13
CNIDARIA DIADUMENE SP. CAMPANULARIA SP. HALIPLANELLA SP.	1 P --	-- -- --	2 P 19		22	3 P 19
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	--	--	6		6	6
NEMATODA NEMATODA-UNIDENTIFIED SPP.	652	540	782		1974	1974
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	1908	714	1419		4041	4041
ANNELIDA-POLYCHAETA HAPLOSCOPUS PUGETTENSIS GLYCIDE SP. STREBLOSPIO BENEDICTI SPHAEROSYLIS SP. EKOGONE LOUREI COSSURA PYGODACTYLATA THARYX PARVUS ETEDNE LIGHTI ASYCHIS SP. HARMOTHE IMBRICATA PSEUDOPOLYDORA KEMPI CALIFORNICA HEMEROMASTUS FILIPONIS CAPITELLA CAPITATA PSEUDOPOLYDORA PAUCIBRANCHIATA POLYDORA LIGNI ETEDNE LUNGA CALIFORNICA AUTOLYTUS SP.	3 1 47 33 339 15 7 1 1 1 1 63 44 1 -- -- -- --	1- 2 21 12 348 8 1 1 -- 1 1 39 54 18 1 -- -- -- --	-- -- 16 99 231 1 1 2 1 1 1 3 66 7 -- -- -- -- -- --		1551	4 3 84 144 918 24 6 3 3 3 105 164 26 1 3 1 2

SB-A
Survey 2

STATION SB-A SURVEY NO. 2 (CONT.) TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	1	2	4			
THARYX SP.	1	1	3			3
NARINOTHOE SP. - JUVENILE	1	2	2			1
SCHISTOMERINGOS LONGICORNIS	7	2	2			11
POLYDORA CAULLERYI	4	25	5			36
NARINOTHOE SP.	1	1	1			1
NARINOTHOE SP.	2	1	1			3
ARTHROPODA					291	
AMPELISCIA MILLERI	4	51	5			60
PARAPLEUSTES PUGETENSIS	1	1	1			2
GRANDIDIERELLA JAPONICA	1	2	1			3
ACARINA-UNIDENTIFIED SPP.	14	29	29			43
COPEPODA-UNIDENTIFIED SPP.	8	1	15			24
CORPULUM ACHERUSICUM	1	1	4			4
SYNDOTEA LATICAUDA	2	2	2			4
PSYCHRODONTIA-UNIDENTIFIED JUVENILE	1	1	1			1
SARSIELLA ZOSTERICOLA	39	7	102			148
CORPULUM INSIDIOSUM	1	1	1			1
OSTRACODA-UNIDENTIFIED SPP.	1	1	1			1
MOLLUSCA					938	
MUSCULUS SEMMOUSIA	1	1	1			1
TAPES JAPONICA	148	189	434			791
GENNA GENNA	1	15	44			60
ISELIGIA OVOIDES	15	19	35			69
MYA ARENARIA	1	2	1			2
MACDONA NASUTA	1	2	1			2
CREPIDULA CORVEE	1	1	3			4
OSTOSTOMIA (MENESTHO) FETELLA	1	1	1			1
OSTREA LURIDA - JUVENILE	1	1	1			1
MACDONA BALTHICA	1	1	2			2
NUDIBRANCHIA-UNIDENTIFIED SPP.	1	1	5			5
ECTOPROCTA					P	
HEMIRANIPORELLA SP.	1	1	P			P
CORPEUM RETICULUM	1	1	P			P
CHEILOSTOMATA-UNIDENTIFIED SPP.	1	1	P			P
CHORDATA					23	
CIONA INTESTINALIS	7	1	16			23
GRAND TOTALS	3383	2101	3375		9859	8850

SB-B
Survey 2

STATION SB-B

SURVEY NO. 2

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
Cnidaria					
Campanulata sp.					
Nemertea					
Nemertea-identified spp.	1	—	—	1	1
Nematoda					
Nematoda-identified spp.	917	15	30	962	962
Annelida-Oligochaeta					
Oligochaeta-identified spp.	1345	467	313	2125	2125
Annelida-Polychaeta					
Harmothoe imbricata	4	—	1	489	5
Haploscoloplos pugettensis	8	2	11		11
Eteone ligiti	4	4	12		20
Streblospio benedicti	3	59	721		783
Asychis sp.	11	59	33		102
Cossura pygocetylata	42	37	37		116
Pseudopolydora paucibranchiata	2	—	—		2
Pseudopolydora kempii californica	4	17	63		34
Polydora ligni	15	54	137		206
Sphaerosyllis sp.	252	4	16		274
Eteone lourei	1683	204	212		2159
Heteronastus filiformis	293	109	96		498
Cirratus cirratus	266	47	28		361
Capitella capitata	8	2	1		11
Eteone longa californica	—	12	16		28
Glycinde sp.	—	1	—		1
Polynoidae-identified juvenile	—	1	1		2
Cirriformia spirabranchia	—	—	1		1
Lumbrineridae-identified spp.	—	—	1		1
Nephtys cornuta franciscana	—	—	1		1
Schistomerinus longicornis	68	29	2		99
Schistomerinus sp. - juvenile	—	—	4		4
Lysidice ninetta	24	1	1		30

SB-B
Survey 2

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
POLYDORA CAECA	2	--	--		2
AUTOMYTUS SP.	--	3	--		3
EUMIDA SP.	--	1	--		1
THARYX SP. - JUVENILE	--	--	1		1
CHAETOLONE SP. - JUVENILE	--	--	1		1
ARTHROPODA				2733	
LINNAEIA QUADRIPUNCTATA	1	--	--		1
COROPHIUM ACHERUSICUM	2	--	--		2
COPEPODA-UNIDENTIFIED SPP.	270	1	--		271
LEPTOCHELIA DUBIA	75	2	1		78
PHYCONEIDA-UNIDENTIFIED SPP.	4	--	--		7
ACARINA-UNIDENTIFIED SPP.	1856	--	--		1856
AMPELISCA MILLERI	5	49	291		345
GRANDIDIERELLA JAPONICA	--	3	2		5
SARSIELLA SP.	--	25	--		25
CIRRIPEdia-UNIDENTIFIED SPP.	--	1	--		1
COROPHIUM SP.	--	1	--		1
CIRRIPEdia-UNIDENTIFIED LARVA	--	20	--		20
SARSIELLA ZOSTERICOLA	62	--	59		121
MOLLUSCA				336	
MUSCULUS-SEMIOUSIA	164	26	15		205
MYA ARENARIA	1	--	--		1
TAPES JAPONICA	71	30	10		111
MACOMA BALTICA	1	--	--		1
ISELICA OVOIDEA	6	3	--		9
CREPIDULA CONVEXA	6	--	--		6
OS/REA LURIDA	--	1	--		1
GENNA GENNA	--	--	1		1
MACOMA NASUTA	--	--	1		1
ECTOPROCTA				P	
SNITTOIDEA PROLIFICA	P	--	--		P
CONOPEUM RETICULUM	P	--	--		P
TRICELLARIA SP.	P	--	--		P
BOWERSANKIA GRACILIS	P	--	--		P
CHORDATA				L	
CIONA INTESTINALIS	--	2	2		4
ANAROCUUM SP.	--	--	P		P
GRAND TOTALS	61	7502	1291	10969	10969

STATION RCH-A

SURVEY NO. 2

RCH-A
Survey 2

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
PROTOZOA					
FORAMINIFERA-UNIDENTIFIED SPP.	--	--	1	1	1
CNIDARIA					
CAMPANULARIA SP.	P	P	--	2	P
DIADUMENE SP.	1	--	1		2
NEMATODA					
NEMATODA-UNIDENTIFIED SPP.	122	249	91	462	462
ANNELIDA-OLIGOCHAETA					
OLIGOCHAETA-UNIDENTIFIED SPP.	792	972	402	2166	2166
ANNELIDA-POLYCHAETA					
PSEUDOPOLYDORA PAUCIORANCHIATA	9	31	17	1375	57
POLYDORA LIGNI	57	163	242		462
SPHAEROSYLIS SP.	6	111	29		146
EXOCOME LOUREI	77	240	272		589
HETERONASTUS FILIFORMIS	40	10	31		81
STREBLOSPIO BENEDICTI	--	1	2		3
ETEDNE LONGA CALIFORNICA	--	1	1		2
ETEDNE LIGHTI	--	1	1		1
POLYCTRAUS SP.	--	2	--		4
CUSSURA PYGODACTYLATA	--	15	4		19
ASYCHIS SP.	--	3	--		3
PSEUDOPOLYDORA KENPI CALIFORNICA	--	1	1		1
GLYCINDE SP.	--	--	1		1
PYGOSPIO SP.	--	--	1		1
MARPHISA SANGUINEA	2	3	--		5
ARTHROPODA					
GRANDIDIERELLA JAPONICA	2	19	10	5462	51
COROPHIUM SP., CF INSIDIOSUM	1	--	--		1
AMPELISCA MILLERI	291	2172	3531		2004
ACARINA-UNIDENTIFIED SPP.	173	12	--		145

RCH-A
Survey 2

STATION RCH-A SURVEY NO. 2 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF SPECIMENS GROUP	SPECIMENS TAXA
	1	2	3		
SARISTELLA SP.	4	--	--		4
COMPTONIA-UNIDENTIFIED SPP.	3	33	--		36
SARISTELLA ZOSTERICOLA	--	90	93		183
SYNDOTEA SP.	--	1	--		1
LEPTOCHEILIA DUBIA	--	2	1		3
COROPHIUM SP.	--	--	4		4
MOLLUSCA				165	
MUSCULUS SEMIDUSIA	21	49	73		143
TAPES JAPONICA	--	10	10		20
MYA AREMARIA	--	1	--		1
MACOMA BALTHICA -- JUVENILE	--	--	1		1
ECTOPROCTA				P	P
ELECTRA ARCTICA	P	--	--		
CHORDATA					
CIDNA INTESTINALIS	--	--	1	1	1
GRAND TOTALS	36	1601	4192	4821	10614

STATION RCH-8					
TAXA	SURVEY NO. 2			NUMBER OF GROUP	SPECIMENS TAXA
	SAMPLE NO.				
	1	2	3		
PROTOZOA FORAMINIFERA-UNIDENTIFIED SPP.	18	26	--	44	44
CNIDARIA CAMPANULARIA SP.	P	--	--	P	P
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	8	9	--	17	17
NEMATODA NEMATODA-UNIDENTIFIED SPP.	110	97	54	251	261
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	399	215	85	699	699
ANNELIDA-POLYCHAETA STREMLCSPIO BENEDICTI PSEUDOPOLYDORA PAUCIBRANCHIATA PSEUDOPOLYDORA KEMPI CALIFORNICA EXOGENE LOUREI SPHAEROSYLLIS SP. COSSURA PYGODACTYLATA HETERCHASTUS FILIFORMIS CAPITELLA CAPITATA THARYX PARVUS CIRRIFORMIA SPIRABRANCHIA POLYDORA LIGNI SCHISTOHERINGUS LONGICORNIS	1261 18 7 158 54 72 10 2 1 1 4 1	1016 15 37 91 21 76 9 17 -- -- -- -- --	578 5 4 44 8 56 18 -- -- -- -- 1	3585	2855 38 48 293 83 204 37 19 1 1 4 2
ARTHROPODA AMPELISCA MILLERI ARACHNIDA-UNIDENTIFIED SPP. COPEPODA-UNIDENTIFIED SPP. PYCNOGONIDA-UNIDENTIFIED SPP.	1117 1 33 --	602 -- 14 1	535 -- 8 --	2583	2254 1 55 1

RCH-B
Survey 2

STATION RCH-B SURVEY NO. 2 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS , VA
	1	2	3		
GRANDIDIERELLA JAPONICA	1	1	1		2
SARSTIELLA ZOSTERICOLA	127	99	44		270
MOLLUSCA				47	
MUSCULUS SENNOISTA	17	6	6		29
MACOMA NASUTA - JUVENILE	2	2	2		2
TAPES JAPONICA	2	2	2		4
ODOSTOMIA (EVALEA) SP. A	1	1	1		1
GENNA GENNA	1	4	1		5
NASSARIUS DRSOLETUS	1	1	1		1
ODOSTOMIA (EVALEA) FRANCISCANA	1	1	1		1
ODOSTOMIA (EVALEA) TENUTISCUPTA	1	1	1		1
MACOMA NASUTA	1	1	2		2
MYA ARENARIA	1	1	1		1
GRAND TOTALS	3425	2358	1453	7236	7236

MIS-A
Survey 3

STATION MIS-A

SURVEY NO. 3

TAXA	SAMPLE NO.			NUMBER OF SPECIMENS GROUP	SPECIMENS TAXA
	1	2	3		
NEMATODA NEMATODA-UNIDENTIFIED SPP.	3	6	14	23	23
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	1	4	6	11	11
ANNELIDA-POLYCHAETA STREBLOSPIO BENEDICTI	--	1	--	1	1
ARTHROPODA COPEPODA-UNIDENTIFIED SPP. AMPELISCA MILLERI INSECTA-UNIDENTIFIED LARVA	-- -- --	1 1 --	15 -- 1	18	16 1 1
ECTOPROCTA MEMBRANIPORA PERFRAGILIS	P	P	P	P	P

GRAND TOTALS	7	4	13	36	53	53

MIS-B
Survey 3

STATION MIS-B

SURVEY NO. 3

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
NEMATODA					
NEMATODA-UNIDENTIFIED SPP.	30	100	54	184	184
ANNELIDA-OLIGOCHAETA					
OLIGOCHAETA-UNIDENTIFIED SPP.	3752	4185	3777	11714	11714
ANNELIDA-POLYCHAETA					
STRELOSPIO BENEDICTI	9	46	64	124	119
NEANTHES SUCCINEA	3	2	--		5
SIPUNCULA					
SIPUNCULA-UNIDENTIFIED SPP.	1	--	--	1	1
ARTHROPODA					
COPEPODA-UNIDENTIFIED SPP.	1	52	38	91	91
MOLLUSCA					
MACOMA BALTHICA	4	11	5	36	20
MUSCULUS-SENHOUZIA	--	1	--		1
MYA ARENARIA	--	6	7		13
ODOSTOMIA (MENESTHO) FETELLA	--	--	1		1
PELECYPODA-UNIDENTIFIED JUVENILE	1	--	--		1
ECTOPROCTA					
MEMBRANIPORA PERFRAGILIS	P	P	P	P	P
GRAND TOTALS	3801	4403	3946	12150	12150

CS-A
Survey 3

STATION CS-A						
TAXA	SURVEY NO. 3			NUMBER OF GROUP	SPECIMENS TAXA	
	SAMPLE NO.					
	1	2	3			
NEMATODA						
NEMATODA-UNIDENTIFIED SPP.	26	1	10	37	37	
ANNELIDA-OLIGOCHAETA						
OLIGOCHAETA-UNIDENTIFIED SPP.	72	49	48	169	169	
ANNELIDA-POLYCHAETA						
GLYCINDE SP.	1	1	1	6	3	
STREBLOSPID BENEDICTI	1	--	--		1	
HETEROMASTUS FILIFORMIS	--	--	1		1	
NEANTHES SUCCINEA	--	--	1		1	
ARTHROPODA						
PARAPHOXUS MILLERI	1	7	2	21	10	
DECAPODA-UNIDENTIFIED LARVA	1	--	--		1	
HALACARIDAE-UNIDENTIFIED SPP.	1	--	--		1	
COPEPUDA-UNIDENTIFIED SPP.	--	1	1		2	
BALANUS SP.	--	1	--		1	
BALANUS CARIOSUS	--	--	6		6	
MOLLUSCA						
MYA ARENARIA	1	62	--	67	63	
MYTILUS EDULIS	--	2	--		2	
MUSCULUS SENHOUZIA	--	1	--		1	
NASSARIUS OBSOLETUS	--	1	--		1	
ECTOPROCTA						
CONOPEUM RETICULUM	P	--	--	P	P	
MEMBRANIPORA PERFRAGILIS	--	P	P		P	
GRAND TOTALS	18	104	126	70	300	

CS-B
Survey 3

STATION CS-B			SURVEY NO. 3			SAMPLE NO. 3			NUMBER OF GROUP	SPECIMENS TAXA
TAXA	1	2	3	1	2	3				
CNIDARIA										
CNIDARIA-UNIDENTIFIED SPP.	P	P	P					P		P
NEMATODA										
NEMATODA-UNIDENTIFIED SPP.	69	71	17					157		157
ANNELIDA-OLIGOCHAETA										
OLIGOCHAETA-UNIDENTIFIED SPP.	640	415	337					1392		1392
ANNELIDA-POLYCHAETA										
STREBLOSPIO BENEDICTI	26	11	32					82		69
GLYCINDE SP.	1	2	3							6
ETEDNE LIGHTI	--	1	2							3
METEROMASTUS FILIFORMIS	--	--	1							1
THARYX SP.	--	--	1							1
NEANTHES SUCCINEA	--	2	--							2
ARTHROPODA										
BALINUS CARIOSUS	41	--	--					42		41
PYCNOGONIDA-UNIDENTIFIED SPP.	--	--	1							1
MOLLUSCA										
MYA ARENARIA	9	35	6					122		50
MACOMA BALTHICA	16	16	15							47
MUSCULUS SEMHOUSIA	--	2	--							2
TAPES JAPONICA	--	1	--							1
ODOSTOMIA (MENESTHO) FETELLA	--	11	--							11
ODOSTOMIA (EVALEA) TENUSCULPTA	--	8	--							8
ODOSTOMIA (EVALEA) FRANCISCANA	--	1	--							1
ODOSTOMIA (EVALEA) SP., CF DELICIOSA	--	2	--							2
GRAND TOTALS	802	578	415					1795		1795
				19						

ALC
Survey 3

STATION ALC

SURVEY NO. 3

TAXA	SAMPLE NO.				NUMBER OF GROUP	SPECIMENS TAXA
	1	3	4			
PORIFERA DEMOSPONGIAE-UNIDENTIFIED SPP.	--	--	P		P	P
NEMATODA NEMATODA-UNIDENTIFIED SPP.	--	2	--		2	2
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	--	1	--		1	1
ARTHROPODA DIASTYLOPSIS SP. ISCHYROCERUS SP.	1 --	-- 1	-- --		2	1 1
MOLLUSCA MACOMA NASUTA ADULA DIEGENSIS	1 --	-- 1	-- --		2	1 1
ECTOPROCTA ELECTRA ARCTICA CONOPEUM RETICULUM	P --	-- --	-- P		P	P P

GRAND TOTALS

9

2

5

P

7

7

OIH
Survey 3

		STATION OIH		SURVEY NO. 3		SAMPLE NO. 3		NUMBER OF GROUP	SPECIMENS TAXA
TAXA		1	2	1	2	1	2		
PROTOZOA									
FORAMINIFERA-UNIDENTIFIED SPP.		2	--	--	--			2	2
PORIFERA									
Demospongiae-UNIDENTIFIED SPP.		--	--	--	--	P		P	P
Cnidaria									
STYLATULA ELONGATA		1	--	--	--	4		6	5
CAMPANULARIA SP.		P	--	--	--	--			P
HYDROZOA-UNIDENTIFIED SPP.		--	P	--	--	--			P
HALIPLANELLA SP.		--	--	--	--	1			1
NEMERTEA									
NEMERTEA-UNIDENTIFIED SPP.		16	6	22				44	44
NEMATODA									
NEMATODA-UNIDENTIFIED SPP.		1083	240	907				2230	2230
ANNELIDA-OLIGOCHAETA									
OLIGOCHAETA-UNIDENTIFIED SPP.		5541	3284	4259				13084	13084
ANNELIDA-POLYCHAETA									
HAPLOSCOPLOS PUGETTENSIS		10	4	--	--			14991	14
PHOLOE MINUTA		3	5	6					14
AMANDIA BREVIS		1	1	--	--				2
ETEONE LIGHTI		3	4	1					8
ETEONE LONGA CALIFORNICA		3	5	2					10
DISOMA MULTISETOSUM - JUVENILE		1	--	--	--				1
PSEUDOPOLYDORA PAUCIBRANCHIATA		2	2	2					6
STREBLOSPIO BENEDICTI		5792	3951	4381					14124
ASYCHIS SP.		2	1	2					5
SPHAEROSYLLIS SP.		92	85	38					215
EXOGONE LOUREI		104	218	145					467
CAPITELLA CAPITATA		5	1	1					7

OIH
Survey 3

STATION OIH	SURVEY NO. 3 (CONT.)	SAMPLE NO.			NJWREN JF GROUP	SPECIMENS TAXA
		1	2	3		
GYPTIS BREVIPALPA		1		1		2
NEPHYS CAECIOIDES		2	3			5
NEPHYS CORNUA FRANCISCANA		1	9	5		15
GLYCINDE SP.		6	6	5		17
PECTINARIA CALIFORNIENSIS		5	8	10		23
COSSURA PYGODACTYLATA			1			1
NEANTHES SP.			1			1
CAPITELLA SP.			10			10
POLYDORA LIGNI			1			1
DISONIA MULTISETOSUM			1			1
NEPHYS PARVA				2		2
THARYX PARVUS				1		1
ETEONE SP., CF DILATAE				1		1
HAPLOSCOPLOS PUGETIENSIS - JUVENILE				5		9
MEDOMASTUS CALIFORNIENSIS				1		1
GLYCERA AMERICANA				1		1
ETEONE DILATAE		2				2
SCOLELEPSIS SQUAMATA		2	2			4
MESONELLA MCCULLOCHAE		1				4
SPIOPHANES SP.				3		1
SCHISTOMERINGOS LONGICORNIS		8	1	4		13
POLYDORA CAULERYI			1			1
TEREBELLIDAE-UNIDENTIFIED JUVENILE				1		1
PRIONOSPID-CIRRIFERA				1		1
SIPUNCULA			29		29	
SIPUNCULA-UNIDENTIFIED SPP.						
ARTHROPODA						
COPEPODA-UNIDENTIFIED SPP.		5	2	1		8
ARACHNIDA-UNIDENTIFIED SPP.		1				1
PYCNOGONIDA-UNIDENTIFIED SPP.		1				1
PINNIXA FRANCISCANA		3	2	3		3
SARSTELLA ZOSTERICOLA		206	123	129		458
CUMELLA VULGARIS		151	132	48		331
AMPELISCA MILLERI		4		2		6
LEPTOCHELIA DUBIA		2	1	1		4
EUDORELLA SP.		4	1			5
? COPEPODA-UNIDENTIFIED SPP.						1
INSECTA-UNIDENTIFIED SPP.		1				1
MOLLUSCA						
GEMMA GEMMA		892	1200	821	3036	2913

OIH
Survey 3

STATION OIH SURVEY NO. 3 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
MACOMA NASUTA	47	40	12		99
MYTILUS EDULIS	8	--	--		8
MACOMA INQUINATA	--	1	--		1
MYSELLA FERRUGINOSA	--	1	2		3
MUSCULUS SENHOUSSIA	--	--	4		4
TRANSENNELLA TANTILLA	--	--	8		8
ECTOPROCTA				P	
BUCULA MERITIMA	P	P	--		P
ALCYONIDIUM PARASITICUM	P	--	--		P
COMPEUM RETICULUM	--	P	--		P
ECHINODERMATA					
HOLOTHUROIDEA-UNIDENTIFIED SPP.	41	--	24	65	65
GRAND TOTALS	14055	9384	10872	34311	34311

HP
Survey 3

TAXA	STATION HP			NUMBER OF GROUP	SPECIMENS TAXA
	SURVEY NO. 3				
	SAMPLE NO.				
	1	2	3		
CNIDARIA				19	19
HALIPLANELLA SP.	18	--	1		P
CAMPANULARIA SP.	P	P	P		
NEMERTEA				32	32
NEMERTEA-UNIDENTIFIED SPP.	14	4	14		
NEMATODA				21	21
NEMATODA-UNIDENTIFIED SPP.	8	6	7		
ANNELIDA-OLIGOCHAETA				29	29
OLIGOCHAETA-UNIDENTIFIED SPP.	17	9	3		
ANNELIDA-POLYCHAETA				658	4
POLYDORA SOCIALIS	2	1	1		2
PHOLOE MINUTA	1	1	--		2
ETEONE SP., CF LONGA CALIFORNICA	2	--	--		2
POLYDORA LIGNI	2	--	--		2
CAPITELLA CAPITATA	2	--	--		2
STREBLOSPIROBENEDICTI	5	6	3		14
ARNANDIA BREVIS	2	1	2		5
THARYX SP.	7	6	11		24
NEMPTYS CORNUTA FRANCISCANA	5	6	4		15
GLYCINDE SP.	1	1	--		2
EXOGONE LOUREI	78	65	57		200
SPHAEROSYLLIS SP.	5	6	3		14
MEDIONASTUS CALIFORNIENSIS	111	90	75		276
ASYCNIS SP.	10	27	15		52
CIRRATULUS CIRRATUS	--	5	--		5
ETEONE LONGA CALIFORNICA	--	1	--		1
COSSURA PYGODACTYLATA	--	--	1		1
GYPTIS BREVIPALPA	--	--	1		1
GLYCERA SP.	--	--	1		1
GLYCERA OXYCEPHALA	--	1	--		1
OPHIODROMUS PUGETTENSIS	--	1	--		1
NOTOMASTUS (CLISTOMASTUS) TENUIS	--	1	--		1
	5	--	--		5

HP
Survey 3

STATION HP SURVEY NO. 3 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
SPIOPHARES MISSIONENSIS					3
PILARGIS SP.	1	2	--		1
POLYDORA SOCIALIS - JUVENILE	1	--	--		1
DISONA MULTISEDUM	--	1	--		2
SCHISTOMERINUS LONGICORNIS	2	--	3		5
POLYDORA CAULLERYI	4	5	5		14
POLYDORA - JUVENILE	1	--	--		1
STINELANELLA UNIFORMIS	--	--	1		1
SIPUNCULA				2	2
SIPUNCULA-UNIDENTIFIED SPP.	--	2	--		
ARTHROPODA				65	37
AMPELISCA MILLERI	10	17	10		5
COROPHIUM SP.	2	1	2		7
LEPTOCHELIA DUBIA	5	--	2		1
PYROMAIA TUBERCULATA	1	--	--		12
SARSTIELLA ZOSTERICOLA	4	5	3		1
UPOGEBIA PUGETTENSIS	--	1	--		1
PHOTIS SP.	--	1	--		1
PHOTIS SP., CF. BREVIPE	--	--	1		1
MOLLUSCA				15	4
MACOMA NASUTA	2	2	--		4
GENNA GENNA	3	--	1		4
MYSELLA FERRUGINOSA	1	--	--		1
MUSCULUS SEMHOUSIA	--	1	--		1
MACOMA BALTHICA	--	--	5		5
GRAND TOTALS	334	275	232	341	941

SB-A
Survey 3

STATION SB-A

SURVEY NO. 3

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
PROTOZOA FORAMINIFERA-UNIDENTIFIED SPP.	2	--	--	2	2
CNIDARIA CAMPAULARIA SP. HALIPLANELLA SP. DIAUMENE SP.	P 7 --	P 29 --	P 16 3	55	P 52 3
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	--	3	1	4	4
NEMATODA NEMATODA-UNIDENTIFIED SPP.	40	63	365	449	449
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	230	347	570	1147	1147
ANNELIDA-POLYCHAETA PSEUDOPOLYDORA KEMPİ CALIFORNICA CUSSURA PYGMAEACTYLATA ASYCHIS SP. STREBLUSPIO BENEDICTI CAPITELLIDAE-UNIDENTIFIED SPP. EUDONE LIGHTI POLYDORIDAE-UNIDENTIFIED JUVENILE HARMTHOE IMBRICATA SPHAEROSTYLIS SP. EXOGENE LOUREI POLYDORA LONGI PSEUDOMASTUS FILIFORMIS PSEUDOPOLYDORA PAUCIBRANCHIATA HARMTHOE SP. - JUVENILE MARPHISA SANGUINEA CAPITELLA CAPITATA UDONOSTYLIS PARVA	16 6 14 18 4 1 3 4 163 504 11 64 1 -- -- -- 2	-- 1 -- 7 -- -- -- 5 102 422 6 110 7 9 2 3 9	1 1 2 6 -- -- 3 221 634 3 61 -- -- -- -- -- -- --	2568	17 6 16 31 4 1 6 10 486 1560 20 235 4 4 3 3 20

SB-A
Survey 3

STATION 59-A SURVEY NO. 3 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
POLYDORA CAULLERYI	74	37	1		112
SCHISTOMERINGOS LONGICORNIS	7	4	9		20
ARTHROPODA				2693	383
COPEPODA--UNIDENTIFIED SPP.	38	31	314		4
PSYCHOGONIDA--UNIDENTIFIED SPP.	2	1	1		114
SARISTELLA ZOSTERICOLA	29	63	22		2121
ACARINA--UNIDENTIFIED SPP.	143	279	1699		1
LEPTOCHELIA DUBIA	1	2	2		1
CRAMIDIERELLA JAPONICA	1	1	1		55
AMPELISCA MILLERI	35	15	5		1
SYNIDOTEA LATICAUDA	1	1	1		3
COROPHIUM ACHERUSICUM	1	3	1		1
PARAPLEUSTES SP.	1	1	1		5
COROPHIUM SP. Cf ACHERUSICUM	1	1	5		
MOLUSCA				961	149
TAPES JAPONICA	18	81	50		779
MUSCULUS SEMIROSTIA	34	420	325		1
CREPIDULA PLANA	1	1	1		19
ISELICA OVOIDEA	3	12	4		1
BUSYCON CANALICULATUM	1	1	1		1
MYA ARENARIA	1	1	1		1
EPITOMIUM TINCTUM	1	5	1		5
URDOLPINK CINEREA	1	2	1		2
GENNA GENNA	1	1	1		1
MACOMA BALTHICA	1	1	1		1
CREPIDULA CONVEXA	1	1	1		1
? MUSCULUS SEMIROSTIA - JUVENILE	1	1	1		1
ECTOPROCTA				P	P
ALCYONIDIUM POLYOM	P	1	1		P
ELECTRA CRUSTULENTA	1	1	1		P
CONOPEUM RETICULUM	1	1	1		P
CHORDATA				22	3
FISH LARVAE	3	7	12		10
CIONA INTESTINALIS	1	1	1		
GRAND TOTALS	54	1461	2089	4330	7900

SB-B
Survey 3

TAXA	STATION SB-B			SURVEY NO. 3			SPECIMENS		
							TAXA		
	1	2	3	1	2	3	NUMBERS OF GROUP	P	P
CNIDARIA									
CAMPANULARIA SP.				P	P	P			
NEMATODA									
NEMATODA-UNIDENTIFIED SPP.	2	1	--				3		3
ANNELIDA-OLIGOCHAETA									
OLIGOCHAETA-UNIDENTIFIED SPP.	129	193	583				910		910
ANNELIDA-POLYCHAETA									
ETEONE LIGHTI	1	--	2				1298		3
ETEONE LONGA CALIFORNICA	2	4	1						7
STREBLOSPIO BENEDICTI	45	35	21						101
POLYDORA LIGNI	52	97	89						238
PSEUDOPOLYDORA KEMPI CALIFORNICA	26	46	3						75
HARMOTHOE IMBRICATA	1	--	1						2
COSSURA PYGODACTYLATA	4	3	7						14
HAPLOSCHOLOPUS PUGETTENSIS	1	3	--						4
CIRRATULUS CIRRATUS	9	10	25						44
THARYX PARVUS	1	--	--						1
SMACROSYLLIS SP.	11	10	20						41
EXOONE LOUREI	113	163	125						401
ASYCHIS SP.	9	20	16						45
MARPHISA SANGUINEA	1	1	125						2
METEROMASTUS FILIFORMIS	64	92	--						281
ETEONE SP. CF LONGA CALIFORNICA	--	1	--						1
CAPITELLA CAPITATA	--	--	2						2
GLYCINDE SP.	--	--	1						1
POLYDORA CAULERYI	3	15	--						1
SCHISTOMERINGOS LONGICORNIS	4	4	5						16
HARMOTHOE SP. - JUVENILE	--	2	--						13
THARYX SP.	--	--	1						2
CHAETOZONE SP.	--	--	1						1
ARTHROPODA									
AMPELISCA MILLEKI	29	23	21				164		73

SB-B
Survey 3

STATION SB-3 SURVEY NO. 3 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
SARIELLA ZOSTERICOLA	24	25	18		67
PYCNOGONIDA-UNIDENTIFIED SPP.	2	1	--		3
LEPTOCHELIA DUBIA	1	6	3		10
PARAPLEUSTES SP., CF PUGETTENSIS	6	1	1		8
GRANDIDIERELLA JAPONICA	1	--	--		1
COPEPODA-UNIDENTIFIED SPP.	--	2	--		2
MOLLUSCA					
MYA ARENARIA	1	--	--	80	1
MACOMA SP. - JUVENILE	2	--	--		2
MUSCULUS SEMMOUSIA	10	2	2		14
TAPES JAPONICA	25	14	20		59
CREPIDULA PLANA	1	--	--		1
CREPIDULA CONVEXA	1	1	--		2
MACOMA INQUINATA	--	--	1		1
ECTOPROCTA					
MEMBRANIPORA SP.	--	P	--	P	P
AETEA ANGUTNA	--	P	--	P	P
ALCYONIDIUM POLYDUM	--	P	--	P	P
CHORDATA					
FISH LARVAE	--	1	--	1	1
GRAND TOTALS	44	581	776	1099	2456

RCH-A
Survey 3

STATION RCH-A				SURVEY NO. 3			SAMPLE NO. 3			NUMBER OF GROUP	SPECIMENS TAXA
TAXA	1	2	3	1	2	3					

PROTOZOA											
FORAMINIFERA-UNIDENTIFIED SPP.	1	6	--							7	7
CNIDARIA											
CAMPANULARIA SP.	P	P	P							2	P
DIADUMENE SP.	--	2	--								2
NEMERTEA											
NEMERTEA-UNIDENTIFIED SPP.	--	1	--							1	1
NEMATODA											
NEMATODA-UNIDENTIFIED SPP.	247	344	26							617	617
ANNELIDA-OLIGOCHAETA											
OLIGOCHAETA-UNIDENTIFIED SPP.	547	670	44							1261	1261
ANNELIDA-POLYCHAETA											
HETEROMASTUS FILIFORMIS	17	31	8							2106	56
GLYCINDE SP.	2	--	--								2
ETEONE LONGA CALIFORNICA	3	--	1								4
POLYNOIDAE-UNIDENTIFIED JUVENILE	2	--	--								2
STREBLOSPID BENEDICTI	176	122	15								313
THARYX SP.	1	4	--								5
PSEUDOPOLYDORA KEMPI CALIFORNICA	12	21	14								47
POLYDORA LIGNI	50	73	52								175
PSEUDOPOLYDORA PAUCIBRANCHIATA	1	--	--								1
ASYCHNIS SP.	12	14	14								40
COSSURA PYGODACTYLATA	104	99	7								210
SPHAEROSYLLIS SP.	198	143	4								345
EXOONE LOUREI	439	397	46								882
HAPLOTHOE IMBRICATA	--	2	3								5
HAPLOSCOPELOS PUGETTENSIS	--	1	1								2
CAPITELLA CAPITATA	--	1	1								2
TEREBELLIDAE-UNIDENTIFIED JUVENILE	--	4	--								4
ETEONE LIGHTI	--	--	1								1

RCH-A
Survey 3

STATION RCH-A SURVEY NO. 3 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
POLYCIARUS SP. - JUVENILE	--	--	1		1
ETEONE LIGHTI - JUVENILE	--	1	--		1
SCHISTOSOMERINGS LONGICORNIS	--	2	--		2
HARMOTHOE SP. - JUVENILE	--	3	--		3
CAPITELLA SP.	--	2	--		2
AUTOLYTUS SP.	--	--	1		1
ARTHROPODA					
COPEPODA-UNIDENTIFIED SPP.	29	42	1	2866	72
PYCNOGONIDA-UNIDENTIFIED SPP.	2	--	--		2
ACARINA-UNIDENTIFIED SPP.	411	156	2		569
SARSIELLA ZOSTERICOLA	97	110	22		229
SYNDOTEA LATICAUDA	1	--	1		2
LEPTOCHELIA DUBIA	1	--	--		1
AMPELISCA MILLERI	774	525	676		1975
COROPHIUM SP.	1	--	--		1
COROPHIUM ACHERUSICUM	1	9	4		13
GRANDIDIERELLA JAPONICA	--	1	1		2
MOLLUSCA					
TAPES JAPONICA	4	7	16	61	27
GENNA GENNA	1	--	--		1
MUSCULUS SEMHOUSIA	12	2	14		28
MACOMA NASUTA	2	1	2		5
ECTOPROCTA					
ECTOPROCTA-UNIDENTIFIED SPP.	--	P	--	P	P
GRAND TOTALS	3147	2796	978	5921	6921

RCH-B
Survey 3

STATION RCH-8			SURVEY NO. 3			NUMBER OF GROUP	SPECIMENS TAXA	
TAXA	SAMPLE NO.			1	2			3
	1	2	3					
PROTOZOA								
FORAMINIFERA-UNIDENTIFIED SPP.	--	84	14			98	98	
CNIDARIA								
CAMPANULARIA SP.	--	P	--			P	P	
NEMERTEA								
NEMERTEA-UNIDENTIFIED SPP.	5	1	5			11	11	
NEMATODA								
NEMATODA-UNIDENTIFIED SPP.	85	87	30			202	202	
ANNELIDA-OLIGOCHAETA								
OLIGOCHAETA-UNIDENTIFIED SPP.	514	604	311			1429	1429	
ANNELIDA-POLYCHAETA								
EXOGONE LOUREI	40	3	15			4348	58	
STREBLOSPIO BENEDICTI	1781	887	1276				3944	
COSSURA PYGODACTYLATA	140	43	46				229	
POLYDORA LIGNI	1	--	--				1	
CAPITELLA CAPITATA	5	4	--				9	
CAPITELLIDAE-UNIDENTIFIED JUVENILE	2	--	--				2	
SPHAEROSYLLIS SP.	2	--	2				4	
PSEUDOPOLYDORA KEMPI CALIFORNICA	29	6	23				58	
ETEONE LIGHTI	1	--	--				1	
HETEROMASTUS FILIFORMIS	15	8	14				37	
NEPHTYS CAECINIDES	--	--	1				1	
NEANTHES SUCCINEA	--	--	2				2	
SCHISTOMERINGOS LONGICORNIS	2	--	--				2	
ARTHROPODA								
COPEPODA-UNIDENTIFIED SPP.	2	--	--			2392	2	
SARIELLA ZOSTERICOLA	48	37	51				146	
PYCNOGONIDA-UNIDENTIFIED SPP.	1	--	--				1	

RCH-B
Survey 3

STATION RCH-B SURVEY NO. 3 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
COROPHIUM SP. CF ACHERUSICUM	2	--	--		2
ANPELISCA MILLERI	1343	15	883		2241
MOLLUSCA				45	
MUSCULUS SEMMOUSIA	12	6	10		28
TAPES JAPONICA	2	--	2		4
NACOMA BALTHICA	4	--	--		4
ODOSTOMIA (EVALEA) VALDEZI	3	--	--		3
GEMMA GEMMA	1	3	--		4
ODOSTOMIA (EVALEA) SP.	--	1	--		1
NACOMA NASUTA	--	--	1		1
CHORDATA					
CIONA INTESTINALIS	1	--	--	1	1
GRAND TOTALS	4051	1789	2686	9526	8526
	31				

MIS-A
Survey 4

STATION MIS-A

SURVEY NO. 4.

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIENS TAXA
	1	2	3		
PROTOZOA VORTICELLA SP.	--	P	--	P	P
CNIDARIA HYDROZOA-UNIDENTIFIED SPP.	P	P	P	P	P
NEMATODA NEMATODA-UNIDENTIFIED SPP.	7	69	17	93	93
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	33	132	32	197	197
ARTHROPODA COPEPODA-UNIDENTIFIED SPP. AMPELISCA MILLERI ARACHNIDA-UNIDENTIFIED SPP.	5 -- --	6 1 --	12 -- 1	25	23 1 1
MOLLUSCA MACOMA BALTHICA ODOSTOMIA (EVALEA) FRANCISCANA	4 --	6 1	7 --	18	17 1
ECTODERMATA MEMBRANIPURA PERFRAGILIS	--	P	P	P	P
GRAND TOTALS	49	215	69	333	333

MIS-B
Survey 4

STATION MIS-B

SURVEY NO. 4

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
CNIDARIA HYDROZOA-UNIDENTIFIED SPP.	P	--	--	P	P
NEMATODA NEMATODA-UNIDENTIFIED SPP.	52	37	46	135	135
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	3812	4423	3690	11925	11925
ANNELIDA-POLYCHAETA ETEONE LIGHTI NEANTHES SUCCINEA STRELOSPIO BENEDICTI	1 3 28	1 3 42	2 1 65	146	4 7 135
ARTHROPODA COPEPODA-UNIDENTIFIED SPP. INSECTA-UNIDENTIFIED SPP.	21 --	15 --	12 1	49	48 1
MOLLUSCA MACOMA BALTHICA MYA ARENARIA	15 --	13 --	18 6	52	46 6
GRAND TOTALS	3932	4534	3841	12307	12307

CS-A
Survey 4

STATION CS-A

SURVEY NO. 4

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
CNIDARIA CAMPANULARIA SP.	--	P	--	P	P
NEMATODA NEMATODA-UNIDENTIFIED SPP.	54	942	271	1267	1267
ANNELIDA-OLIGCHAETA OLIGCHAETA-UNIDENTIFIED SPP.	1223	1779	1112	4114	4114
ANNELIDA-POLYCHAETA STREBLOSPIO BENEDICTI ETHEONE LIGHTI METEOMASTUS FILIFORMIS THARYX SP. NEANTHES SUCCINEA GLYCINDE SP. THARYX PARVUS PSEUDOPOLYDORA KEMPI CALIFORNICA	103 8 2 -- 2 1 1 1	42 8 1 2 1 2 -- --	36 2 1 -- -- 1 -- --	214	191 18 4 2 3 4 1 1
ARTHROPODA SYNDOTTEA LATICAUDA INSECTA-UNIDENTIFIED SPP.	1 --	-- --	-- 2	1	1 2
MOLLUSCA MACOMA BALTHICA MYA ARENARIA	24 5	35 --	36 --	130	95 5
ECTOPROCTA MEMBRANIPORA VILLOSA MEMBRANIPORA PERFRAGILIS ELECTRA ARCTICA CONUPEUM RETICULUM	-- -- -- --	P P -- --	-- P P P	P	P P P P
GRAND TOTALS	19	1425	2812	1461	5634

CS-B
Survey 4

STATION CS-8									
TAXA	SURVEY NO. 4			NUMBER OF GROUP	SPECIMENS TAXA				
	SAMPLE NO.								
	1	2	3						
PROTOZOA FORAMINIFERA-UNIDENTIFIED SPP.	--	2	--	2	2				
CNIDARIA HYDROZOA-UNIDENTIFIED SPP.	P	--	--	P	P				
NEMATODA NEMATODA-UNIDENTIFIED SPP.	3	68	14	85	85				
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	180	327	139	646	646				
ANNELIDA-POLYCHAETA STREBLOSPIO BENEDICTI EYEDONE LONGA CALIFORNICA POLYDORA LIGHTI - JUVENILE EYEDONE LIGHTI GLYCINDE SP.	1 1 -- --	1 -- 4 3 1	4 -- -- 3 --	18	6 1 4 6 1				
ARTHROPODA COPEPODA-UNIDENTIFIED SPP. AMPELISCA MILLERI MYSIDACEA-UNIDENTIFIED SPP.	1 -- --	4 2 --	2 -- 1	10	7 2 1				
MOLLUSCA MACOMA BALTHICA TAPES JAPONICA MYA ARENARIA	8 1 17	13 -- 2	11 -- --	52	32 1 19				
ECTOPROCTA MEMBRANIPORA VILLOSA MEMBRANIPORA PERFRAGILIS	-- --	-- --	P P	P	P P				

CS-B
Survey 4

STATION CS-B SURVEY NO. 4 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
ENIGNATICA	--	1	--	1	1
ENIGNATICA					
GRAND TOTALS	18	212	428	174	914
					814

ALC
Survey 4

TAXA	STATION ALC			NUMBER OF GROUP	SPECIMENS TAXA
	SURVEY NO. 4				
	SAMPLE NO.				
	1	2	3		
PROTOZOA FORAMINIFERA-UNIDENTIFIED SPP.	--	--	1	1	1
CNIDARIA HYDROZOA-UNIDENTIFIED SPP.	--	--	P	P	P
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	5	12	3	20	20
NEMATODA NEMATODA-UNIDENTIFIED SPP.	--	24	32	56	56
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	2	8	7	17	17
ANNELIDA-POLYCHAETA GLYCERA TENUIS SCOLELEPSIS SQUAMATA ANATIDES WILLIAMSII STREPTOSYLLIS SP. MEDIOMASTUS CALIFORNIENSIS MESOMURA SP. NEPHTYS CALIFORNIENSIS POLYDORA CAULLERYI - JUVENILE SPIOPHANES BOMBAY	9 1 1 122 -- -- -- -- -- -- --	12 -- -- 601 1 115 -- -- -- -- --	8 -- -- 363 -- 74 1 2 4	1314	29 1 1 1086 189 1 2 4
ARTHROPODA LAMPROPS SP., CF QUADRIPALATA AMPELISCA MILLERI COROPHIUM ACHERUSICUM PARAPHOXUS MILLERI PHOTIS SP.	1 2 -- -- --	-- 1 -- -- --	1 -- 1 1 1	8	2 2 2 1 1

ALC
Survey 4

STATION ALC SURVEY NO. 4 (CONT.)				
TAXA	SAMPLE NO.			NUMBER OF SPECIMENS GROUP TAXA
	1	2	3	
MOLLUSCA				
ADULA DIEGENSIS	1	--	--	3
TELLINA MODESTA	1	1	--	2
ECTOPROCTA				
HIPPOTHOA HYALINA	P	--	P	P
CALLOPORA ARMATA	--	--	P	P
SCRUPOCELLARIA SP.	--	--	P	P
TEGELLA ARMIFERA	--	--	P	P
TRICELLARIA SP.	--	--	P	P
CRISTIA MAXIMA	--	--	P	P
SCHIZOPORELLA SP.	--	--	P	P
GRAND TOTALS	28	145	775	499
				1410
				1410

OIH
Survey 4

STATION OIH						
TAXA	SURVEY NO. 4		NJ496A UP GROUP	SPECIMENS TAXA		
	SAMPLE NO.					
	1	2			3	

Cnidaria						
STYLATULA ELONGATA	--	1	1	1		
PLUMULARIA SP.	--	P	--	P		
Nemertea						
NEMERTEA-UNIDENTIFIED SPP.	5	--	13	13		
Nematoda						
NEMATODA-UNIDENTIFIED SPP.	20	206	1366	1592		
Annnelida-Oligochaeta						
OLIGOCHAETA-UNIDENTIFIED SPP.	378	585	2136	2136		
Annnelida-Polychaeta						
NEPHTYS CORNUTA FRANCISCANA	2	--	4	6		
PHOLOE MINUTA	3	--	3	6		
DISOMA MULTISETOSUM	1	1	--	2		
NEPHTYS CAECOIDES	3	4	2	9		
ETEONE LIGHTI	21	14	26	61		
GLYCINDE SP.	1	1	--	2		
SCOLELEPSIS SQUAMATA	2	2	1	5		
SCOLELEPSIS SQUAMATA - JUVENILE	3	--	--	3		
CAPITELLA CAPITATA	3	1	3	7		
STREBLOSPIO BENEDICTI	139	154	286	579		
SCHISTOMERINGOS LONGICORNIS	3	1	4	P		
SPHAEROSYLLIS SP.	4	3	8	15		
EXOONE LOUREI	64	53	208	325		
POLYDORA LIGNI	--	--	3	3		
COSSURA PYGODACTYLATA	--	1	2	3		
PECTINARIA CALIFORNIENSIS	--	2	1	3		
MEDIONASTUS CALIFORNIENSIS	--	--	1	1		
HARMOTHOE IMBRICATA	--	--	3	3		
ETEONE LONGA CALIFORNICA	--	--	1	1		
HETERONASTUS FILIFORMIS	--	2	--	2		
SPIOPHANES MISSIONENSIS	--	1	--	1		
GYPTIS BREVIPALPA	--	1	--	1		

OIH
Survey 4

STATION OIH SURVEY NO. 4 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
CIRRATULUS CIRRATUS	--	1	--		1
ARTHROPODA				132	2
PINNIXA FRANCISCANA	1	--	1		1
PSYCHOGONIDA-UNIDENTIFIED SPP.	1	--	--		1
SARSIELLA ZOSTERICOLA	11	3	4		18
EUDORELLA SP.	1	--	1		2
CUMELLA VULGARIS	45	11	9		65
COPEPODA-UNIDENTIFIED SPP.	1	8	10		19
AMPELISCA MILLERI	4	1	7		14
COROPHIUM ACHERUSICUM	6	--	4		10
CALLIANASSA CALIFORNIENSIS	--	--	1		1
MOLLUSCA				315	86
MACOMA NASUTA	19	38	29		14
MACOMA INQUINATA	7	3	4		4
MYTILUS EDULIS	2	--	2		1
MUSCULUS SENHOUZIA	1	--	--		5
MYSELLA FERRUGINOSA	3	2	--		204
GEMMA GEMMA	120	35	49		1
TELLINA MODESTA	--	--	1		
ECTOPROCTA				P	P
CRYPTOSULA PALLASIANA	--	--	P		

GRAND TOTALS 45 876 1135 3225 5236 5236

HP
Survey 4

STATION HP

SURVEY NO. 4

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
PORIFERA PORIFERA-UNIDENTIFIED SPP.	—	—	P	P	P
Cnidaria MALIOLANELLA SP. CAMPAULARIA SP. BIMERIA SP.	3 P —	1 P P	16 P P	20	20 P P
NEMERTEA NEMERTEA-UNIDENTIFIED SPP.	22	8	13	43	43
NEMATODA NEMATODA-UNIDENTIFIED SPP.	20	22	9	51	51
ANNELIDA-OLIGOCHAETA OLIGOCHAETA-UNIDENTIFIED SPP.	7	15	19	41	41
ANNELIDA-POLYCHAETA NEPTYS CORNUTA FRANCISCANA GLYCINE SP. STRELOSPID BENEDICTI SCHISTOMERUS LONGICORNIS CIRRATUS CIRRATUS HAPLOSCOPUS PUGETTENSIS THARYX PARVUS GYPTIS BREVIPALPA DISOMA MULTISETOSUM ANATIDES SP. POLYDORA CAULLERYI POLYDORA LIGNI - JUVENILE POLYDORA SOCIALIS ENODINE LOUREI SPHAEROSYLIS SP. ASYCHIS SP.	20 10 3 1 3 12 1 6 1 3 1 9 5 208 7 8	43 8 — — 2 15 — — — 1 1 7 — 245 7 11	30 11 2 2 1 14 — 15 — — 2 9 — — 303 6 11	1534	93 29 5 3 6 41 21 1 1 6 1 25 5 2 756 20 30

HP
Survey 4

STATION HP SURVEY NO. 4 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
MEDIOASTUS CALIFURNIENSIS	101	160	143		404
CAPITELLIDAE-UNIDENTIFIED JUVENILE	1				1
PALEANDIUS BELLIS			1		1
POLYDORA LIGNI		23	24		47
PHILOE MINUTA			1		1
PRIONOSPIO SP.			1		1
ETEONE LONGA CALIFORNICA		1	1		2
CAPITELLA CAPITATA		2	1		3
NEAR AMPHIDUROS-PACIFICUS			1		1
AUTOLYTUS SP.		2	3		5
TYPOSYLLIS SP.			1		1
ARMANDIA BREVIS		1			1
ETEONE SP. CF LONGA CALIFORNICA		2			2
GLYCERA SP.		3			3
THANX SP.		9			9
COSSURA PYGOMAGNYLATA		3			3
SABELLIDAE-UNIDENTIFIED spp.		1			1
SABELLARIA SP.		1			1
SPIOPHANES MISSIONENSIS		2			2
SIPUNCULA				3	
SIPUNCULA-UNIDENTIFIED SPP.	1				1
SIPUNCULUS SP.			2		2
ARTHROPODA				474	
SARSIELLA ZOSTERICOLA	22	19	19		60
EUDORELLA SP.	6	4	4		14
LEPTOCHELIA DUBIA	12	3	12		27
COROPHIUM ACHERUSICUM	66	92	114		272
AMPELISCA MILLERI	131	161	145		437
PROTOMEDEIA SP.	1				1
PARAPLEUSTES PUGETTENSIS	1				1
DECAPODA-UNIDENTIFIED SPP.		1			1
ACARINA-UNIDENTIFIED SPP.		33	9		42
COPEPODA-UNIDENTIFIED SPP.		1	3		4
CUMELLA VULGARIS		2			2
PARAPLEUSTES SP.		4			4
ANOMURA-UNIDENTIFIED LARVA		1			1
RITHROPODOPUS HARRISI		1			1
PYRUMATA TUBERCULATA			1		1
CANCER JORDANI			1		1
PARAPLEUSTES SP. CF PUGETTENSIS			2		2
CAPRELLIDEA-UNIDENTIFIED SPP.			2		2
PYCNOGONIDA-UNIDENTIFIED SPP.			1		1

HP
Survey 4

STATION HP SURVEY NO. 4 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
MOLLUSCA				29	
OSTREA LURIDA	1	1	1		1
MUSCULUS SEMMOUSIA	2	1	1		2
MYTILUS EDULIS	1	1	2		11
TRANSNELLIA TANTILLA	1	2	1		3
TAPES JAPONICA	1	1	1		1
MYZELLA FERRUGINOSA	1	1	1		1
NACOMA BALTICA	2	1	1		2
MODIOLUS SP.	1	1	1		1
MYTILUS ARCTICA	1	1	1		1
NACOMA INQUINATA	1	1	1		3
MYA ARENARIA	1	1	1		1
GENNA GENNA	1	1	2		2
ECTOPROCTA					
HIPPOINOA MYALINA	1	1	1	P	P
SMITTOIDEA PROLIFICA	1	1	1	P	P
MYTILUS					
MYTILUS SP.	P	1	1	P	P
ECHINODERMATA					
OPHIOUREIS SP.	1	1	1	2	1
MOLOTURIDAE-UNIDENTIFIED SPP.	1	1	1		1
PHORONIDA					
PHORONIDA-UNIDENTIFIED SPP.	1	1	1	2	1
PHORONIS SP.	1	1	1		1
ENICHTICA					
ENICHTICA	1	2	1	2	2
GRAND TOTALS	84	703	934	964	2601

STATION SB-A

SURVEY NO. 4

SAMPLE NO. 3

NUMBER OF SPECIMENS
GROUP TAXA

TAXA

TAXA	SAMPLE NO.			NUMBER OF SPECIMENS GROUP	TAXA
	1	2	3		
CNIDARIA					
SERTULARIA SP.	P	--	--	P	P
CAMPANULARIA SP.	P	P	--		P
NEMATODA					
NEMATODA-UNIDENTIFIED SPP.	69	30	17	116	116
ANNELIDA-OLIGOCHAETA					
OLIGOCHAETA-UNIDENTIFIED SPP.	591	304	398	1293	1293
ANNELIDA-POLYCHAETA					
CAPITELLA CAPITATA	22	8	12	1057	42
HETEROMASTUS FILIFORMIS	106	36	115		257
EXOGONE LOUREI	94	125	64		283
SCHISTOMERINGOS LONGICORNIS	2	1	2		5
STREBLOSPIO BENEDICTI	45	150	5		200
ETEONE LONGA CALIFORNICA	24	38	3		65
CIRRATULUS CIRRATUS	--	2	1		3
HARMOTHOE IMBRICATA	3	4	5		12
SPHAEROSYLLIS SP.	5	15	2		22
ETEONE LIGHTI	8	8	10		26
PSEUDOPOLYDORA KEMPI CALIFORNICA	5	10	1		16
POLYDORA CAULLERYI	12	10	1		23
POLYDORA LIGNI	14	33	11		58
MARPHYSA SANGUINEA	--	--	2		2
GLYCINDE SP.	4	7	7		16
HAPLOSCOLOPLOS PUGETTENSIS	3	--	--		3
THARYX SP.	2	--	--		2
ASYCHIS SP.	5	12	--		17
COSSURA PYGODACTYLATA	--	2	--		2
CIRRIFORNIA SPIRABRANCHIA	--	1	--		1
ARTHROPODA					
COPEPODA-UNIDENTIFIED SPP.	2	10	--	1341	12
SARSIELLA ZOSTERICOLA	4	37	2		43
SYNDOTEA LATICAUDA	3	--	--		3

SB-A
Survey 4

STATION SB-A SURVEY NO. 4 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
LEPTOCHELIA DUBIA	1	1	1		3
AMPELISCA MILLERI	66	684	24		774
COROPHIUM ACHERUSICUM	109	297	49		455
GRANDIERELLA JAPONICA	5	4	7		16
PYCNOGONIDA-UNIDENTIFIED SPP.	--	2	--		2
ACARINA-UNIDENTIFIED SPP.	--	17	--		17
CUMELLA VULGARIS	--	1	--		1
PARAPLEUSTES PUGETTENSIS	--	14	--		14
COROPHIUM SP.	--	--	1		1
MOLLUSCA					
TAPEA JAPONICA	362	27	375	828	764
MUSCULUS SENHOUSSIA	8	2	11		21
MYA ARENARIA	2	3	1		6
NUDIBRANCHIA-UNIDENTIFIED SPP.	4	--	2		6
ISELICA OVOIDEA	7	--	16		23
CREPIDULA CONVEXA	1	3	1		5
GENNA GENNA	--	2	1		3
ECTOPROCTA					
ALCYONIDIUM POLYDUM	P	--	--	P	P
ELECTRA CRUSTULENTA	P	P	--		P
CONOPEUM COMMENSALIS	P	--	--		P
ALCYONIDIUM PARASITICUM	--	--	P		P
MEMBRANIPORA VILLOSA	--	--	P		P
SCRUPOCCELLARIA SP.	--	P	--		P
CHORDATA					
CIONA INTESTINALIS	6	79	--	85	85
ENIGMATICA					
ENIGMATICA	1	--	--	1	1
GRAND TOTALS	1595	1979	1147	4721	4721
	51				

SB-B
Survey 4

STATION SB-8

SURVEY NO. 4

NUMBER OF SPECIMENS
GROUP TAXA

SAMPLE NO. 3
1 2

TAXA

PROTOZOA	2	1	--	3	3
FORAMINIFERA-UNIDENTIFIED SPP.					
PORIFERA	P	--	--	P	P
DENDROSPONGIAE-UNIDENTIFIED SPP.					
CNIDARIA	P	P	P	P	P
CAMPANULARIA SP.	P	--	--		P
HYDROZOA-UNIDENTIFIED SPP.	P	--	--		P
NEMATODA	17	16	3	36	36
NEMATODA-UNIDENTIFIED SPP.					
ANNELIDA-OLIGOCHAETA	334	136	210	580	680
OLIGOCHAETA-UNIDENTIFIED SPP.					
ANNELIDA-POLYCHAETA	26	16	27	3224	69
ASYCHIS SP.	44	81	46		171
HETEROMASTUS FILIFORMIS	6	9	7		22
HARMOTHUE IMBRICATA	4	11	7		22
GLYCINDE SP.	10	5	9		24
ETEONE LONGA CALIFORNICA	57	54	45		156
SCHISTOMERINGOS LONGICORNIS	5	3	4		12
CAPITELLA CAPITATA	33	26	32		81
MEDIOMASTUS CALIFORNIENSIS	1	--	--		1
COSSURA PYGODACTYLATA	10	1	5		16
CIRRATULUS CIRRATUS	21	11	9		41
POLYDORA CAULLERYI	18	33	11		62
POLYDORA LIGNI	40	54	47		141
PSEUDOPOLYDORA KEMPI CALIFORNICA	20	40	51		111
DISOMA MULTISETOSUM	1	--	--		1
STREBLOSPIO BENEDICTI	569	405	560		1534
EXOgone LOUREI	267	222	156		645
SPHAEROSYLLIS SP.	32	40	26		98

SB-B
Survey 4

STATION SB-8 SURVEY NO. 4 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
EIEONE SP., CF LIGHTII	--	3	--		3
HAPLOSCOPLOS PUGETIENSIS	--	3	--		3
LYSIDICE NINETTA	--	1	--		1
ARTHROPODA				6072	
SARSIELLA ZOSTERICOLA	48	51	40		139
PYCNOGONIDA-UNIDENTIFIED SPP.	4	16	13		33
LEPTOCHEMELIA DUBIA	1	1	--		2
COROPHIUM ACHERUSICUM	245	373	269		887
AMPELISCA MILLERI	711	2351	1845		4907
PARAPLEUSTES PUGETIENSIS	30	36	--		66
GRANDIDIERELLA JAPONICA	2	5	7		14
COPEPODA-UNIDENTIFIED SPP.	--	3	--		3
CUMELLA VULGARIS	--	2	2		4
ISOPODA-UNIDENTIFIED SPP.	--	3	--		3
? PYCNOGONIDA-UNIDENTIFIED JUVENILE	--	3	--		3
ACARINA-UNIDENTIFIED SPP.	--	8	--		8
SYNIDOTEA LATICAUDA	--	3	--		3
MOLLUSCA				84	
MACOMA BALTHICA	1	--	1		2
TAPES JAPONICA	16	20	3		39
GENNA GENNA	1	--	2		3
MUSCULUS SENHOUZIA	9	6	9		24
MYA ARENARIA	2	3	6		11
MYTILUS EDULIS	--	1	3		4
MACOMA NASUTA	--	--	1		1
ECTOPROCTA				P	P
MEMBRANIPORA VILLOSA	--	P	P		
CHORDATA				25	
CIONA INTESTINALIS	11	1	13		25
GRAND TOTALS	2598	4057	3469	13124	10124

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RCH-A
Survey 4

STATION RCH-A

SURVEY NO. 4

TAXA	SAMPLE NO.			NUMBER OF SPECIMENS	TAXA
	1	2	3	GROUP	
PROTOZOA					
FURANINIFERA-UNIDENTIFIED SPP.	6	--	5	11	11
PORIFERA					
HEXACTINELLIDA-UNIDENTIFIED SPP.	--	P	--	P	P
PORIFERA-UNIDENTIFIED SPP.	--	P	--		
CNIDARIA					
HYDROZOA-UNIDENTIFIED SPP.	--	P	--	1	P
CNIDARIA-UNIDENTIFIED SPP.	--	--	1		P
SERTULARIA SP.	--	--	P		P
CAMPANULARIA SP.	--	--			
NEMATODA					
NEMATODA-UNIDENTIFIED SPP.	418	762	142	1322	1322
ANNELIDA-DILICHAETA					
DILICHAETA-UNIDENTIFIED SPP.	2718	3180	3983	9981	9981
ANNELIDA-POLYCHAETA					
SCHISTONERINQOS LONGICORNIS	3	4	9	4507	16
COSSURA PYGODACTYLATA	9	44	49		102
SPHAEROSYLIS SP.	109	39	109		257
GLYCINDE SP.	7	3	12		27
HARMOTHOE IMBRICATA	11	6	12		29
STREBLOSPIO BENEICTI	441	1054	444		2139
HETEROMASTUS FILIFORMIS	73	76	94		243
ASYCHIS SP.	1	3	6		10
CAPITELLA CAPITATA	7	14	16		37
POLYDORA LIGNI	20	42	26		88
PSEUDOPOLYDORA KEMPI CALIFORNICA	51	119	50		220
EXOGONE LOUREI	300	255	475		1030
MARPHISA SANGUINEA	17	5	5		27
ETPONE LIGHTI	38	33	39		110
ETPONE LONGA CALIFORNICA	41	63	56		170

RCH-A
Survey 4

STATION RCH-A SURVEY NO. 4 (CONT.) TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
7 POLYCIRUS SP. HAPLOSCOPLOS PUGETENSIS POLYCIRUS SP. STREPTOSYLLIS SP. CAPITELLA SP. - JUVENILE SYLLIDAE-UNIDENTIFIED SP.	1 1 1 1 1	2 1 1 1 1	3 1 1 1 1		2 1 1 1 1 1
ARTHROPODA COROPHIUM ACHERUSICUM CUMELLA VULGARIS ACANTHA-UNIDENTIFIED SPP. GRANDIDIERELLA JAPONICA SYNDOTEA SP. PARAPLEUSTES SP. CF PUGETENSIS COPEPODA-UNIDENTIFIED SPP. SYNDOTEA LATICAUDA COROPHIUM SP. CF ACHERUSICUM AMPELISCA MILLERI PARAPLEUSTES PUGETENSIS SARSIGELLA ZOSTERICOLA SYNDOTEA SP. - JUVENILE INSECTA-UNIDENTIFIED SPP. BALANUS IMPROVISUS - JUVENILE MERICRAPSUS OREGONENSIS	85 13 145 10 1 1 34 1 75 2542 146 5 1 1	61 2 155 5 2 34 34 977 33 2 2 2 2	75 5 557 5 1 114 626 85 1 1 1 1 1	5825	221 20 857 20 1 6 192 1 75 4165 264 5 2 1 1
MOLLUSCA MACOMA NASUTA TAPES JAPONICA GEMMA GEMMA MYTILUS EDULIS MUSCULUS SEMMOUSTIA NASSARIUS OBSOLETUS MYA ARENARIA	80 2 1 3 2	3 80 1 1 1	180 4 1 1 1	165	3 340 7 2 10 1 2
ECTOPROCTA ELECTRA ARCTICA MEMBRANIPORA VILLOSA MEMBRANIPORELLA SP.	P P P	P P P	P P P	P	P P P
CHORDATA CICOMA INTESTINALIS			2	2	2
GRAND TOTALS	57	7639	7063	7212	21914

RCH-B
Survey 4

STATION RCH-B

SURVEY NO. 4

SAMPLE NO. 3

NUMBER OF SPECIMENS TAXA

TAXA

	1	2	3		520	520
PROTOZOA	143	134	243			520
FORAMINIFERA-UNIDENTIFIED SPP.						
CNIDARIA	--	P	--	P		P
SYNCORYNE SP.	--	P	P			P
HYDROZOA-UNIDENTIFIED SPP.						
NEMERTEA	--	7	1	8		8
NEMERTEA-UNIDENTIFIED SPP.						
NEMATODA	147	206	1231	1584		1584
NEMATODA-UNIDENTIFIED SPP.						
ANNELIDA-OLIGOCHAETA	444	1211	1266	2921		2921
OLIGOCHAETA-UNIDENTIFIED SPP.						
ANNELIDA-POLYCHAETA	13	4	7	2542		24
PSEUDOPOLYDORA KEMPI CALIFORNICA	1	--	8			9
POLYDORA LIGNI	2	4	3			9
GLYCINDE SP.	7	19	55			81
HETEROMASTUS FILIFORMIS	3	4	14			21
CAPITELLA CAPITATA	130	344	808			1282
STREBLOSPIO BENEDICTI	11	48	17			76
COSSURA PYGODACTYLATA	2	--	3			5
ETEONE LONGA CALIFORNICA	41	68	135			244
ETEONE LIGHTI	42	104	192			338
SPHAEROSYLLIS SP.	71	147	221			439
EXOGONE LOUREI	--	1	1			2
SCHISTONERINGS LONGICORNIS	--	1	3			4
ASYCHIS SP.	--	--	1			1
HARMOTHE SP. - JUVENILE	--	--	1			1
PSEUDOPOLYDORA PAUCIBRANCHIATA	--	--	1			1
SPIONIDAE-UNIDENTIFIED JUVENILE	--	--	1			1
MEDIOMASTUS CALIFORNIENSIS	1	--	2			3
CAPITELLIDAE-UNIDENTIFIED SPP.	--	--	2			2

RCH-B
Survey 4

STATION RCH-B SURVEY NO. 4 (CONT.)

TAXA	SAMPLE NO.			NUMBER OF GROUP	SPECIMENS TAXA
	1	2	3		
ARTHROPODA				6979	360
SARSIELLA ZOSTERICOLA	40	114	206		1
PYGMOGONIDA-UNIDENTIFIED SPP.	1	--	--		577
COPEPODA-UNIDENTIFIED SPP.	47	172	458		64
CUMELLA VULGARIS	6	17	41		245
COROPHIUM ACHERUSICUM	19	43	183		72
GRANDIDIERELLA JAPONICA	8	14	50		5438
AMELISCA MILLERI	1098	2164	2176		17
ACARINA-UNIDENTIFIED SPP.	--	3	14		1
SYNIDOTEA HARFORDI	--	--	1		1
OSTRACODA-UNIDENTIFIED SPP.	--	--	4		4
MOLLUSCA				128	61
MUSCULUS SENHOUSTIA	9	21	31		16
GEMMA GEMMA	4	6	6		30
MYA ARENARIA	12	9	18		1
TAPES JAPONICA	--	1	--		6
MACOMA NASUTA	--	5	1		1
SILTIQUA PATULA	--	1	--		1
ODOSTOMIA (EVALEA) VALDEZI	--	1	--		1
MYTILUS EDULIS	--	--	1		1
NASSARIUS OBSOLETUS	--	--	1		1
ODOSTOMIA (EVALEA) FRANCISCANA	--	--	1		1
GRAND TOTALS	2302	4873	7407	14582	14582
	44				

APPENDIX B
PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER

Survey P

PRELIMINARY SURVEY

SAMPLE NO.	TEMPERATURE (CENTIGRADE)	SALINITY (PARTS/1000)	DISSOLVED OXYGEN (MILLIGRAMS/LITER)	TURBIDITY (NU)	TOTAL SULFIDES (MICROGRAMS/LITER)	PH	DEPTH (FEET)	
MIS-A	1	12.9	4.3	8.6	450	10.0	7.7	36
	2	12.7	4.0	8.5	65	4.2	7.8	
MIS-B	1	12.0	3.4	9.0	130	6.1	7.7	36
	2	12.5	3.2	8.9	65	8.6	7.8	
CS-A	1	13.2	12.4	7.7	240	2.6	7.9	48
	2	13.1	5.2	8.2	85	7.3	7.9	
CS-B	1	13.5	7.6	8.0	>500	7.6	7.8	46
	2	13.0	6.8	8.4	>500	15.0	7.8	
ALC	1	11.5	28.5	7.4	11	2.1	8.0	90-150
UIH	1	14.2	23.0	7.3	2	.7	7.7	38
	2	12.4	21.0	7.1	3	2.4	7.9	
HP	1	12.0	24.0	7.7	5	2.7	7.9	58
	2	11.4	23.2	7.1	2	2.3	7.9	
SB-A	1	13.0	16.8	8.9	14	2.8	7.8	40
	2	12.0	17.8	8.6	11	3.2	7.9	
SB-B	1	12.4	17.0	8.6	10	3.3	7.7	36
	2	12.8	16.0	9.5	9	4.4	7.8	
RCH-A	1	12.9	14.0	8.9	11	4.9	7.9	47
	2	13.0	15.2	9.2	17	6.3	7.8	
RCH-B	1	13.1	17.8	8.6	11	3.7	7.8	38
	2	12.6	17.5	8.7	11	2.2	7.9	

Survey 1

SURVEY NO. 1

STATION	SAMPLE NO.	TEMPERATURE (CENTIGRADE)	SALINITY (PARTS/1000)	DISSOLVED OXYGEN (MILLIGRAMS/LITER)	TURBIDITY (NU)	TOTAL SULFIDES (MICROGRAMS/LITER)	PH	DEPTH (FEET)
MIS-A	1	20.0	10.0	8.2	100	2.1	7.4	30
	2	20.0	10.0	8.1	120	3.0	7.3	
MIS-B	1	19.9	23.5	7.2	100	3.0	7.5	25
	2	19.8	23.5	7.3	85	2.5	7.6	
CS-A	1	19.0	21.0	7.3	21	.5	7.7	48
	2	19.0	21.0	7.4	15	.2	7.7	
CS-B	1	19.0	22.0	7.3	10	.4	7.5	42
	2	19.0	22.0	7.5	10	.4	7.4	
ALC	1	15.7	30.0	7.7	5	.2	7.6	67
	2	15.6	30.5	7.7	5	0.0	7.6	
OIH	1	17.9	29.0	6.9	6	.6	7.5	30
	2	17.8	29.0	6.9	5	.5	7.5	
HP	1	18.3	30.0	7.3	8	0.0	7.4	50
	2	18.3	30.0	6.9	6	.8	7.6	
SB-A	1	19.0	29.5	6.9	2	2.8	7.5	42
	2	19.0	29.5	6.8	2	3.2	7.5	
SB-B	1	19.8	30.0	6.5	1	1.4	7.5	36
	2	19.6	30.0	6.6	2	1.7	7.5	
RCH-A	1	19.2	29.5	6.8	2	1.9	7.6	24
	2	19.2	29.5	6.7	1	3.5	7.6	
RCH-B	1	19.8	29.0	6.8	5	4.2	7.5	24
	2	19.8	29.0	6.6	5	2.5	7.6	

SURVEY NO. 2

Survey 2

STATION	SAMPLE NO.	TEMPERATURE (CENTIGRADE)	SALINITY (PARTS/1000)	DISSOLVED OXYGEN (MILLIGRAMS/LITER)	TURBIDITY (NU)	TOTAL SULFIDES (MICROGRAMS/LITER)	PH	DEPTH (FEET)
MIS-A	1	9.8	4.0	9.6	190	4.0	7.5	12
	2	10.0	4.0	9.7	110	3.5	7.5	
MIS-B	1	10.0	3.0	9.9	65	2.5	7.5	21
	2	10.0	3.0	9.8	95	4.3	7.4	
CS-A	1	10.0	7.0	9.3	130	1.9	7.5	50
	2	10.0	7.0	9.5	150	2.8	7.5	
CS-B	1	10.0	6.5	9.6	110	1.9	7.5	40
	2	10.0	6.0	10.0	120	2.6	7.5	
ALC	1	11.0	24.5	8.6	24	5.5	7.3	60
	2	11.0	24.0	8.6	23	4.4	7.4	
OIH	1	11.0	22.0	7.8	24	4.1	7.4	30
	2	11.0	22.0	7.9	24	2.1	7.6	
HP	1	11.0	22.0	7.7	7	.6	7.7	45
	2	11.0	22.0	8.4	12	--	7.7	
SB-A	1	12.0	20.0	8.5	7	1.5	7.7	44
	2	12.0	22.0	8.4	7	2.7	7.8	
SB-B	1	11.0	20.0	9.3	2	1.1	6.9	30
	2	10.9	22.0	8.8	1	1.3	7.5	
RCH-A	1	12.0	22.0	8.1	7	3.4	7.8	34
	2	12.0	22.0	8.3	6	1.5	7.7	
RCH-B	1	12.0	22.0	8.1	7	3.5	7.7	30
	2	12.0	22.0	8.2	7	4.9	7.7	

Survey 3

SURVEY NO. 3

STATION	SAMPLE NO.	TEMPERATURE (CENTIGRADE)	SALINITY (PARTS/1000)	DISSOLVED OXYGEN (MILLIGRAMS/LITER)	TURBIDITY (NU)	TOTAL SULFIDES (MICROGRAMS/LITER)	PH	DEPTH (FEET)
MIS-A	1	11.0	4.0	6.7	37500	--	7.7	30
	2	11.0	4.0	7.5	10000	1.8	7.8	
MIS-B	1	11.0	2.0	10.2	500	0.0	7.6	20
	2	11.0	1.5	10.0	500	--	7.6	
CS-A	1	11.0	15.5	9.0	160	1.4	7.9	50
	2	11.0	15.0	9.2	130	.2	7.9	
CS-B	1	11.0	14.0	9.1	100	.6	7.9	42
	2	11.0	15.5	8.9	140	1.6	8.0	
ALC	1	10.0	28.0	8.3	5	.4	8.0	60
	2	10.0	27.5	8.3	10	.2	8.0	
OIM	1	11.0	22.0	8.0	18	0.0	8.0	31
	2	11.4	22.5	8.1	18	--	8.0	
MP	1	11.0	21.0	8.4	45	1.8	8.2	48
	2	11.0	20.5	8.4	45	.4	8.1	
SB-A	1	11.0	18.0	9.3	45	.3	8.0	40
	2	11.0	19.0	9.2	40	1.5	8.0	
SB-B	1	11.2	18.5	8.8	23	.5	7.8	34
	2	11.2	18.5	9.0	34	.5	7.9	
ACH-A	1	11.6	18.0	9.0	33	0.0	8.0	38
	2	11.6	19.0	9.0	33	0.0	7.9	
ACH-B	1	12.0	18.0	8.5	14	0.0	7.9	30
	2	11.8	18.0	8.9	21	0.0	7.9	

Survey 4

SURVEY NO. 4

STATION	SAMPLE NO.	TEMPERATURE (CENTIGRADE)	SALINITY (PARTS/1000)	DISSOLVED OXYGEN (MILLIGRAMS/LITER)	TURBIDITY (NU)	TOTAL SULFIDES (MICROGRAMS/LITER)	PH	DEPTH (FEET)
MIS-A	1	17.5	7.5	8.4	85	0.0	7.8	30
	2	17.5	7.5	8.5	70	0.0	7.9	
MIS-B	1	17.5	6.0	8.7	60	1.1	7.8	20
	2	17.5	6.5	8.4	30	0.0	7.8	
CS-A	1	16.0	18.0	8.1	120	1.1	7.9	48
	2	16.5	17.0	8.4	150	1.3	7.9	
CS-B	1	17.0	18.0	8.3	390	1.4	7.8	40
	2	17.0	16.0	8.4	260	0.0	7.9	
ALC	1	12.6	29.5	7.9	11	0.0	7.8	58
	2	12.3	29.5	7.8	12	0.0	7.9	
OIH	1	15.7	26.5	7.9	35	0.0	7.9	34
	2	15.3	26.5	7.8	37	0.0	7.8	
HP	1	15.0	25.0	8.0	35	0.0	7.9	52
	2	14.8	26.0	8.1	35	0.0	7.9	
SB-A	1	18.8	21.0	7.5	11	0.0	7.9	41
	2	18.3	21.0	7.5	13	0.0	7.8	
SB-B	1	18.8	21.0	7.3	--	0.0	7.8	32
	2	18.7	21.5	7.5	10	0.0	7.9	
RCH-A	1	18.7	21.5	7.1	40	0.0	7.8	45
	2	18.5	21.5	7.1	40	0.0	7.9	
RCH-B	1	18.8	21.5	7.0	28	0.0	7.9	32
	2	18.8	21.5	7.3	17	0.0	7.9	

APPENDIX C

PHYSICAL AND CHEMICAL CHARACTERISTICS OF SEDIMENT

TEMPERATURE, SULFIDES, SALINITY, pH,
AND SAMPLE VOLUME

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey P

PRELIMINARY SURVEY

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/MG)	SALINITY (PARTS/1000)	PH
MIS-A	1	10.0	12.3	.4	--	7.0
	2	10.0	12.2	2.4	--	7.0
	3	10.0	12.5	3.1	--	7.0
	4	10.0	12.3	2.0	--	7.0
	5	10.1	12.5	2.3	--	7.0
	6	10.0	12.2	--	--	7.1
	7	10.0	12.2	--	--	7.0
	MEAN	10.0	12.3	2.0	--	7.0
	STD. DEV.	0.0	.1	1.0	--	7.1
MIS-B	1	10.3	12.0	78.4	--	7.3
	2	9.6	12.0	.3	--	7.2
	3	10.1	11.7	1.8	--	7.2
	4	10.2	11.5	0.0	--	7.3
	5	10.1	12.1	4.4	--	7.1
	6	10.2	11.7	--	--	7.2
	MEAN	10.1	11.8	17.0	--	7.1
	STD. DEV.	.2	.2	34.4	--	7.3
						MIN
						MAX

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey P

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
CS-A	1	10.5	12.5	136.0	--	7.2
	2	10.5	11.9	.8	--	7.1
	3	10.5	11.5	129.0	--	7.1
	4	10.6	11.9	180.0	--	7.1
	5	10.7	12.4	168.0	--	7.2
	6	10.7	11.6	--	--	7.1
	7	10.7	11.5	--	--	7.1
	MEAN	10.6	11.9	122.8	--	MIN 7.1
	STD. DEV.	.1	.4	71.4	--	MAX 7.2
CS-B	1	10.0	13.0	.8	--	7.3
	2	9.1	12.5	.2	--	7.3
	3	10.8	12.5	.3	--	7.3
	4	10.0	12.5	1.6	--	7.3
	5	8.4	12.0	1.2	--	7.3
	6	9.9	11.9	--	--	7.3
	7	10.0	11.8	--	--	7.3
	MEAN	9.7	12.3	.8	--	MIN 7.3
	STD. DEV.	.8	.4	.6	--	MAX 7.3

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey P

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/ML)	SALINITY (PARTS/1000)	PH
ALC	1	5.3	11.8	1.0	--	7.9
	2	6.4	11.8	136.0	--	7.2
	3	6.8	11.0	42.7	--	7.4
	MEAN	6.2	11.5	59.9	--	7.2
	STD. DEV.	.8	.5	69.1	--	7.9
OIH	1	7.0	11.9	283.0	--	7.2
	2	5.8	11.4	354.0	--	7.3
	3	6.1	11.3	236.0	--	7.2
	4	8.5	11.1	443.0	--	7.3
	5	7.0	11.2	892.0	--	7.2
	6	8.0	11.0	--	--	7.2
	7	9.2	11.2	--	--	7.2
	MEAN	7.4	11.3	441.6	--	7.2
	STD. DEV.	1.2	.3	263.6	--	7.3

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey P

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
HP	1	10.7	11.3	19.1	--	7.1
	2	10.3	11.5	22.4	--	7.0
	3	9.0	11.5	57.8	--	7.3
	4	10.2	11.1	39.7	--	7.4
	5	10.7	11.2	46.1	--	7.1
	6	10.7	11.2	--	--	7.1
	7	10.8	11.1	--	--	7.2
	MEAN	10.3	11.3	37.0	--	7.0
	STD. DEV.	.6	.2	16.3	--	7.4
SB-A	1	11.1	13.0	560.0	--	6.1
	2	11.0	12.3	370.0	--	7.5
	3	10.9	12.5	--	--	7.4
	4	11.2	12.5	125.0	--	6.4
	5	11.0	12.5	--	--	7.5
	6	11.0	12.5	410.0	--	7.5
	7	11.1	12.3	360.0	--	7.4
	MEAN	11.0	12.5	365.0	--	6.1
	STD. DEV.	.1	.2	156.3	--	7.5

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey P

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/ML)	SALINITY (PARTS/1000)	PH
SB-B	1	10.4	12.5	0.0	--	7.4
	2	10.3	12.3	320.0	--	7.2
	3	10.5	12.0	290.0	--	7.2
	4	10.3	12.0	290.0	--	7.3
	5	10.6	12.0	230.0	--	7.4
	6	10.5	12.0	260.0	--	7.2
	7	10.2	12.0	--	--	7.3
	MEAN	10.4	12.1	278.0	--	7.2
	STD. DEV.	.1	.2	31.2	--	MAX 7.4
RCH-A	1	10.2	14.0	300.0	--	7.4
	2	10.3	14.0	300.0	--	7.3
	3	10.2	14.0	260.0	--	7.3
	4	10.1	14.0	250.0	--	7.4
	5	10.6	13.5	--	--	7.3
	6	10.5	13.7	--	--	7.3
	7	10.5	13.5	196.0	--	7.3
	MEAN	10.4	13.8	261.2	--	MIN 7.3
	STD. DEV.	.2	.2	43.0	--	MAX 7.4

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey P

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
RCH-8	1	10.5	12.3	270.0	--	8.4
	2	10.8	12.3	116.0	--	7.4
	3	11.0	12.3	290.0	--	7.4
	4	11.0	12.0	188.0	--	7.5
	5	10.8	11.9	146.0	--	7.5
	6	10.0	11.9	103.0	--	7.4
	7	10.9	11.8	100.0	--	7.3
	MEAN	10.7	12.1	173.3	--	7.3
	STD. DEV.	.4	.2	79.1	--	8.4
					MIN	7.3
					MAX	8.4

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 1

SURVEY NO. 1

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/100)	SALINITY (PARTS/1000)	PH
MIS-A	1	9.5	19.0	23.0	--	6.7
	2	9.3	19.0	26.0	--	6.8
	3	9.7	19.0	40.0	--	6.8
	4	9.3	18.5	7.6	--	6.8
	5	9.1	18.5	5.4	--	6.8
	6	10.5	18.5	6.3	--	6.9
	MEAN	9.6	18.8	18.0	--	MIN 6.7
	STD. DEV.	.5	.3	14.0	--	MAX 6.9
MIS-B	1	10.5	19.0	190.0	--	7.0
	2	10.5	19.0	89.0	--	7.0
	3	10.8	19.0	210.0	--	7.0
	4	10.4	19.0	190.0	--	7.1
	5	10.5	19.0	180.0	--	7.1
	6	10.3	19.0	170.0	--	7.1
	MEAN	10.5	19.0	171.5	--	MIN 7.0
	STD. DEV.	.2	0.0	42.5	--	MAX 7.1

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/EG)	SALINITY (PARTS/1000)	PH
CS-A	1	10.3	18.5	370.0	--	6.4
	2	9.1	18.0	400.0	--	6.5
	3	9.1	18.0	170.0	--	6.7
	4	11.2	18.0	300.0	--	6.5
	5	12.0	18.0	320.0	--	6.4
	6	11.4	18.0	320.0	--	6.5
	MEAN	10.5	18.1	313.3	--	6.4
	STD. DEV.	1.2	.2	79.4	--	5.7
CS-8	1	10.2	18.5	73.0	--	6.7
	2	9.6	18.0	320.0	--	6.8
	3	10.0	18.5	140.0	--	6.8
	4	11.0	18.5	170.0	--	6.7
	5	10.0	18.5	290.0	--	6.6
	6	9.9	18.5	150.0	--	6.7
	MEAN	10.1	18.4	190.5	--	6.6
	STD. DEV.	.5	.2	95.0	--	6.8
						MIN
						MAX

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 1

SURVEY NO. 1 (CONTINUED)						
STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
ALC	1	7.0	16.0	1.8	--	7.3
	2	7.3	16.0	2.0	--	7.1
	3	7.7	15.0	20.0	--	7.2
	4	7.3	16.0	10.0	--	6.9
	5	8.4	15.5	4.3	--	7.0
	6	7.3	16.0	.6	--	7.3
	MEAN	7.5	15.8	6.4	--	MIN 6.9
	STD. DEV.	.5	.4	7.4	--	MAX 7.3
OIH	1	11.1	17.5	380.0	--	7.2
	2	11.0	17.5	300.0	--	7.3
	3	11.0	17.0	650.0	--	7.2
	4	11.8	17.0	630.0	--	7.1
	5	11.3	17.0	580.0	--	7.2
	6	11.4	17.0	620.0	--	7.1
	MEAN	11.3	17.2	526.7	--	MIN 7.1
	STD. DEV.	.3	.3	148.5	--	MAX 7.3

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
HP	1	11.3	18.0	30.0	--	6.9
	2	10.2	18.0	42.0	--	7.1
	3	10.6	18.0	30.0	--	7.0
	4	10.0	18.0	52.0	--	7.0
	5	10.0	18.0	76.0	--	7.0
	6	10.3	18.0	150.0	--	7.1
	MEAN	10.4	18.0	63.3	--	6.9
	STD. DEV.	.5	0.0	45.8	--	7.1
SB-A	1	11.3	19.0	150.0	--	6.7
	2	9.6	19.0	110.0	--	6.8
	3	11.4	19.0	180.0	--	7.0
	4	11.3	19.0	100.0	--	6.9
	5	11.6	19.0	110.0	--	7.0
	6	11.8	19.0	240.0	--	7.0
	MEAN	11.2	19.0	148.3	--	6.7
	STD. DEV.	.8	0.0	54.2	--	7.0
						MIN
						MAX

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
SB-8	1	11.4	19.0	560.0	--	6.7
	2	11.2	19.0	510.0	--	6.5
	3	11.8	19.0	570.0	--	6.4
	4	11.8	19.0	460.0	--	7.0
	5	10.9	19.0	610.0	--	6.8
	6	11.0	19.0	560.0	--	7.0
	MEAN	11.3	19.0	545.0	--	6.4
	STD. DEV.	.4	0.0	52.4	--	7.0
RCH-A	1	10.9	19.0	140.0	--	6.9
	2	11.4	19.0	130.0	--	7.0
	3	10.7	19.0	120.0	--	7.0
	4	11.0	19.0	160.0	--	7.0
	5	11.2	19.0	190.0	--	7.1
	6	10.8	19.0	150.0	--	7.1
	MEAN	11.0	19.0	148.3	--	6.9
	STD. DEV.	.3	0.0	24.9	--	7.1
					MIN	
					MAX	

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
RCH-B	1	9.8	19.0	480.0	--	7.1
	2	11.0	20.0	440.0	--	7.0
	3	10.8	19.0	470.0	--	6.9
	4	11.1	19.0	730.0	--	7.0
	5	10.4	19.5	490.0	--	7.0
	6	10.9	19.5	600.0	--	6.9
	MEAN	10.7	19.3	535.0	--	6.9
	STD. DEV.	.5	.4	110.0	--	7.1
					MIN	6.9
					MAX	7.1

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 2

SURVEY NO. 2

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
MIS-A	1	9.8	11.0	.5	--	7.1
	2	10.1	11.0	.7	--	7.1
	3	10.5	11.0	12.0	--	7.0
	4	10.3	10.9	.4	--	7.1
	5	10.3	11.0	1.2	--	7.0
	6	10.6	11.0	.3	--	7.0
	MEAN	10.3	11.0	2.5	--	7.0
	STD. DEV.	.3	0.0	4.7	--	7.1
MIS-B	1	11.0	10.2	69.0	--	7.2
	2	11.0	10.4	96.0	--	7.2
	3	11.2	10.4	86.0	--	7.3
	4	11.0	10.6	170.0	--	7.3
	5	11.4	10.3	35.0	--	7.3
	6	11.0	10.4	27.0	--	7.3
	MEAN	11.1	10.4	80.5	--	7.2
	STD. DEV.	.2	.1	51.7	--	7.3
						MIN
						MAX

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 2

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	pH
CS-A	1	10.4	10.7	150.0	--	6.8
	2	10.4	10.8	240.0	--	6.9
	3	10.7	10.9	180.0	--	6.9
	4	11.4	10.4	110.0	--	6.9
	5	10.5	10.7	14.0	--	6.9
	6	10.8	10.5	50.0	--	6.8
	MEAN	10.7	10.7	124.0	--	6.8
	STD. DEV.	.4	.2	83.7	--	6.9
CS-B	1	8.9	10.8	40.0	--	7.0
	2	10.4	10.9	240.0	--	7.0
	3	10.4	10.9	46.0	--	6.9
	4	10.7	10.6	57.0	--	7.0
	5	9.5	10.6	15.0	--	7.0
	6	10.1	11.0	41.0	--	7.0
	MEAN	10.0	10.8	73.2	--	6.9
	STD. DEV.	.7	.2	82.9	--	7.0

HP
Survey 1

STATION HP SURVEY NO. 1 (CONT.)		SAMPLE NO.						NUMBER OF GROUP	SPECIMENS TAXA
TAXA		1	2	3	4	5	6		
POLYDORA SOCIALIS		1	2						3
GLYCINDE SP.			6						7
SPIOPHANES FIMBRIATA			1						1
HETEROMASTUS FILIFORMIS									4
POLYDORA SP., CF SOCIALIS									1
SIPUNCULA									
SIPUNCULA-UNIDENTIFIED SPP.			1					1	1
ARTHROPODA									
AMPELISCA MILLERI		1952	2382					9103	2335
LEPTOCHEILIA DUBIA		77	97						239
SAKSIELLA ZOSTERICOLA			1						5
COROPHIUM ACHERUSICUM			6						10
PYROMATA TUBERCULATA		1							1
OSTRACODA-UNIDENTIFIED SPP.		4							4
COROPHIUM INSIOTOSUM		7							7
COROPHIUM SP.		2							2
MOLLUSCA									
PETRICOLA SP., CF CARDITOIDES								6	1
LYONSIA SP., CF CALIFORNICA									1
ADULA DIEGENSIS		1							1
MUSCULUS SENHOUSSIA		1							1
TRANSENNELLA TANTILLA			1						1
MACOMA NASUTA									1
ECHINODERMATA									
MOLOTHURIDEA-UNIDENTIFIED SPP.								1	1
PHORONIDA									
PHORONIS SP.		1						1	1
CHORDATA									
TUNICATA-UNIDENTIFIED SPP.								5	5
GRAND TOTALS	50	2791	2842	4841				10514	10514

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 2

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
ALC	1	8.1	11.6	3.8	--	7.1
	2	8.1	11.2	7.6	--	7.0
	3	7.9	11.2	39.0	--	7.5
	4	8.3	11.4	24.0	--	7.4
	5	7.5	11.3	170.0	--	7.7
	6	7.0	11.7	180.0	--	7.7
	MEAN	7.8	11.4	70.7	--	7.0
	STD. DEV.	.5	.2	81.8	--	7.7
OIH	1	7.5	11.0	420.0	--	7.3
	2	7.5	11.0	440.0	--	7.3
	3	7.7	11.0	530.0	--	7.4
	4	9.4	11.0	630.0	--	7.4
	5	8.9	11.0	390.0	--	7.4
	6	9.1	11.0	520.0	--	7.4
	MEAN	8.3	11.0	488.3	--	7.3
	STD. DEV.	.9	0.0	88.9	--	7.4

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 2

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	pH
HP	1	10.4	11.0	290.0	--	7.3
	2	9.6	11.0	100.0	--	7.4
	3	9.8	11.0	280.0	--	7.0
	4	9.6	11.0	230.0	--	7.3
	5	9.0	11.0	180.0	--	7.4
	6	9.9	11.0	170.0	--	7.3
	MEAN	9.7	11.0	208.0	--	MIN 7.0
	STD. DEV.	.5	0.0	72.5	--	MAX 7.4
SB-A	1	10.8	11.5	58.0	--	7.2
	2	10.1	11.2	130.0	--	7.1
	3	10.6	11.5	140.0	--	7.1
	4	9.9	11.2	160.0	--	7.2
	5	10.1	11.2	240.0	--	7.2
	6	11.0	11.5	180.0	--	7.3
	MEAN	10.4	11.3	151.3	--	MIN 7.1
	STD. DEV.	.4	.2	60.1	--	MAX 7.3

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 2

STATION		SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
SB-8	1	11.5	11.5	72.0	--	7.4
	2	11.7	11.8	100.0	--	7.5
	3	11.3	11.5	62.0	--	7.3
	4	10.4	11.8	70.0	--	7.4
	5	11.4	11.5	70.0	--	7.4
	6	10.9	11.5	90.0	--	7.4
MEAN		11.2	11.6	77.3	--	7.3
STD. DEV.		.5	.2	14.5	--	7.5
RCH-A	1	11.2	12.0	260.0	--	7.3
	2	10.9	11.8	180.0	--	7.2
	3	10.8	12.0	200.0	--	7.3
	4	10.9	11.8	240.0	--	7.3
	5	10.3	11.8	260.0	--	7.2
	6	11.0	11.5	280.0	--	7.3
MEAN		10.9	11.8	236.7	--	7.2
STD. DEV.		.2	.2	38.8	--	7.3

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 2

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
RCH-B	1	10.5	12.0	430.0	--	7.1
	2	10.5	12.0	1200.0	--	7.0
	3	10.7	12.0	620.0	--	7.1
	4	10.6	11.5	370.0	--	7.3
	5	10.7	12.0	760.0	--	7.0
	6	10.8	12.0	390.0	--	7.2
	MEAN	10.6	11.9	628.3	--	7.0
	STD. DEV.	.1	.2	318.5	--	7.3
						MIN
						MAX

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 3

SURVEY NO. 3

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	pH
MIS-A	1	10.8	12.0	24.0	10.5	7.0
	2	10.5	12.0	19.0	8.5	7.1
	3	10.0	11.5	5.8	8.5	7.1
	4	10.4	12.0	--	8.8	7.0
	MEAN	10.4	11.9	16.2	9.1	7.0
	STD. DEV.	.3	.3	2.4	1.0	7.1
MIS-B	1	11.0	11.0	59.0	5.5	7.3
	2	9.4	11.0	64.0	5.0	7.2
	3	10.2	11.0	60.0	5.5	7.2
	4	10.8	11.0	--	5.8	7.2
	MEAN	10.3	11.0	61.0	5.4	7.2
	STD. DEV.	.7	0.0	2.6	.3	7.3
CS-A	1	7.0	11.0	3.4	12.2	7.3
	2	8.9	11.0	.9	12.2	7.0
	3	8.7	11.0	27.0	12.0	7.3
	4	9.3	11.0	--	12.2	7.4
	MEAN	8.5	11.0	10.4	12.4	7.3
	STD. DEV.	1.0	0.0	14.4	.4	7.4

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 3

SURVEY NO. 3 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MO/KG)	SALINITY (PARTS/1000)	PH
CS-8	1	10.0	12.0	89.0	14.0	7.1
	2	10.5	12.0	220.0	13.5	7.1
	3	10.8	11.5	53.0	13.8	7.0
	4	10.5	11.5	--	13.5	7.2
	MEAN	10.4	11.8	120.7	13.7	MIN 7.0
	STD. DEV.	.3	.3	87.9	.2	MAX 7.2
ALC	1	9.5	10.2	77.0	23.0	7.4
	2	8.9	10.2	31.0	23.5	7.2
	3	9.8	10.2	120.0	23.5	7.1
	4	10.2	10.2	--	23.5	7.2
	MEAN	9.6	10.2	76.0	23.4	MIN 7.1
	STD. DEV.	.5	0.0	44.5	.3	MAX 7.4
OIH	1	8.7	11.5	600.0	24.2	7.7
	2	7.9	11.5	550.0	24.0	7.8
	3	8.0	11.5	560.0	23.6	7.7
	4	8.8	10.2	--	24.0	7.7
	MEAN	8.3	11.2	570.0	24.0	MIN 7.7
	STD. DEV.	.5	.7	26.5	.2	MAX 7.6

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 3

SURVEY NO. 3 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADES)	TOTAL SULFIDES (MG/100)	SALINITY (PARTS/1000)	pH
HP	1	10.1	11.0	390.0	24.2	7.2
	2	9.6	12.0	150.0	23.5	7.3
	3	10.1	12.0	230.0	24.5	7.3
	4	9.9	12.0	--	23.8	7.3
	MEAN	9.9	11.8	256.7	24.0	7.2
	STD. DEV.	.2	.5	122.2	.4	MAX 7.3
S9-A	1	10.1	11.0	870.0	18.5	7.2
	2	10.5	11.0	600.0	18.5	7.2
	3	11.0	11.0	330.0	18.0	7.5
	4	9.5	11.1	--	18.5	7.4
	MEAN	10.3	11.0	600.0	18.4	7.2
	STD. DEV.	.6	.1	270.0	.3	MAX 7.5
S8-B	1	11.0	12.0	340.0	18.5	7.1
	2	10.5	10.2	810.0	19.0	7.2
	3	10.0	11.2	320.0	19.2	7.1
	4	11.5	11.2	--	18.5	7.5
	MEAN	10.8	11.1	490.0	18.8	7.1
	STD. DEV.	.6	.7	277.3	.4	MAX 7.5

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 3

SURVEY NO. 3 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	pH
RCH-A	1	9.5	11.5	200.0	18.0	7.6
	2	9.5	11.5	340.0	18.0	7.5
	3	10.0	11.8	9.1	18.0	7.5
	4	11.0	11.3	--	17.5	7.6
	MEAN	10.0	11.5	183.0	17.9	7.5
	STD. DEV.	.7	.2	166.1	.3	7.6
RCH-B	1	10.0	12.0	140.0	18.5	7.4
	2	9.5	12.0	130.0	17.5	7.2
	3	11.0	12.0	104.0	18.2	7.4
	4	11.0	12.0	--	18.2	7.3
	MEAN	10.4	12.0	124.7	18.1	7.2
	STD. DEV.	.8	3.0	18.6	.4	7.4

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 4

SURVEY NO. 4						
STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADES)	TOTAL SULFIDES (MG/100)	SALINITY (PARTS/1000)	PH
MIS-A	1	9.2	16.0	0.0	12.0	7.5
	2	9.8	15.8	0.0	11.5	7.4
	3	10.5	15.5	0.0	10.0	7.3
	4	9.6	15.5	--	9.5	7.3
	MEAN	9.8	15.7	0.0	10.8	MIN 7.3
	STD. DEV.	.5	.2	0.0	1.2	MAX 7.5
MIS-B	1	10.1	17.0	11.0	10.0	7.1
	2	10.9	17.0	5.3	10.0	7.1
	3	10.9	17.0	8.8	9.5	7.1
	4	10.8	17.0	--	10.0	7.2
	MEAN	10.7	17.0	8.4	9.9	MIN 7.1
	STD. DEV.	.4	0.0	2.9	.3	MAX 7.2
CS-A	1	9.9	17.0	37.0	16.8	7.0
	2	11.3	16.2	420.0	17.0	7.1
	3	10.0	16.2	200.0	15.8	7.1
	4	9.6	16.5	--	16.0	7.0
	MEAN	10.2	16.5	219.0	16.4	MIN 7.0
	STD. DEV.	.8	.4	192.2	.6	MAX 7.1

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 4

SURVEY NO. 4 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH
CS-8	1	9.2	17.0	320.0	15.5	7.0
	2	10.6	17.0	310.0	15.5	7.1
	3	8.6	16.5	--	16.0	7.1
	4	8.7	17.1	--	15.2	7.2
	MEAN	9.3	16.9	315.0	15.5	7.0
	STD. DEV.	.9	.3	7.1	.3	MAX 7.2
ALC	1	8.9	14.0	4.5	30.8	7.3
	2	6.4	13.6	1.9	--	7.3
	3	7.8	13.8	2.5	29.0	7.4
	4	7.2	14.5	--	29.0	7.2
	MEAN	8.1	14.0	3.0	29.6	7.2
	STD. DEV.	.7	.3	1.4	1.0	MAX 7.4
OIH	1	10.1	15.0	690.0	26.2	7.3
	2	11.4	16.0	620.0	26.8	7.4
	3	10.3	15.0	870.0	27.0	7.4
	4	9.0	15.5	--	26.8	7.4
	MEAN	10.2	15.4	730.0	26.7	7.3
	STD. DEV.	1.0	.5	134.5	.3	MAX 7.4

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 4

SURVEY NO. 4 (CONTINUED)		STATION		SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADES)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	PH	
HP	1			9.0	15.6	23.0	26.5		7.3
	2			10.2	15.5	90.0	26.8		7.1
	3			9.4	15.5	49.0	27.0		7.2
	4			9.9	15.5	--	26.5		7.2
	MEAN			9.6	15.5	70.7	26.7	MIN	7.1
	STD. DEV.			.5	.1	18.6	.2	MAX	7.3
SB-A	1			11.0	18.0	240.0	21.5		7.1
	2			12.0	18.0	470.0	22.0		6.9
	3			11.6	18.0	230.0	22.0		7.3
	4			12.0	18.0	--	22.0		6.9
	MEAN			11.6	18.0	313.3	21.9	MIN	6.9
	STD. DEV.			.5	0.0	135.8	.3	MAX	7.3
SB-B	1			10.5	18.0	520.0	21.5		7.4
	2			11.5	17.8	320.0	21.8		6.9
	3			11.0	17.8	490.0	22.0		6.9
	4			11.0	17.9	--	21.6		7.4
	MEAN			11.0	17.9	443.3	21.8	MIN	6.9
	STD. DEV.			.4	.1	107.9	.2	MAX	7.4

Temperature, Sulfides, Salinity, pH,
Sample Volume
Survey 4

SURVEY NO. 4 (CONTINUED)

STATION	SAMPLE NO.	SAMPLE VOLUME (LITERS)	TEMPERATURE (CENTIGRADE)	TOTAL SULFIDES (MG/KG)	SALINITY (PARTS/1000)	pH
RCH-A	1	10.0	18.5	450.0	22.0	7.4
	2	11.5	18.0	390.0	21.2	7.3
	3	9.0	18.5	280.0	22.0	7.2
	4	11.0	18.0	--	22.0	7.3
	MEAN	10.4	18.3	373.3	21.8	MIN 7.2
	STD. DEV.	1.1	.3	86.2	.4	MAX 7.4
RCH-B	1	10.0	18.0	120.0	20.2	7.0
	2	10.5	18.0	89.0	20.2	7.0
	3	10.0	18.1	130.0	21.0	7.1
	4	10.5	18.5	--	20.2	7.1
	MEAN	10.3	18.1	113.0	20.4	MIN 7.0
	STD. DEV.	.3	.2	21.4	.4	MAX 7.1

CUMULATIVE SEDIMENT GRAIN-SIZE CHARACTERIZATION

Cumulative Sediment Grain-Size Characterization
Survey 1

		SURVEY NO. 1											
		PERCENTAGE DISTRIBUTION (MICRONS)											
STATION	SAMPLE NO.	<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5	
MIS-A	1	98.9	98.3	97.8	97.4	96.8	93.9	89.3	78.5	72.5	63.6	51.1	
	2	99.9	99.8	99.1	99.7	89.3	87.5	84.1	75.2	68.8	62.5	50.9	
	3	100.0	99.8	98.8	97.6	91.8	90.2	87.2	78.0	69.9	61.2	48.8	
	MEAN	99.6	99.3	98.6	98.2	92.0	90.5	87.5	77.2	70.4	62.4	50.3	
	STD. DEV.	.6	.9	.7	1.3	2.8	3.2	1.6	1.8	1.9	1.2	1.3	
MIS-B	1	99.9	99.7	99.5	99.4	98.5	96.7	96.7	90.7	85.8	81.5	63.6	
	3	100.0	99.9	98.9	98.2	94.2	92.8	90.7	86.7	77.5	72.2	56.2	
	5	100.0	99.4	98.8	98.3	95.8	94.3	92.8	85.5	80.1	72.9	54.7	
	MEAN	100.0	99.7	99.1	98.6	94.2	94.6	93.4	87.6	81.2	75.5	58.2	
	STD. DEV.	.1	.3	.4	.7	2.2	2.0	3.0	2.7	4.2	5.2	4.8	

Cumulative Sediment Grain-Size Characterization
Survey 1

SURVEY 1 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)											
		<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5	
CS-A	1	99.8	98.4	94.8	91.3	87.4	86.5	84.8	83.9	81.9	68.2	55.3	
	3	99.3	98.7	82.9	68.7	62.9	61.0	57.7	53.0	48.8	41.8	32.4	
	4	100.0	99.2	97.8	96.6	93.7	93.0	91.9	86.5	79.3	72.5	58.6	
	MEAN	99.7	98.8	91.8	85.5	81.3	80.2	78.1	74.5	70.0	60.8	48.8	
	STD. DEV.	.4	.4	7.9	14.8	16.3	16.9	18.0	18.6	18.4	16.6	14.3	
CS-B	1	99.1	96.8	72.7	39.8	27.4	26.8	25.9	23.6	22.2	19.8	15.6	
	2	99.4	99.0	93.8	86.3	77.0	74.5	71.5	66.8	62.4	55.1	43.4	
	4	98.9	96.5	80.0	64.1	52.1	49.7	49.2	43.5	40.0	38.0	27.9	
	MEAN	99.1	97.4	82.2	63.4	52.2	50.3	48.9	44.6	41.5	37.6	29.0	
	STD. DEV.	.5	1.4	10.7	23.3	24.8	23.9	22.8	21.6	20.1	17.7	13.9	

Cumulative Sediment Grain-Size Characterization Survey 1

SURVEY 1 (CONTINUED)

PERCENTAGE DISTRIBUTION (MICRONS)

STATION

SAMPLE NO.

<99.1

<350

<180

<125

<43

<60

<30

<20

<15

<10

<5

ALC

2

99.7

89.4

16.5

3.6

3.0

2.8

2.8

2.7

2.3

2.2

1.8

4

99.9

89.4

23.1

3.8

2.6

2.3

2.1

1.8

1.7

1.7

1.5

5

99.8

91.6

25.8

3.0

1.6

1.6

1.5

1.2

1.0

1.0

.6

MEAN

99.8

90.1

21.8

3.5

2.4

2.2

2.1

1.9

1.7

1.6

1.3

STD. DEV.

.1

1.3

4.8

.4

.7

.6

.7

.8

.7

.6

.6

D1H

1

99.8

97.9

76.5

55.3

40.2

38.5

37.4

37.3

36.8

36.3

21.7

2

99.3

97.7

68.8

42.0

28.6

28.4

27.7

24.8

23.0

21.8

18.3

4

99.2

97.0

87.7

78.4

66.0

64.6

59.5

55.2

48.0

44.3

35.7

MEAN

99.4

97.5

77.7

58.6

44.9

43.8

41.5

39.1

35.9

34.1

25.2

STD. DEV.

.3

.5

9.5

18.4

19.1

18.7

16.3

15.3

12.5

11.4

9.2

HP

3

99.6

97.8

92.3

87.2

76.4

73.4

68.5

62.6

55.9

52.0

43.8

5

96.2

93.5

82.1

75.6

67.1

65.9

63.4

57.9

55.2

49.5

42.9

MEAN

97.9

95.7

87.2

81.4

71.7

69.7

65.9

60.2

55.5

50.7

43.3

STD. DEV.

2.4

3.0

7.2

8.2

6.6

5.3

3.6

3.3

.5

1.8

.6

Cumulative Sediment Grain-Size Characterization Survey 1

SURVEY 1 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<90	<150	<250	<350	<450	<550	<650	<750	<850	<950	<5
SB-A	1	97.0	90.0	84.2	83.0	81.8	79.6	80.6	76.8	71.7	65.1	56.6
	3	99.9	99.2	98.6	98.3	97.4	97.4	94.1	87.2	83.5	75.2	62.0
	4	99.9	98.8	97.6	96.9	95.8	94.8	93.1	87.7	77.0	73.2	67.6
	MEAN	98.9	96.0	93.5	92.7	91.7	90.6	89.3	83.9	77.4	71.2	62.1
SB-B	2	100.0	99.8	99.5	99.1	94.2	88.7	85.7	79.8	74.5	66.8	54.2
	3	99.0	98.9	98.2	97.6	96.0	90.2	88.1	76.4	70.3	63.6	54.0
	4	99.9	99.4	98.8	98.0	93.5	93.2	88.2	77.4	70.1	62.5	53.1
	MEAN	99.6	99.4	98.8	98.2	95.2	90.7	87.3	77.9	71.6	64.3	53.8
STD. DEV.		1.7	5.2	8.0	8.5	8.6	9.6	7.5	6.2	6.0	5.3	5.5
SB-B	2	100.0	99.8	99.5	99.1	94.2	88.7	85.7	79.8	74.5	66.8	54.2
	3	99.0	98.9	98.2	97.6	96.0	90.2	88.1	76.4	70.3	63.6	54.0
	4	99.9	99.4	98.8	98.0	93.5	93.2	88.2	77.4	70.1	62.5	53.1
	MEAN	99.6	99.4	98.8	98.2	95.2	90.7	87.3	77.9	71.6	64.3	53.8
STD. DEV.		1.7	5.2	8.0	8.5	8.6	9.6	7.5	6.2	6.0	5.3	5.5

Cumulative Sediment Grain-Size Characterization Survey 1

SURVEY 1 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)											
		<99.1	<350	<180	<125	<85	<60	<30	<20	<15	<10	<5	
RCH-A	2	98.8	98.0	96.4	95.1	93.3	93.1	90.2	81.4	76.2	67.8	58.5	
	3	98.8	97.2	93.3	90.8	88.3	88.2	83.6	78.3	72.6	63.5	61.5	
	4	96.6	95.2	91.0	88.0	85.1	83.0	82.0	75.8	71.7	64.6	54.4	
	MEAN	98.1	96.8	93.6	91.3	88.9	88.1	85.3	78.5	73.5	65.3	58.1	
	STD. DEV.	1.3	1.4	2.7	3.6	4.1	5.1	4.3	2.8	2.4	2.2	3.6	
RCH-B	1	100.0	98.8	97.7	97.0	94.7	94.9	94.0	88.8	80.6	72.9	58.7	
	3	99.9	98.4	97.5	96.9	94.6	93.1	91.0	83.1	76.4	67.1	54.4	
	4	99.9	99.4	97.5	96.4	92.8	93.9	90.6	81.7	78.8	70.7	58.7	
	MEAN	99.9	98.9	97.6	96.8	94.0	94.0	91.9	84.5	78.6	70.2	57.3	
	STD. DEV.	.1	.5	.1	.3	1.1	.9	1.9	3.8	2.1	2.9	2.5	

Cumulative Sediment Grain-Size Characterization
Survey 2

SURVEY NO. 2

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<99.1	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
MIS-A	1	99.6	99.4	99.2	99.1	95.7	97.6	94.6	86.8	56.2	25.9	7.4
	3	98.4	98.0	97.7	97.6	96.2	96.0	94.5	82.5	43.4	10.8	10.2
	5	98.8	98.5	98.4	98.4	97.0	97.7	95.8	76.6	39.0	9.3	1.4
	MEAN	98.9	98.6	98.4	98.4	96.3	97.1	95.0	82.0	46.2	15.3	6.3
	STD. DEV.	.6	.7	.8	.8	.7	1.0	.7	5.1	8.9	9.2	4.5
MIS-B	1	99.9	99.5	99.2	98.9	95.3	94.9	91.7	63.7	24.4	9.0	4.8
	3	99.3	98.8	98.5	98.2	95.2	93.9	93.8	65.3	27.9	10.7	7.8
	5	99.5	99.0	98.6	98.2	94.3	96.0	90.4	61.1	16.3	9.3	1.8
	MEAN	99.6	99.1	98.8	98.4	94.9	94.9	92.0	63.4	22.9	9.7	4.8
	STD. DEV.	.3	.4	.4	.4	.6	1.1	1.7	2.1	6.0	.9	3.0

Cumulative Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<99.1	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
CS-A	1	99.3	98.8	97.5	94.8	90.0	90.0	88.9	74.6	42.7	13.4	2.7
	3	99.1	98.0	95.1	91.1	86.7	84.4	82.9	82.7	67.6	16.1	10.5
	5	98.7	97.7	95.4	91.7	86.2	87.2	86.1	80.5	25.6	5.8	10.4
	MEAN	99.0	98.2	96.0	92.5	87.6	87.2	86.0	79.3	45.3	11.8	7.9
	STD. DEV.	.3	.6	1.3	2.0	2.1	2.8	3.0	4.2	21.1	5.3	4.5
CS-B	1	99.6	98.7	91.1	79.1	70.8	71.0	70.9	64.1	33.2	7.7	2.8
	3	97.0	94.2	66.8	48.2	42.0	41.5	41.5	26.6	27.6	11.1	2.1
	5	99.3	98.4	94.6	89.7	82.8	80.0	82.5	77.8	60.1	5.3	1.3
	MEAN	98.6	97.1	84.2	72.3	65.2	64.2	65.0	56.2	40.3	8.0	2.1
	STD. DEV.	1.4	2.5	5.1	21.6	21.0	20.1	21.1	26.5	17.4	2.9	.8

Cumulative Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
ALC	1	106.0	99.9	99.6	99.3	94.3	94.9	91.2	86.9	76.5	36.1	4.0
	3	99.9	99.7	99.0	98.4	90.7	92.7	93.4	85.2	66.5	4.6	6.6
	5	97.3	92.1	81.0	78.3	70.4	69.5	75.2	70.7	40.7	4.1	.6
	MEAN	99.1	97.2	93.2	92.0	85.1	85.7	86.6	80.9	61.2	14.9	3.7
	STD. DEV.	1.5	4.4	10.6	11.9	12.9	14.1	9.9	8.9	18.5	18.3	3.0
OIH	1	98.7	96.2	66.4	44.1	31.3	30.7	28.8	23.0	12.2	4.8	2.1
	3	99.1	96.8	63.6	39.2	26.3	26.6	24.6	21.6	14.4	6.9	.4
	5	99.1	96.3	66.6	45.1	32.8	32.7	30.4	26.6	12.1	3.3	1.8
	MEAN	99.0	96.4	65.5	42.8	30.1	30.0	27.9	23.7	12.9	5.0	1.4
	STD. DEV.	.2	.3	1.7	3.2	3.4	3.1	3.0	2.6	1.3	1.8	.9

Cumulative Sediment Grain-Size Characterization Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
HP	1	74.5	71.9	70.6	68.4	59.2	58.9	53.9	51.6	39.5	14.0	4.3
	3	93.5	92.1	90.5	86.3	74.3	72.9	70.9	57.1	31.3	9.8	.3
	5	91.8	90.3	88.6	84.7	73.8	72.7	67.1	58.7	31.1	13.9	8.6
	MEAN	86.6	84.8	83.2	79.8	69.1	68.2	64.0	55.8	34.0	12.6	4.4
	STD. DEV.	10.5	11.2	11.0	9.9	8.6	8.0	8.9	3.7	4.8	2.4	4.2
SB-A	1	74.6	58.3	46.4	43.0	38.4	37.3	37.0	32.5	27.9	5.4	.1
	3	78.8	60.3	49.6	46.8	43.4	43.4	41.6	40.2	37.1	13.1	2.3
	5	54.5	35.3	24.8	22.6	19.8	19.7	20.5	17.4	17.0	1.9	0.0
	MEAN	69.3	51.3	40.3	37.5	33.9	33.5	33.0	30.0	27.3	6.8	.8
	STD. DEV.	13.0	13.9	13.5	13.0	12.4	12.3	11.1	11.6	10.1	5.7	1.3

Cumulative Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
SB-B	1	92.7	90.8	89.0	87.5	81.8	84.1	78.1	74.3	61.3	16.4	4.0
	3	100.0	99.9	99.9	99.8	93.6	98.6	91.4	86.8	66.0	5.4	4.4
	5	99.9	99.7	99.6	99.5	94.6	97.9	97.4	93.1	64.5	17.2	.1
	MEAN	97.5	96.8	96.2	95.6	90.0	93.5	89.0	84.7	63.9	13.0	2.8
	STD. DEV.	4.2	5.2	6.2	7.0	7.1	8.2	9.9	9.6	2.4	6.6	2.4
RCH-A	1	99.5	97.8	81.6	74.3	71.5	71.4	68.7	64.7	38.2	10.3	4.0
	3	93.4	92.2	87.5	84.9	79.4	82.4	81.0	73.0	49.2	8.8	4.9
	5	98.5	98.1	97.5	96.9	95.1	94.5	93.0	86.7	59.7	8.3	2.3
	MEAN	97.2	96.0	88.9	85.4	82.0	82.8	82.6	74.8	49.0	9.1	3.7
	STD. DEV.	3.1	3.3	8.0	11.3	12.0	11.6	14.7	11.1	10.8	1.0	1.3

Cumulative Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)											
		<991	<350	<180	<125	<63	<40	<30	<20	<15	<10	<5	
RCH-B	1	99.9	99.7	99.6	99.4	97.6	98.1	97.8	87.1	46.4	11.1	3.4	
	3	100.0	99.5	99.1	98.9	97.4	97.1	92.7	66.8	17.7	7.2	3.5	
	5	99.4	99.0	98.6	98.2	96.0	93.3	96.8	69.8	20.1	16.1	8.6	
	MEAN	99.8	99.4	99.1	98.8	97.0	96.2	95.8	74.6	28.1	11.5	5.8	
	STD. DEV.	.3	.4	.5	.6	.9	2.5	2.7	11.0	15.9	4.5	2.6	

Cumulative Sediment Grain-Size Characterization
Survey 3

SURVEY NO. 3

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<991	<350	<180	<125	<63	<40	<30	<20	<15	<10	<5
MIS-A	1	100.0	99.0	98.4	98.0	95.7	95.5	91.6	88.5	81.7	72.8	59.1
	2	100.0	99.4	98.9	98.7	97.1	88.7	96.1	93.4	90.5	80.1	62.8
	3	100.0	99.8	99.4	99.1	97.6	96.1	90.8	86.1	80.8	73.0	60.4
	MEAN	100.0	99.4	98.9	98.6	96.8	93.4	92.8	89.3	84.3	75.3	60.8
	STD. DEV.	0.0	.4	.5	.6	1.0	4.1	2.9	3.7	5.4	4.2	1.9
MIS-B	1	99.9	99.3	98.7	98.2	94.3	93.1	91.4	85.2	77.7	68.2	55.7
	2	99.9	99.0	98.3	97.7	93.3	87.4	85.4	78.5	75.1	67.1	53.2
	3	100.0	99.1	98.4	98.0	94.9	94.5	92.4	86.5	80.4	71.6	58.6
	MEAN	99.9	99.1	98.5	98.0	94.2	91.7	89.7	83.4	77.7	69.0	55.8
	STD. DEV.	.1	.2	.2	.3	.8	3.8	3.8	4.3	2.7	2.3	2.7

Cumulative Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<99.1	<35.0	<18.0	<12.5	<4.3	<4.0	<3.0	<2.0	<1.5	<1.0	<.5
CS-A	1	98.6	89.4	53.9	31.6	24.7	24.3	23.5	20.6	19.9	17.9	14.4
	2	98.7	83.8	40.3	20.1	16.5	15.7	15.4	14.8	13.9	13.2	11.5
	3	95.4	81.9	46.8	28.7	25.1	24.0	23.6	21.9	20.3	18.5	15.1
	MEAN	97.6	85.0	47.0	26.8	22.1	21.3	20.8	19.1	18.0	16.5	13.7
	STD. DEV.	1.9	3.9	6.8	6.8	4.9	4.9	4.7	3.8	3.6	2.9	1.9
CS-B	1	98.0	94.5	62.9	45.9	39.1	38.9	38.6	37.1	31.2	27.9	25.4
	2	99.2	96.9	77.0	65.3	59.4	57.5	56.9	53.7	49.5	44.6	36.7
	3	99.4	96.1	65.9	51.3	46.0	45.7	44.3	42.3	39.0	35.7	29.2
	MEAN	98.9	95.8	68.6	56.2	48.2	47.4	46.6	44.4	39.9	36.1	30.4
	STD. DEV.	.8	1.2	7.4	10.0	10.3	9.4	9.4	8.5	9.2	8.4	5.8

Cumulative Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<95.1	<150	<125	<100	<75	<60	<50	<40	<30	<20	<15
ALC	1	97.1	96.5	91.8	88.5	84.8	78.1	72.4	66.9	62.3	55.7	45.1
	3	99.2	98.7	97.0	95.8	92.6	92.5	87.9	81.3	75.2	68.5	55.1
	4	94.9	94.1	89.6	87.4	82.9	81.4	80.5	73.3	68.0	61.0	49.3
	MEAN	97.1	96.4	92.8	90.6	86.8	84.0	80.3	73.8	68.5	61.7	49.8
	STD. DEV.	2.2	2.3	3.8	4.6	5.1	7.5	7.8	7.2	6.5	6.4	5.0
OIH	1	99.8	98.2	71.9	49.1	36.5	34.2	31.4	30.2	27.4	25.5	19.9
	2	99.5	97.4	66.4	45.5	35.1	34.2	32.5	30.2	29.9	26.3	20.7
	3	99.3	97.8	71.3	48.6	36.0	32.6	32.7	29.3	27.0	25.0	20.9
	MEAN	99.5	97.8	69.9	47.7	35.9	33.7	32.2	29.9	28.1	25.6	20.5
	STD. DEV.	.3	.4	3.0	2.0	.7	.9	.7	.5	1.6	.7	.5

Cumulative Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<99.1	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
HP	1	96.1	94.4	92.0	88.7	80.0	72.4	71.9	64.4	59.9	53.7	43.4
	2	99.8	98.5	95.2	88.7	74.3	70.0	66.4	61.1	55.6	51.2	42.0
	3	92.7	91.7	91.7	87.9	75.4	70.5	66.5	67.4	67.5	55.5	46.2
	MEAN	96.2	94.9	93.0	88.4	76.6	71.0	68.3	64.3	58.7	53.5	43.9
	STD. DEV.	3.6	3.4	1.9	.5	3.0	1.3	3.1	3.2	2.7	2.2	2.1
SB-A	1	99.9	99.6	99.1	98.8	97.2	87.4	87.0	80.3	72.0	66.1	54.0
	2	97.0	96.3	95.4	94.8	88.8	91.2	79.3	80.0	72.4	65.0	54.7
	3	96.0	94.8	93.6	92.7	89.1	82.6	80.8	75.5	69.2	63.5	52.7
	MEAN	97.6	96.9	96.0	95.4	91.7	87.1	82.4	78.6	71.2	64.9	53.8
	STD. DEV.	2.0	2.5	2.8	3.1	4.8	4.3	4.1	2.7	1.7	1.3	1.0

Cumulative Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
SB-B	1	96.4	95.5	94.8	94.2	91.7	89.9	85.5	77.3	71.9	63.5	50.5
	2	99.7	99.3	98.7	98.1	95.4	94.9	87.2	79.9	74.1	70.0	53.0
	3	99.7	99.2	98.6	98.1	95.7	94.1	92.0	89.3	82.8	74.6	60.6
	MEAN	98.6	98.0	97.4	96.8	94.3	93.0	88.2	82.2	76.3	69.4	54.7
	STD. DEV.	1.9	2.2	2.2	2.3	2.2	2.7	3.4	6.3	5.8	5.6	5.3
RCH-A	1	98.9	98.3	97.7	96.0	92.1	92.0	88.3	82.9	76.1	68.6	59.3
	2	99.1	98.7	98.1	96.4	92.9	91.5	87.7	85.4	75.7	69.3	56.0
	3	94.5	93.6	92.5	90.6	87.0	85.9	81.9	75.4	68.6	64.0	52.5
	MEAN	97.5	96.9	96.1	94.3	90.7	89.8	86.0	81.2	73.5	67.3	55.9
	STD. DEV.	2.6	2.8	3.1	3.2	3.2	3.4	3.5	5.2	4.2	2.9	3.4

Cumulative Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
RCH-B	1	99.5	93.9	98.3	97.9	95.6	93.5	91.5	88.3	79.3	73.1	60.0
	2	99.6	99.2	98.7	98.4	96.2	91.0	90.3	89.8	83.0	79.4	62.5
	3	99.8	99.3	99.0	98.8	97.1	93.7	89.1	82.5	77.1	70.6	58.5
	MEAN	99.6	99.1	98.7	98.4	96.3	92.7	90.3	86.9	79.8	74.4	60.3
	STD. DEV.	.2	.2	.4	.5	.8	1.5	1.2	3.9	3.0	4.5	2.0

Cumulative Sediment Grain-Size Characterization
Survey 4

SURVEY NO. 4

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<99.1	<350	<190	<125	<43	<40	<30	<20	<15	<10	<5
MIS-A	1	100.0	99.6	99.2	99.0	98.2	97.5	97.0	92.7	87.2	81.0	64.3
	2	100.0	99.5	99.3	99.2	99.1	95.2	96.4	92.1	86.5	79.8	63.8
	3	100.0	99.7	99.4	99.2	99.0	98.7	96.9	96.5	91.4	81.7	41.7
	MEAN	100.0	99.6	99.3	99.1	98.6	97.1	96.8	93.8	88.4	80.8	56.6
	STD. DEV.	0.0	.1	.1	.1	.5	1.8	.3	2.4	2.7	1.0	12.9
MIS-B	1	98.4	97.9	97.5	97.2	95.2	95.1	90.5	85.7	78.7	72.6	52.0
	2	99.9	99.4	99.1	98.8	96.7	95.1	92.2	86.2	81.4	72.8	56.5
	3	100.0	99.6	99.3	99.1	99.0	98.8	95.4	90.6	82.3	73.7	53.4
	MEAN	99.4	99.0	98.6	98.4	97.0	96.3	92.7	87.5	80.8	73.0	54.0
	STD. DEV.	.9	.9	1.0	1.0	1.9	2.1	2.5	2.7	1.9	.6	2.3

Cumulative Sediment Grain-Size Characterization Survey 4

SURVEY 4 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<99.1	<350	<180	<125	<43	<60	<30	<20	<15	<10	<5
CS-A	1	98.1	96.9	89.6	82.8	77.2	78.1	77.6	71.2	67.5	52.0	46.6
	2	99.6	98.2	90.0	84.5	78.2	80.9	78.5	73.6	67.9	61.3	48.8
	3	96.3	91.5	65.8	47.2	42.4	43.8	44.3	41.0	37.4	33.7	26.5
	MEAN	98.0	95.5	81.8	71.5	65.9	67.6	66.8	61.9	57.5	49.0	40.6
	STD. DEV.	1.7	3.6	13.9	21.1	20.4	20.7	19.5	18.2	17.5	14.0	12.3
CS-B	1	99.5	97.1	85.6	66.8	48.8	47.0	46.1	43.3	39.8	36.0	29.3
	2	99.6	98.1	87.6	67.5	49.3	47.6	47.4	44.8	42.0	37.8	30.2
	3	99.8	98.5	82.0	86.9	45.4	44.6	43.2	40.9	38.3	35.0	28.9
	MEAN	99.6	97.9	85.1	73.7	47.8	46.4	45.6	43.0	40.0	36.3	29.5
	STD. DEV.	.2	.7	2.8	11.4	2.1	1.6	2.2	2.0	1.9	1.4	.7

Cumulative Sediment Grain-Size Characterization
Survey 4

SURVEY 4 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
ALC	1	100.0	92.3	20.1	1.9	.7	.3	.1	.1	.1	.1	.1
	2	99.9	88.9	14.6	1.0	.3	.3	.2	.1	.1	.1	.1
	3	100.0	94.0	19.0	1.4	.5	.4	.4	.2	.2	.1	0.0
	MEAN	100.0	91.7	17.9	1.4	.5	.3	.2	.1	.1	.1	.1
	STD. DEV.	.1	2.6	2.9	.5	.2	.1	.2	.1	.1	.0	.1
OJH	1	99.5	95.0	59.4	42.0	31.4	30.3	30.1	28.1	26.1	23.4	17.8
	2	98.1	93.6	58.9	42.1	33.0	31.0	30.4	27.7	25.3	22.6	18.8
	3	98.9	95.0	64.4	47.5	37.0	35.3	32.2	30.9	28.0	25.1	20.8
	MEAN	98.8	94.5	60.9	43.9	33.8	32.2	30.9	28.9	26.5	23.7	19.1
	STD. DEV.	.7	.8	3.0	3.1	2.9	2.7	1.1	1.7	1.4	1.3	1.5

Cumulative Sediment Grain-Size Characterization
Survey 4

SURVEY 4 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)										
		<991	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
HP	1	98.8	97.6	95.8	92.5	79.8	78.5	78.0	70.2	63.3	60.8	52.8
	2	93.4	91.8	89.9	87.1	77.0	71.0	70.1	68.1	60.1	59.4	50.2
	3	99.8	98.2	96.2	93.5	84.1	77.7	78.6	72.4	66.9	60.2	51.2
	MEAN	97.3	95.9	94.0	91.0	80.3	75.7	75.6	70.2	63.4	60.1	51.4
	STD. DEV.	3.4	3.5	3.5	3.4	3.6	4.1	4.7	2.2	3.4	.7	1.3
SB-A	1	89.9	76.9	64.8	63.9	62.9	59.8	58.0	54.5	50.4	44.2	33.4
	2	99.7	98.9	97.8	97.2	94.3	92.4	87.9	78.7	70.7	62.8	51.6
	3	82.3	62.8	49.1	47.4	44.1	45.6	45.1	40.3	36.7	33.2	25.4
	MEAN	90.6	79.5	70.6	69.5	67.1	65.6	63.7	57.8	52.6	46.7	36.8
	STD. DEV.	8.7	18.2	24.9	25.4	25.4	24.1	22.0	19.4	17.1	15.0	13.4

Cumulative Sediment Grain-Size Characterization
Survey 4

SURVEY 4 (CONTINUED)

STATION	SAMPLE NO.	PERCENTAGE DISTRIBUTION (MICRONS)											
		<991	<350	<180	<125	<63	<40	<30	<20	<15	<10	<5	
SB-8	1	99.0	98.5	98.1	97.8	96.0	91.4	89.8	82.6	73.1	64.3	47.7	
	2	100.0	99.3	98.7	98.2	97.6	90.5	46.1	16.8	12.5	9.6	5.0	
	3	100.0	99.2	98.7	98.4	97.8	92.2	88.3	80.5	66.5	55.3	34.6	
	MEAN	99.7	99.0	98.5	98.1	97.1	91.4	74.7	60.0	50.7	43.1	29.1	
	STD. DEV.	.6	.4	.3	.3	1.0	.9	24.8	37.4	33.2	29.3	21.9	
RCN-A	1	92.5	89.2	81.2	70.4	64.5	62.9	61.5	56.2	52.9	48.4	40.4	
	2	90.9	88.4	83.2	77.1	73.7	73.7	72.3	66.0	60.6	55.4	46.0	
	3	90.0	86.1	80.0	73.3	71.8	70.3	67.2	63.7	59.7	54.0	44.8	
	MEAN	91.1	87.9	81.5	73.6	70.0	69.0	67.0	62.0	57.7	52.6	43.7	
	STD. DEV.	1.3	1.6	1.6	3.4	4.9	5.5	5.4	5.1	4.2	3.7	2.9	

Cumulative Sediment Grain-Size Characterization
Survey 4

SURVEY 4 (CONTINUED)

PERCENTAGE DISTRIBUTION (MICRONS)												
STATION	SAMPLE NO.	<99.1	<350	<180	<125	<43	<40	<30	<20	<15	<10	<5
ACH-8	1	99.9	99.5	99.3	99.1	97.8	97.5	93.8	86.4	80.2	73.1	61.2
	2	99.9	99.1	98.7	98.5	96.8	90.2	91.5	84.5	78.9	70.8	58.9
	3	99.7	99.3	99.0	98.7	97.0	95.9	94.3	85.8	79.5	71.7	59.1
	MEAN	99.8	99.3	99.0	98.8	97.2	94.5	93.2	85.5	79.5	71.9	59.7
	STD. DEV.	.1	.2	.3	.3	.5	3.8	1.5	1.0	.7	1.2	1.3

CATEGORICAL SEDIMENT GRAIN-SIZE CHARACTERIZATION

Categorical Sediment Grain-Size Characterization Survey 1

STATION	SAMPLE NO.	SURVEY NO. 1 PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
		>991	350-990	180-349	125-179	4.5-124	60-42	30-39	20-29	15-19	10-14	5-9	<5
MIS-A	1	1.1	.6	.5	.4	2.6	.9	4.6	10.8	6.0	8.9	12.5	51.1
	2	.1	.1	.7	.6	10.4	1.8	1.4	10.9	6.4	6.3	11.6	50.9
	3	0.0	.2	1.0	1.2	5.8	1.6	3.0	9.2	8.1	8.7	12.4	48.8
	MEAN	.4	.3	.7	.3	6.3	1.4	3.0	10.3	6.8	8.0	12.2	50.3
	STD. DEV.	.6	.3	.3	.9	3.9	.5	1.6	1.0	1.1	1.4	.5	1.3
MIS-B	1	.1	.2	.2	.1	.9	1.8	0.0	6.0	4.9	4.3	17.9	63.6
	3	0.0	.1	1.0	.7	4.0	1.4	2.1	4.0	9.1	5.4	16.0	56.2
	5	0.0	.6	.6	.5	2.5	1.5	1.5	7.3	5.4	7.2	18.2	56.7
	MEAN	.0	.3	.6	.4	2.5	1.6	1.2	5.8	6.5	5.6	17.4	58.2
	STD. DEV.	.1	.3	.4	.3	1.6	.2	1.1	1.7	2.3	1.5	1.2	4.9

Categorical Sediment Grain-Size Characterization Survey 1

SURVEY 1 (CONTINUED)

		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
CS-A	1	.2	1.4	3.6	3.5	3.0	.9	1.7	.9	2.0	13.7	12.9	55.3
	3	.7	.6	15.8	14.2	5.8	1.9	3.3	4.7	4.2	7.0	9.4	32.4
	4	0.0	.8	1.4	1.2	2.9	.7	1.1	5.4	7.2	6.8	13.9	58.5
	MEAN	.3	.9	6.9	6.3	4.2	1.2	2.0	3.7	4.5	9.2	12.1	48.8
	STD. DEV.	.4	.4	7.8	6.9	1.5	.6	1.1	2.4	2.6	1.9	2.4	14.3
CS-B	1	.9	2.3	24.1	32.9	12.4	.6	.9	2.3	1.4	2.4	4.2	15.6
	2	.6	.4	5.2	7.5	9.3	2.5	3.0	4.7	4.4	7.2	11.7	43.4
	4	1.1	2.4	16.5	15.9	12.0	2.4	.5	5.7	3.5	2.0	10.1	27.9
	MEAN	.9	1.7	15.3	18.8	11.2	1.8	1.5	4.2	3.1	3.9	9.7	29.0
	STD. DEV.	.3	1.1	9.5	12.9	1.7	1.1	1.3	1.7	1.5	3.0	4.0	13.9

Categorical Sediment Grain-Size Characterization Survey 1

SURVEY 1 (CONTINUED)

STATION		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)												
SAMPLE NO.		>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5	
ALC	2	.3	10.3	72.9	12.9	.6	.2	0.0	.1	.4	.1	.4	1.9	
	4	.1	10.5	66.3	19.3	1.2	.3	.2	.3	.1	0.0	.2	1.5	
	5	.2	8.2	65.8	22.8	1.4	0.0	.1	.3	.2	0.0	.4	.6	
	MEAN	.2	9.7	68.3	18.3	1.1	.2	.1	.2	.2	.0	.3	1.3	
	STD. DEV.	.1	1.3	4.0	5.0	.4	.2	.1	.1	.2	.1	.1	.6	
OTH	1	.2	1.9	21.4	21.2	15.1	1.7	1.1	.1	.5	.5	14.6	21.7	
	2	.7	1.6	28.9	26.8	13.4	.2	.7	2.9	1.8	1.2	3.5	18.3	
	4	.8	2.2	9.3	9.3	12.4	1.4	5.1	4.3	7.2	3.7	8.6	35.7	
	MEAN	.6	1.9	19.9	19.1	13.6	1.1	2.3	2.4	3.2	1.8	8.9	25.2	
	STD. DEV.	.3	.3	9.9	8.9	1.4	.8	2.4	2.1	3.6	1.7	5.6	7.2	
P	3	.4	1.8	5.5	5.1	10.8	3.0	4.9	5.9	6.7	3.9	8.2	43.8	
	5	3.8	2.7	11.4	6.5	8.5	1.2	2.5	5.5	2.7	5.7	6.6	42.9	
	MEAN	2.1	2.2	6.5	5.8	9.6	2.1	3.7	5.7	4.7	4.8	7.4	43.3	
	STD. DEV.	2.4	.6	4.2	1.0	1.6	1.3	1.7	.3	2.9	1.3	1.1	.6	

Categorical Sediment Grain-Size Characterization Survey 1

SURVEY 1 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-62	30-39	20-29	15-19	10-14	5-9	<5
SB-A	1	3.0	7.0	5.8	1.2	1.2	2.2	-1.0	3.8	5.1	6.6	8.5	56.5
	3	.1	.7	.6	.3	.9	0.0	3.3	6.9	3.6	8.4	3.2	62.0
	4	.1	1.1	1.2	.7	1.1	1.0	1.7	5.4	10.7	3.8	5.6	67.6
	MEAN	1.1	2.9	2.5	.7	1.1	1.1	1.3	5.4	6.5	6.3	9.1	62.1
	STD. DEV.	1.7	3.5	2.8	.5	.2	1.1	2.2	1.6	3.7	2.3	3.8	5.5
SB-B	2	0.0	.2	.3	.4	2.9	7.5	3.0	5.9	5.3	7.7	12.6	54.2
	3	1.0	.1	.7	.6	1.6	5.8	2.1	11.7	6.1	6.7	9.6	54.0
	4	.1	.5	.6	.8	4.5	.3	5.0	10.8	7.3	7.6	9.4	53.1
	MEAN	.4	.3	.5	.6	3.0	4.5	3.4	9.5	6.2	7.3	10.5	53.9
	STD. DEV.	.6	.2	.2	.2	1.5	3.8	1.5	3.1	1.0	.6	1.8	.6

Categorical Sediment Grain-Size Characterization Survey 1

SURVEY 1 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>1	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
RCH-A	2	1.2	.8	1.6	1.3	1.8	.2	2.9	8.8	5.2	8.4	9.3	58.5
	3	1.2	1.6	3.9	2.5	2.5	.1	4.6	5.3	5.7	9.1	2.0	61.5
	4	3.4	1.4	4.2	3.0	2.9	2.1	1.0	6.2	4.1	7.1	10.2	54.4
	MEAN	1.9	1.3	3.2	2.3	2.4	.8	2.8	6.8	5.0	8.2	7.2	58.1
	STD. DEV.	1.3	.4	1.4	.9	.6	1.1	1.8	1.8	.8	1.0	4.5	3.6
RCH-B	1	0.0	1.2	1.1	.7	2.3	-.2	.9	5.2	8.2	7.7	14.2	58.7
	3	.1	1.5	.9	.6	2.3	1.5	2.1	7.9	6.7	9.3	12.7	54.4
	4	.1	.5	1.9	1.1	3.6	-1.1	3.3	8.9	2.9	8.1	12.0	58.7
	MEAN	.1	1.1	1.3	.8	2.7	.1	2.1	7.3	5.9	8.4	13.0	57.3
	STD. DEV.	.1	.5	.5	.3	.8	1.3	1.2	1.9	2.7	.8	1.1	2.5

Categorical Sediment Grain-Size Characterization
Survey 2

STATION	SAMPLE NO.	>991	SURVEY NO. 2 PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)										<5
			350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	
MIS-A	1	.4	.2	.2	.1	3.4	-1.9	3.0	7.8	30.6	40.3	18.5	7.4
	3	1.6	.4	.3	.1	1.4	.2	1.5	12.0	39.1	32.6	.6	10.2
	5	1.2	.3	.1	0.0	1.4	-.7	1.9	19.2	37.6	29.7	7.9	1.4
	MEAN	1.1	.3	.2	.1	2.1	-.8	2.1	13.0	35.8	30.9	9.0	6.3
	STD. DEV.	.6	.1	.1	.1	1.2	1.1	.5	5.8	4.5	1.5	9.0	4.5
MIS-B	1	.1	.4	.3	.3	3.6	.4	3.2	28.0	39.3	15.4	4.2	4.8
	3	.7	.5	.3	.3	3.0	1.3	.1	28.5	37.4	17.2	2.9	7.8
	5	.5	.5	.4	.4	3.9	-1.7	5.6	29.3	44.8	7.0	7.5	1.8
	MEAN	.4	.5	.3	.3	3.5	0.0	3.0	28.6	40.5	13.2	4.9	4.8
	STD. DEV.	.3	.1	.1	.1	.5	1.5	2.8	.7	3.8	5.4	2.4	3.0

Categorical Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-174	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
CS-A	1	.7	.5	1.3	2.7	4.8	0.0	1.1	14.3	31.9	29.3	10.7	2.7
	3	.9	1.1	2.9	4.0	4.4	2.3	1.5	.2	15.1	51.5	5.6	10.5
	5	1.3	1.0	2.3	3.7	5.5	-1.0	1.1	5.6	54.9	19.8	-4.6	10.4
	MEAN	1.0	.9	2.2	3.5	4.9	.4	1.2	6.7	34.0	33.5	3.9	7.9
	STD. DEV.	.3	.3	.8	.7	.6	1.7	.2	7.1	20.0	16.3	7.8	4.5
CS-B	1	.4	.9	7.6	12.0	8.3	-.2	.1	6.8	30.9	25.5	4.9	2.8
	3	3.0	2.8	27.4	18.6	6.2	.5	0.0	14.9	-1.0	16.5	9.0	2.1
	5	.7	.9	3.8	4.9	6.9	2.8	-2.5	4.7	17.7	54.8	4.0	1.3
	MEAN	1.4	1.5	12.9	11.8	7.1	1.0	-.8	8.8	15.9	32.3	6.0	2.1
	STD. DEV.	1.4	1.1	12.7	6.9	1.1	1.6	1.5	4.4	16.0	20.0	2.7	.8

Categorical Sediment Grain-Size Characterization
Survey 2

SURVEY 2 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
ALC	1	0.0	.1	.3	.3	5.0	-1.6	3.7	4.3	10.4	40.4	32.1	4.0
	3	.1	.2	.7	.6	7.7	-2.0	-7	8.2	18.7	61.9	-2.0	6.6
	5	2.7	5.2	11.1	2.7	7.9	.9	-5.7	4.5	30.0	36.6	3.5	.6
	MEAN	.9	1.8	4.0	1.2	6.9	-1.6	-9	5.7	19.7	46.3	11.2	3.7
	STD. DEV.	1.5	2.9	6.1	1.3	1.6	1.5	4.7	2.2	9.8	13.6	18.3	3.0
OIH	1	1.3	2.5	29.8	22.3	12.8	.6	1.9	5.8	10.8	7.4	2.7	2.1
	3	.9	2.3	33.2	24.4	12.9	-2.3	2.0	3.0	7.2	7.5	6.5	.4
	5	.9	2.8	29.7	21.5	12.3	.1	2.3	3.8	14.5	8.9	1.5	1.8
	MEAN	1.0	2.5	30.9	22.7	12.7	.1	2.1	4.2	10.8	7.9	3.6	1.4
	STD. DEV.	.2	.3	2.0	1.5	.3	.5	.2	1.4	3.7	.8	2.6	.9

Categorical Sediment Grain-Size Characterization Survey 2

SURVEY 2 (CONTINUED)

STATION	SAMPLE NO.	PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
		>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
HP	1	25.5	2.6	1.3	2.2	9.2	.3	5.0	2.3	12.1	25.5	9.7	4.3
	3	6.5	1.4	1.6	4.2	12.0	1.4	2.0	13.8	25.8	21.5	9.5	.3
	5	8.2	1.5	1.7	3.9	10.9	1.1	5.6	8.4	27.6	17.2	5.3	8.6
	MEAN	13.4	1.8	1.5	3.4	10.7	.9	4.2	8.2	21.8	21.4	8.2	4.4
	STD. DEV.	10.5	.7	.2	1.1	1.4	.6	1.9	5.8	8.5	4.2	2.5	4.2
SB-A	1	25.4	16.3	11.9	3.4	4.6	1.1	.3	4.5	4.6	22.5	5.3	.1
	3	21.2	18.5	10.7	2.8	3.4	0.0	1.8	1.4	3.1	24.0	10.8	2.3
	5	45.5	19.2	10.5	2.2	2.8	.1	-.8	3.1	.4	15.1	1.9	0.0
	MEAN	30.7	18.0	11.0	.8	3.6	.4	.4	3.0	2.7	20.5	6.0	.8
	STD. DEV.	13.0	1.5	.8	.6	.9	.6	1.3	1.6	2.1	4.8	4.5	1.3

Categorical Sediment Grain-Size Characterization Survey 2

SURVEY 2 (CONTINUED)													
PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)													
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	63-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
SB-8	1	7.3	1.9	1.8	1.5	5.7	-2.3	6.0	3.8	13.0	44.9	12.4	4.0
	3	0.0	.1	0.0	.1	6.2	-5.0	7.2	4.6	20.8	60.6	1.0	4.4
	5	.1	.2	.1	.1	4.9	-3.3	.5	4.3	28.6	47.3	17.1	.1
	MEAN	2.5	.7	.6	.6	5.6	-3.5	4.6	4.2	20.8	50.9	10.2	2.8
	STD. DEV.	4.2	1.0	1.0	.8	.7	1.4	3.6	.4	7.8	8.5	8.3	2.4
RCN-A	1	.5	1.7	16.2	7.3	2.8	.1	2.7	4.0	26.5	27.9	6.3	4.0
	3	6.6	1.2	4.7	2.6	5.5	-3.0	1.4	8.0	23.8	40.4	3.9	4.9
	5	1.4	.5	.6	.6	1.8	.6	-3.5	11.3	27.0	51.4	6.0	2.3
	MEAN	2.8	1.1	7.2	3.5	3.4	-.8	.2	7.8	25.8	39.9	5.4	3.7
	STD. DEV.	3.3	.6	8.1	3.4	1.9	2.0	3.3	3.7	1.7	11.8	1.3	1.3

Categorical Sediment Grain-Size Characterization Survey 2

SURVEY 2 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
ACH-8	1	.1	.2	.1	.2	1.8	-.5	.3	10.7	40.7	35.3	7.7	3.4
	3	0.0	.5	.4	.2	1.5	.3	4.4	25.9	49.1	10.5	1.7	5.5
	5	.6	.4	.4	.4	2.2	2.7	-3.5	27.0	49.7	4.0	7.5	8.6
	MEAN	.2	.4	.3	.3	1.8	.8	.4	21.2	46.5	16.6	5.6	5.8
	STD. DEV.	.3	.2	.2	.1	.4	1.7	4.0	9.1	5.0	16.5	3.4	2.6

Categorical Sediment Grain-Size Characterization Survey 3

STATION	SAMPLE NO.	SURVEY NO. 3 PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)												<5
		>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9		
MIS-A	1	0.0	1.0	.6	.4	2.3	.2	3.9	3.1	6.8	8.9	13.7	59.1	
	2	0.0	.6	.5	.2	1.6	8.4	-7.4	2.7	2.9	10.4	17.3	62.8	
	3	0.0	.2	.4	.3	1.5	1.5	5.3	4.7	5.3	7.8	12.6	60.4	
	MEAN	0.0	.6	.5	.3	1.8	3.4	.6	3.5	5.0	9.0	14.5	60.8	
	STD. DEV.	0.0	.4	.1	.1	.4	4.4	7.0	1.1	2.0	1.3	2.5	1.9	
MIS-B	1	.1	.6	.6	.5	3.9	1.2	1.7	6.2	7.5	9.5	12.5	55.7	
	2	.1	.9	.7	.6	4.4	5.9	2.0	6.9	3.4	8.0	13.9	53.2	
	3	0.0	.9	.7	.4	3.1	.4	2.1	5.9	6.1	8.8	13.0	58.6	
	MEAN	.1	.8	.7	.5	3.8	2.5	1.9	6.3	5.7	8.8	13.1	55.8	
	STD. DEV.	.1	.2	.1	.1	.7	3.0	.2	.5	2.1	.8	.7	2.7	

Categorical Sediment Grain-Size Characterization Survey 3

SURVEY 3 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	63-124	40-62	30-39	20-29	15-19	10-14	5-9	<5
CS-A	1	1.4	9.2	35.5	22.3	6.9	.4	.8	2.9	.7	2.0	3.5	14.4
	2	1.3	14.9	43.5	20.2	3.6	.8	.3	.6	.9	.7	1.7	11.5
	3	4.6	13.5	35.1	18.1	3.6	1.1	.4	1.7	1.6	1.8	3.4	15.1
	MEAN	2.4	12.5	38.0	20.2	4.7	.8	.5	1.7	1.1	1.5	2.9	13.7
	STD. DEV.	1.9	3.0	4.7	2.1	1.9	.4	.3	1.2	.5	.7	1.0	1.9
CS-B	1	2.0	3.5	31.6	17.0	6.8	.2	.3	1.5	5.9	3.3	2.5	25.4
	2	.8	2.3	19.9	11.7	5.9	1.9	.6	3.2	4.2	4.9	7.9	36.7
	3	.6	3.3	30.2	14.6	5.3	.3	1.4	2.0	3.3	3.3	6.5	29.2
	MEAN	1.1	3.0	27.2	14.4	6.0	.8	.8	2.2	4.5	3.8	5.6	30.4
	STD. DEV.	.8	.6	6.4	2.7	.8	1.0	.6	.9	1.3	.9	2.8	5.8

Categorical Sediment Grain-Size Characterization Survey 3

SURVEY 3 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
ALC	1	2.9	.6	4.7	3.3	3.7	6.7	5.7	5.5	4.6	6.6	10.6	45.1
	3	.8	.5	1.7	1.2	3.2	.1	4.6	6.6	6.1	6.7	13.4	55.1
	4	5.1	.8	4.5	2.2	4.5	1.5	.9	7.2	5.3	7.0	11.7	49.3
	MEAN	2.9	.6	3.6	2.2	3.8	2.8	3.7	6.4	5.3	6.8	11.9	49.8
	STD. DEV.	2.2	.2	1.7	1.1	.7	3.5	2.5	.9	.8	.2	1.4	5.0
DWH	1	.2	1.6	26.3	22.6	12.6	2.3	2.8	1.2	2.8	1.9	5.6	19.9
	2	.5	2.1	31.0	20.9	10.4	.9	1.7	2.3	.3	3.6	5.6	20.7
	3	.7	1.5	26.5	22.7	12.6	3.4	-.1	3.4	2.3	2.0	4.1	20.9
	MEAN	.5	1.7	27.9	22.1	11.9	2.2	1.5	2.3	1.8	2.5	5.1	20.5
	STD. DEV.	.3	.3	2.7	1.1	1.3	1.3	1.5	1.1	1.3	1.0	.9	.5

Categorical Sediment Grain-Size Characterization Survey 3

SURVEY 3 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
HP	1	3.9	1.7	2.4	3.3	8.7	7.6	.7	7.5	4.5	6.2	10.3	43.4
	2	.2	1.3	3.3	6.5	14.4	4.3	3.6	5.3	5.5	4.4	9.2	42.0
	3	7.3	1.0	0.0	3.8	12.5	4.9	4.0	-.9	6.9	5.0	9.3	46.2
	MEAN	3.8	1.3	1.9	4.5	11.9	5.6	2.7	4.0	5.6	5.2	9.6	43.9
	STD. DEV.	3.6	.4	1.7	1.7	2.9	1.8	1.9	4.4	1.2	.9	.6	2.1
SB-A	1	.1	.3	.5	.3	1.6	9.8	.4	6.7	8.3	5.9	12.1	54.0
	2	3.0	.7	.9	.6	6.0	-2.4	11.9	-.7	7.6	7.4	10.3	54.7
	3	4.0	1.2	1.2	.9	3.6	6.5	1.8	5.3	6.3	5.7	10.8	52.7
	MEAN	2.4	.7	.9	.6	3.7	4.6	4.7	3.8	7.4	6.3	11.1	53.8
	STD. DEV.	2.0	.5	.4	.3	2.2	6.3	6.3	3.9	1.0	.9	.9	1.0

Categorical Sediment Grain-Size Characterization
Survey 3

SURVEY 3 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
SB-B	1	3.1	.9	.7	.6	2.5	1.8	4.4	8.2	5.4	8.4	13.0	50.5
	2	.3	.4	.6	.6	2.7	.5	7.7	7.3	5.8	4.1	17.0	53.0
	3	.3	.5	.6	.5	2.4	1.6	2.1	2.7	6.5	8.2	14.0	60.6
	MEAN	1.4	.6	.6	.6	2.5	1.3	4.7	6.1	5.9	6.9	11.7	54.7
	STD. DEV.	1.9	.3	.1	.1	.2	.7	2.8	3.0	.6	2.4	2.1	5.3
RCN-A	1	1.1	.6	.6	1.7	3.9	.1	3.7	5.4	6.8	7.5	9.3	59.3
	2	.9	.4	.6	1.7	3.5	1.4	3.8	2.3	9.7	6.4	13.3	56.0
	3	5.5	.9	1.1	1.9	3.6	1.1	4.0	6.5	6.8	4.6	11.5	52.5
	MEAN	2.5	.6	.8	1.8	3.7	.9	3.8	4.7	7.8	6.2	11.4	55.9
	STD. DEV.	2.6	.3	.3	.1	.2	.7	.2	2.2	1.7	1.5	2.0	3.4

Categorical Sediment Grain-Size Characterization Survey 3

SURVEY 3 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
RGH-8	1	.5	.6	.6	.4	2.3	2.1	2.0	3.2	9.0	6.2	13.1	60.0
	2	.4	.4	.5	.3	2.2	5.2	.7	.5	6.8	3.6	16.9	62.5
	3	.2	.5	.3	.2	1.7	3.4	4.6	6.6	5.4	6.5	12.1	58.5
	MEAN	.4	.5	.5	.3	2.1	3.6	2.4	3.4	7.1	5.4	14.0	60.3
	STD. DEV.	.2	.1	.2	.1	.3	1.6	2.0	3.1	1.8	1.6	2.5	2.0

Categorical Sediment Grain-Size Characterization Survey 4

STATION	SAMPLE NO.	SURVEY NO. 4 PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											<5
		>991	350-900	180-349	125-179	43-124	20-42	30-39	20-29	15-19	10-14	5-9	
MIS-A	1	0.0	.4	.4	.2	.8	.7	.5	4.3	5.5	6.2	16.7	64.3
	2	0.0	.5	.2	.1	.1	3.9	-1.2	4.3	5.6	6.7	16.0	63.8
	3	0.0	.3	.3	.2	.2	.3	1.8	.4	5.1	9.7	40.0	41.7
	MEAN	0.0	.4	.3	.2	.4	1.6	.4	3.0	5.4	7.5	24.2	56.6
	STD. DEV.	0.0	.1	.1	.1	.4	2.0	1.5	2.3	.3	1.9	13.7	12.9
MIS-B	1	1.6	.5	.4	.3	2.0	.1	4.6	4.8	7.0	6.1	20.6	52.0
	2	.1	.5	.3	.3	2.1	1.6	2.9	6.0	4.8	8.6	16.3	56.5
	3	0.0	.4	.3	.2	.1	.2	3.4	4.8	8.3	8.6	20.3	53.4
	MEAN	.6	.5	.3	.2	1.4	.6	3.6	5.2	6.7	7.8	19.1	54.0
	STD. DEV.	.9	.1	.1	.1	1.1	.8	.9	.7	1.8	1.4	7.4	2.3

Categorical Sediment Grain-Size Characterization Survey 4

SURVEY 4 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
CS-A	1	1.9	1.2	7.3	6.8	5.6	-0.9	.5	6.4	3.7	15.5	5.4	46.6
	2	.4	1.4	8.2	5.5	6.3	-2.7	2.4	4.9	5.7	6.6	12.5	48.8
	3	3.7	4.8	25.7	18.6	4.8	-1.4	-0.5	3.3	3.6	3.7	7.2	26.5
	MEAN	2.0	2.5	13.7	10.3	5.6	-1.7	.8	4.9	4.3	8.6	9.4	40.6
	STD. DEV.	1.7	2.0	10.4	7.2	.8	.9	1.5	1.6	1.2	6.1	3.7	12.3
CS-B	1	.5	2.4	11.5	18.8	18.0	1.8	.9	2.8	3.5	3.8	6.7	29.3
	2	.4	1.5	10.5	20.1	18.2	1.7	.2	2.6	2.8	4.2	7.6	30.2
	3	.2	1.3	16.5	-4.9	41.5	.8	1.4	2.3	2.6	3.3	6.1	28.9
	MEAN	.4	1.7	12.8	11.3	25.9	1.4	.8	2.6	3.0	3.8	6.8	29.5
	STD. DEV.	.2	.6	3.2	14.1	13.5	.6	.6	.3	.5	.5	.8	.7

Categorical Sediment Grain-Size Characterization Survey 4

SURVEY 4 (CONTINUED)

PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)													
STATION	SAMPLE #	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
ALC	1	0.0	7.7	72.2	18.2	1.2	.4	.2	0.0	0.0	0.0	0.0	.1
	2	.1	11.0	74.3	13.6	.7	0.0	.1	.1	0.0	0.0	0.0	.1
	3	0.0	6.0	75.0	17.6	.9	.1	0.0	.2	0.0	.1	.1	0.0
	MEAN	.0	8.2	73.8	16.5	.9	.2	.1	.1	0.0	.0	.0	.1
	STD. DEV.	.1	2.5	1.5	2.5	.3	.2	.1	.1	0.0	.1	.1	.1
OIN	1	.5	4.5	35.6	17.4	10.6	1.1	.2	2.0	2.0	2.7	5.6	17.8
	2	1.9	4.5	34.7	16.8	9.1	2.0	.6	2.7	2.4	2.7	3.8	18.8
	3	1.1	3.9	30.6	16.9	10.5	1.7	3.1	1.3	2.9	2.9	4.3	20.8
	MEAN	1.2	4.3	33.6	17.0	10.1	1.6	1.3	2.0	2.4	2.6	4.6	19.1
	STD. DEV.	.7	.3	2.7	.3	.8	.5	1.6	.7	.5	.1	.9	1.5

Categorical Sediment Grain-Size Characterization Survey 4

SURVEY 4 (CONTINUED)

STATION

SAMPLE NO.

>991

350-990

180-349

125-179

43-124

40-42

30-39

20-29

15-19

10-14

5-9

<5

MP

1

1.2

1.2

1.8

3.3

12.7

1.3

.5

7.8

6.9

2.5

8.0

52.8

2

6.6

1.4

1.9

2.8

10.1

6.0

.9

2.0

8.0

.7

9.2

50.2

3

.2

1.6

2.0

2.7

9.4

6.4

-.9

6.2

5.5

6.7

9.0

51.2

MEAN

2.7

1.5

1.9

2.9

10.7

4.6

.2

5.3

6.8

3.3

8.7

51.4

STD. DEV.

3.4

.2

.1

.3

1.7

2.8

.9

3.0

1.3

3.1

.6

1.3

SB-A

1

10.1

13.0

12.1

.9

1.0

4.1

.8

3.5

4.1

6.2

10.8

33.4

2

.3

.8

1.1

.6

2.9

1.9

4.5

9.2

8.0

7.9

11.2

51.6

3

17.7

15.5

13.7

1.7

3.3

-1.5

.5

4.8

3.6

3.5

7.8

25.4

MEAN

9.4

11.1

9.0

1.1

2.4

1.5

1.9

5.8

5.2

5.9

9.9

36.8

STD. DEV.

8.7

9.5

6.9

.6

1.2

2.8

2.2

3.0

2.4

2.2

1.9

13.4

Categorical Sediment Grain-Size Characterization Survey 4

SURVEY 4 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
SB-B	1	1.0	.5	.4	.3	1.8	4.6	1.6	7.2	9.5	8.8	16.6	47.7
	2	0.0	.7	.6	.5	.6	7.1	44.4	29.3	4.3	2.9	4.6	5.0
	3	0.0	.8	.5	.3	.6	5.6	3.9	7.8	14.0	11.2	20.7	34.6
	MEAN	.3	.7	.5	.4	1.0	5.8	16.6	14.8	9.3	7.6	14.0	29.1
	STD. DEV.	.6	.2	.1	.1	.7	1.3	24.1	12.6	4.9	4.3	8.4	21.9
RCH-A	1	7.5	3.3	8.0	10.8	5.9	1.6	1.4	5.3	3.3	4.5	8.0	40.4
	2	9.1	2.5	5.2	6.1	3.4	0.0	1.4	6.3	5.4	5.2	9.4	46.0
	3	10.0	3.9	6.1	6.7	1.5	1.5	3.1	3.5	4.0	5.7	9.2	44.8
	MEAN	8.9	3.2	6.4	7.9	3.6	1.0	2.0	5.0	4.2	5.1	8.9	43.7
	STD. DEV.	1.3	.7	1.4	2.6	2.2	.9	1.0	1.4	1.1	.6	.8	2.9

Categorical Sediment Grain-Size Characterization
Survey 4

SURVEY 4 (CONTINUED)		PERCENT OF SAMPLE IN EACH GRAIN SIZE CATEGORY (MICRONS)											
STATION	SAMPLE NO.	>991	350-990	180-349	125-179	43-124	40-42	30-39	20-29	15-19	10-14	5-9	<5
RCH-8	1	.1	.4	.2	.2	1.3	.3	3.7	7.4	6.2	7.1	11.9	61.2
	2	.1	.8	.4	.2	1.7	6.6	-1.3	7.0	5.6	8.1	11.9	58.9
	3	.3	.4	.3	.3	1.7	1.1	1.6	8.5	6.3	7.8	12.6	59.1
	MEAN	.2	.5	.3	.2	1.6	2.7	1.3	7.6	6.0	7.7	12.1	59.7
	STD. DEV.	.1	.2	.1	.1	.2	3.4	2.5	.8	.4	.5	.4	1.3

HEAVY-METAL CONCENTRATION

Heavy-Metal Concentration
Survey P

PRELIMINARY SURVEY						
STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
MIS-A	1	39.4	.87	21.3	--	--
	2	48.2	1.07	22.0	--	--
	3	52.8	.94	21.6	--	--
	4	57.9	1.04	24.6	--	--
	MEAN	49.6	.98	22.4	--	--
	STD. DEV.	7.9	.09	1.5	--	--
MIS-B	1	51.2	1.06	25.7	--	--
	2	63.0	1.13	24.1	--	--
	3	52.2	.84	20.2	--	--
	4	59.6	.98	21.1	--	--
	5	58.9	.94	21.8	--	--
	MEAN	57.0	.99	22.6	--	--
	STD. DEV.	5.1	.11	2.3	--	--

Heavy-Metal Concentration Survey P

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
CS-A	1	120.9	2.25	51.3	--	--
	2	97.1	1.59	43.7	--	--
	3	95.5	1.28	41.4	--	--
	4	90.7	7.57	35.1	--	--
	5	86.9	1.75	42.7	--	--
	MEAN	98.2	1.69	42.6	--	--
	STD. DEV.	13.3	.36	5.9	--	--
CS-B	1	65.6	1.84	27.1	--	--
	2	66.2	2.25	37.8	--	--
	3	81.6	2.13	35.1	--	--
	4	85.0	2.45	38.2	--	--
	5	72.1	1.67	36.1	--	--
	MEAN	74.3	2.11	35.1	--	--
	STD. DEV.	9.2	.26	4.6	--	--
ALC	1	23.5	1.58	--	--	--
	2	55.2	1.63	47.9	--	--
	3	27.6	1.96	46.7	--	--
	MEAN	35.4	1.72	47.3	--	--
	STD. DEV.	17.2	.21	0.8	--	--

Heavy-Metal Concentration Survey P

PRELIMINARY SURVEY (CONTINUED)							
STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)	
OIM	1	73.4	2.38	77.8	--	--	
	2	100.2	2.37	72.4	--	--	
	3	85.6	2.49	78.4	--	--	
	4	96.7	2.79	85.5	--	--	
	5	93.0	2.18	71.2	--	--	
	MEAN	89.8	2.44	77.1	--	--	
	STD. DEV.	10.6	.22	5.7	--	--	
HP	1	73.3	1.34	50.3	--	--	
	2	76.5	1.54	46.6	--	--	
	3	60.2	1.22	36.0	--	--	
	4	72.5	1.43	44.7	--	--	
	5	74.7	1.38	45.5	--	--	
	MEAN	71.4	1.38	44.6	--	--	
	STD. DEV.	6.5	.12	5.3	--	--	

Heavy-Metal Concentration Survey P

PRELIMINARY SURVEY (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
SB-A WAS NOT ANALYZED						
SB-B	1	49.0	1.16	26.0	--	--
	2	63.9	1.13	35.4	--	--
	3	46.0	.88	29.9	--	--
	4	54.9	.88	30.7	--	--
	5	44.4	.76	27.4	--	--
	MEAN	51.6	.96	29.9	--	--
	STD. DEV.	7.9	.17	3.6	--	--

RCH-A WAS NOT ANALYZED

RCH-B	1	61.7	1.28	34.8	--	--
	2	50.9	1.04	24.6	--	--
	3	49.9	1.02	30.0	--	--
	4	57.0	.67	19.0	--	--
	5	49.4	1.05	29.8	--	--
	MEAN	53.8	1.01	27.6	--	--
	STD. DEV.	5.4	.22	6.0	--	--

Heavy-Metal Concentration Survey 1

SURVEY NO. 1

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
MIS-A	1	50.8	.66	19.8	--	--
	2	75.5	1.04	35.4	--	--
	3	54.7	.88	23.0	--	--
	MEAN	60.3	.86	26.1	--	--
	STD. DEV.	13.3	.19	8.2	--	--
MIS-B	3	70.0	1.07	31.7	--	--
	4	56.7	.96	25.2	--	--
	5	57.4	.96	28.4	--	--
	MEAN	61.4	1.00	28.4	--	--
	STD. DEV.	7.5	.06	3.3	--	--
CS-A	1	86.9	2.01	50.3	--	--
	3	101.2	2.06	50.7	--	--
	4	96.3	1.74	50.2	--	--
	MEAN	94.8	1.94	50.4	--	--
	STD. DEV.	7.3	.17	.3	--	--

Heavy-Metal Concentration
Survey 1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
CS-8	1	85.8	1.93	56.7	--	--
	2	35.1	1.39	23.6	--	--
	3	115.1	2.12	75.4	--	--
	MEAN	95.3	1.81	51.9	--	--
	STD. DEV.	17.1	.38	26.2	--	--
ALC	2	15.2	1.28	30.2	--	--
	4	17.9	1.46	31.0	--	--
	5	17.6	1.47	41.6	--	--
	MEAN	16.9	1.40	34.3	--	--
	STD. DEV.	1.5	.11	6.4	--	--
OIH	2	69.7	2.18	67.8	--	--
	3	70.4	2.47	66.5	--	--
	6	127.2	3.17	94.5	--	--
	MEAN	89.1	2.61	76.3	--	--
	STD. DEV.	33.0	.51	15.8	--	--

Heavy-Metal Concentration Survey 1

SURVEY NO. 1 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
HP	3	51.3	1.37	65.9	--	--
	5	62.0	1.21	41.8	--	--
	6	52.4	1.09	36.5	--	--
	MEAN	55.3	1.22	49.1	--	--
	STD. DEV.	5.8	.14	15.7	--	--

SB-A WAS NOT ANALYZED

SB-8	2	45.9	1.45	27.8	--	--
	3	35.6	.93	21.8	--	--
	4	44.3	1.26	25.8	--	--
	MEAN	41.9	1.21	25.1	--	--
	STD. DEV.	5.5	.26	3.1	--	--

RCH-A WAS NOT ANALYZED

RCH-8	2	67.5	1.51	47.8	--	--
	3	54.6	1.14	37.4	--	--
	4	47.6	1.10	35.9	--	--
	MEAN	56.6	1.25	40.4	--	--
	STD. DEV.	10.1	.23	6.5	--	--

Heavy-Metal Concentration
Survey 2

SURVEY NO. 2

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
MIS-A	1	36.0	.90	24.0	80.0	.44
	2	77.0	1.40	38.0	178.0	.24
	3	30.0	.66	18.0	63.0	.28
	MEAN	47.7	.99	26.7	107.0	.32
	STD. DEV.	25.6	.38	10.3	62.1	.11
MIS-B	1	31.0	.85	26.0	79.0	.79
	2	50.0	.69	29.0	130.0	.28
	3	51.0	.58	23.0	146.0	.24
	MEAN	44.0	.71	26.0	118.3	.44
	STD. DEV.	11.3	.14	3.0	35.0	.31
CS-A	1	50.0	1.80	48.0	156.0	.34
	2	63.0	1.20	41.0	145.0	.45
	3	51.0	.82	31.0	125.0	--
	MEAN	54.7	1.27	40.0	142.0	.39
	STD. DEV.	7.2	.49	8.5	15.7	.08

Heavy-Metal Concentration Survey 2

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
CS-8	1	39.0	.97	31.0	112.0	.23
	2	40.0	1.30	34.0	107.0	.25
	3	38.0	.94	25.0	117.0	.29
	MEAN	39.0	1.07	30.0	112.0	.26
	STD. DEV.	1.0	.20	4.6	5.0	.03
ALC	1	33.0	1.50	21.0	97.0	.07
	2	21.0	.50	6.9	63.0	.06
	3	15.0	.92	11.0	72.0	.07
	MEAN	23.0	.97	13.0	77.3	.07
	STD. DEV.	9.2	.50	7.2	17.6	.01
OIM	1	32.0	.98	35.0	117.0	.40
	2	28.0	.99	41.0	127.0	.34
	3	25.0	.71	29.0	101.0	.33
	MEAN	28.3	.89	35.0	115.0	.36
	STD. DEV.	3.5	.16	6.0	13.1	.04

Heavy-Metal Concentration
Survey 2

SURVEY NO. 2 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
HP	1	56.0	1.20	47.0	166.0	.41
	2	31.0	1.10	41.0	130.0	.22
	3	40.0	.74	34.0	139.0	.20
	MEAN	42.3	1.01	40.7	145.0	.28
	STD. DEV.	12.7	.24	6.5	18.7	.12

SB-A WAS NOT ANALYZED

SB-B	1	26.0	.97	37.0	113.0	.22
	2	35.0	.60	24.0	101.0	.46
	3	58.0	.76	34.0	163.0	.49
	MEAN	39.7	.78	31.7	125.7	.39
	STD. DEV.	16.5	.19	6.8	32.9	.15

RCH-A WAS NOT ANALYZED

RCH-B	1	30.0	1.30	46.0	133.0	.24
	2	44.0	.97	40.0	135.0	.35
	3	31.0	.43	34.0	122.0	.08
	MEAN	35.0	1.03	40.0	130.0	.22
	STD. DEV.	7.8	.24	6.0	7.0	.14

Heavy-Metal Concentration Survey 3

SURVEY NO. 3

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
MIS-A	1	72.0	1.70	44.0	184.0	.15
	2	47.0	2.30	42.0	156.0	.16
	3	78.0	2.20	36.0	186.0	.11
	MEAN	65.7	2.07	40.7	175.3	.14
	STD. DEV.	16.4	.32	4.2	16.8	.03
MIS-B	1	62.0	1.60	46.0	166.0	.26
	2	69.0	1.70	40.0	164.0	.32
	3	61.0	1.70	56.0	169.0	.22
	MEAN	64.0	1.67	47.3	166.3	.27
	STD. DEV.	4.4	.06	8.1	2.5	.05
CS-A	1	29.0	.82	20.0	93.0	.02
	2	13.0	.71	19.0	77.0	.02
	3	23.0	.77	18.0	76.0	.01
	MEAN	21.7	.77	19.0	82.0	.02
	STD. DEV.	8.1	.06	1.0	9.5	.01

Heavy-Metal Concentration
Survey 3

SURVEY NO. 3 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
CS-B	1	34.0	.96	28.0	104.0	.02
	2	46.0	.88	30.0	122.0	.36
	3	37.0	.95	30.0	102.0	.10
	MEAN	39.0	.93	29.3	109.3	.16
	STD. DEV.	6.2	.04	1.2	11.0	.12
ALC	1	29.0	1.30	26.0	93.0	.14
	2	32.0	1.20	24.0	96.0	.09
	3	32.0	1.20	25.0	80.0	.03
	MEAN	31.0	1.23	25.0	89.7	.10
	STD. DEV.	1.7	.06	1.0	8.5	.03
OIH	1	25.0	1.20	48.0	116.0	.03
	2	27.0	1.40	52.0	109.0	.43
	3	47.0	1.10	45.0	154.0	.38
	MEAN	33.0	1.23	48.3	125.3	.30
	STD. DEV.	12.2	.15	3.5	24.2	.24

Heavy-Metal Concentration Survey 3

SURVEY NO. 3 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
HP	1	50.0	.96	36.0	130.0	--
	2	48.0	1.50	46.0	140.0	--
	3	51.0	1.30	48.0	138.0	--
	MEAN	49.7	1.25	43.3	136.0	--
	STD. DEV.	1.5	.27	6.4	5.3	--

SB-A WAS NOT ANALYZED

SB-B	1	28.0	1.30	37.0	108.0	.42
	2	28.0	1.20	40.0	107.0	.25
	3	31.0	.58	16.0	84.0	.02
	MEAN	29.0	1.03	31.0	99.7	.23
	STD. DEV.	1.7	.39	13.1	13.6	.20

RCH-A WAS NOT ANALYZED

RCH-B	1	34.0	1.60	46.0	145.0	.01
	2	37.0	1.70	53.0	143.0	.02
	3	58.0	.91	39.0	156.0	.06
	MEAN	43.0	1.40	46.0	148.0	.03
	STD. DEV.	13.1	.43	7.0	7.0	.03

Heavy-Metal Concentration
Survey 4

SURVEY NO. 4

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
MIS-A	1	52.0	.75	25.0	121.0	.05
	2	49.0	.80	24.0	102.0	0.00
	3	48.0	.77	23.0	95.0	0.00
	MEAN	49.7	.77	24.0	106.0	.02
	STD. DEV.	2.1	.03	1.0	13.5	.03
MIS-B	1	53.0	.98	25.0	111.0	0.00
	2	47.0	.76	21.0	94.0	.01
	3	47.0	.74	20.0	86.0	.03
	MEAN	49.0	.83	22.0	97.0	.03
	STD. DEV.	3.5	.13	2.4	12.8	.05
CS-A	1	75.0	1.40	38.0	156.0	0.00
	2	54.0	1.40	29.0	119.0	.63
	3	70.0	1.50	35.0	130.0	0.00
	MEAN	66.3	1.43	34.0	151.7	.21
	STD. DEV.	11.0	.06	4.6	30.7	.35

Heavy-Metal Concentration
Survey 4

SURVEY NO. 4 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
CS-8	1	57.0	1.40	45.0	144.0	.03
	2	53.0	.95	31.0	144.0	.15
	3	59.0	1.10	50.0	149.0	.43
	MEAN	56.3	1.15	42.0	145.7	.20
	STD. DEV.	3.1	.23	9.8	2.9	.21
ALC	1	13.0	1.10	32.0	80.0	.01
	2	12.0	.86	40.0	67.0	.13
	3	11.0	.88	29.0	60.0	.02
	MEAN	12.0	.95	33.7	69.0	.05
	STD. DEV.	1.0	.13	5.7	10.1	.07
OIH	1	92.0	2.70	94.0	268.0	0.00
	2	100.0	2.60	89.0	275.0	0.00
	3	59.0	1.30	60.0	173.0	.05
	MEAN	83.7	2.20	81.0	238.7	.02
	STD. DEV.	21.7	.78	13.4	57.0	.03

Heavy-Metal Concentration Survey 4

SURVEY NO. 4 (CONTINUED)

STATION	SAMPLE NO.	COPPER (MG/KG)	CADMIUM (MG/KG)	LEAD (MG/KG)	ZINC (MG/KG)	MERCURY (MG/KG)
HP	1	57.0	1.30	44.0	124.0	.21
	2	73.0	1.60	72.0	211.0	.22
	3	43.0	.82	33.0	134.0	0.00
	MEAN	57.7	1.24	51.3	157.7	.34
	STD. DEV.	15.0	.39	18.1	46.3	.42

SB-A WAS NOT ANALYZED

SB-B	1	43.0	1.00	28.0	116.0	0.00
	2	28.0	.83	22.0	69.0	.72
	3	21.0	.61	16.0	58.0	.41
	MEAN	30.7	.81	22.0	81.0	.38
	STD. DEV.	11.2	.20	6.0	30.3	.36

RCH-A WAS NOT ANALYZED

RCH-B	1	46.0	.89	35.0	119.0	.99
	2	37.0	.88	30.0	90.0	.07
	3	44.0	.86	32.0	112.0	.05
	MEAN	42.3	.88	32.3	107.0	.27
	STD. DEV.	4.7	.02	2.5	15.1	.53