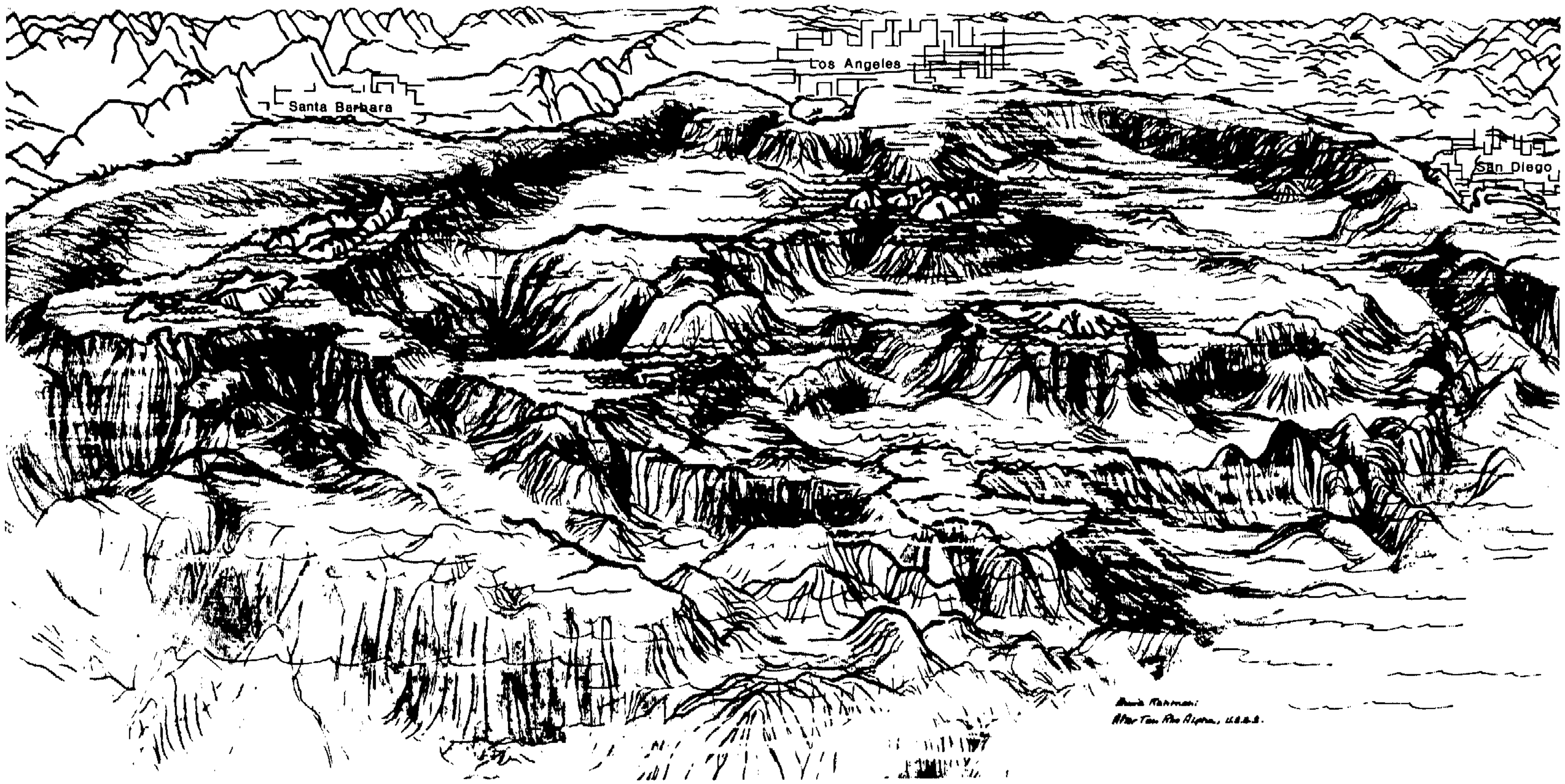
SOUTHERN CALIFORNIA BASELINE STUDY AND ANALYSIS (1975/1976)

VOLUME I - EXECUTIVE SUMMARY

PREPARED BY SCIENCE APPLICATIONS, INC.

FOR THE

BUREAU OF LAND MANAGEMENT



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VOLUME I
EXECUTIVE SUMMARY

by: Richard A. Callahan
and
Robert Shokes

Science Applications, Inc.
1200 Prospect St.
La Jolla, California

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FOREWORD

This program has been performed as a cooperative effort between nineteen scientists with academic affiliations, three private companies and an arm of the federal government.

The successful performance of a program of this size and scope is the result of the hard work and dedication of the '200 participants. Several individuals however played roles which largely determined the success of this study. These include:

Dr. Isaac Kaplan who originally organized the group and performed a leadership role throughout the program. Drs. Arnold Bainbridge, T. Chow, Osmund Helm-Hansen, Gilbert Jones, Mark Littler and Mssrs. Willard Bascom and M. L. Moberg who ably served on the Steering Committee,

Mr. Leonard Cunningham was key to the very successful shipboard operations which characterized this program.

Participation in this program has been a unique and fulfilling experience largely because of the high aspirations, professional standards and performance common to its participants.

R.A. Callahan and R.F. Shokes
La Jolla, California
March 1977

Readers Guide

The final report of the 1975-76 environmental baseline study of the Southern California OCS is contained in three Volumes. The purpose of Volume I is to describe the scope and approach of the study and to abstract the most significant results. In Volume II, all methods and procedures are clearly delineated, results are presented in some detail, various aspects of the study are integrated and conclusions and interpretations are presented. Volume III consists of a series of detailed final reports, each authored by one of the twenty participating investigators. Volume III is intended to thoroughly document every aspect of the baseline survey to an extent that data collection, data analysis, and data interpretation can be replicated in the future by qualified scientists. In doing this, Volume III provides detailed descriptions of methods, field and laboratory observations, and raw data.

Therefore, Volume I provides a summary of the scope, significant accomplishments and findings of this study to a broad readership. Volume II is a scientific report which systematically describes the programs comprising the study, reports their results and interprets their significance. It is intended for scientists, resource managers and their staffs. Volume III is not designed to be read cover to cover (it is approximately 7000 pages long!), but rather is intended as a reference volume to document the results and interpretations made in Volume I and Volume II.

Significant Accomplishments of the 1975-1976 Southern California OCS Environmental Baseline Study

- The distributions of petroleum related hydrocarbons and trace metals were characterized and found to vary substantially throughout the Southern California OCS.
  - The nearshore environment is broadly contaminated with both refined and crude petroleum. Concentrations of trace metals fluctuate with location, exhibiting enrichments near areas of urban and industrial activity.
  - Areas adjacent to nearshore seeps such as Coal Oil Point and San Pedro are extensively contaminated with crude oil and somewhat enriched in vanadium.
  - Areas adjacent to urban outfalls such as Whites Point near Los Angeles are contaminated with petroleum products and metals such as lead, cadmium, chromium and zinc.
  - Nearshore areas not adjacent to outfalls or seeps do not appear extensively, if at all, contaminated by either petroleum or trace metals. However, chemical data from these areas is sufficient to distinguish them from the outer shelves.
  - The nearshore basins appear to be the final residence for urban effluent materials and nearshore seeps. Sediment concentrations of petroleum and trace metals are elevated in these basins.
  - The outer ridges and basins vary regarding petroleum and trace metal concentrations.

    Most stations near San Nicolas and San Miguel Islands, on Tanner and Cortes Banks and within the outer basins typically have very low concentrations of petroleum. Exceptions include certain areas contaminated by seeps of crude oil. Concentrations of trace metals in these outer areas reflect the complex fluxes natural to the marine environment. These fluxes do not appear to have been appreciably affected by human activity.

- The composition of plant and animal communities were characterized and found to vary substantially throughout the Southern California OCS.
  - Benthic macroinfauna off Southern California can be classified as belonging to nearshore, island or open water groups.
  - Each group is highly variable; community structure within each group changes with water depth and sediment type.
  - The rocky intertidal habitat is typically comprised of upper, middle and lower zones throughout the Southern California area.
  - No alterations in benthic community structure were discernable at stations

heavily contaminated with petroleum, trace metals or urban effluents. However, the ability of this study to discern such changes was limited.

- Mainland rocky intertidal sites have fewer organisms and fewer kinds of organisms than similar island sites. Mainland organisms are also less vigorous than similar island forms. These changes appear to be due to chemical or physical stresses impacting mainland habitats.

- Crude oil appears to have altered the composition of the rocky intertidal plant communities at Coal Oil Point.

- Four communities of microinfauna (foraminifera) live in the Southern California OCS. These communities occupy shallow water, slope or basin habitats.

- All offshore infaunal communities are impoverished in areas of active sediment transport or deposition.

- Seasonal changes in rocky intertidal community structure are slight.

. Animals from locations contaminated with petroleum or trace metals typically incorporate them into their tissues. Information gained during this study was used to select "indicator" species for subsequent studies.

• petroleum hydrocarbons can be measured at predevelopment concentrations and crude petroleum can usually be differentiated from other hydrocarbons, including refined oils.

• The Tanner-Cortes Banks region supports an unusual assemblage of shallow water and open ocean organisms. At least two uncommon organisms occur on these banks; a purple coral and a very primitive mollusc of the order Monoplacophora.

• Significant improvements were made in the collection, analyses and interpretation of petroleum hydrocarbon and trace metal chemical data. These improvements allowed the reliable measurement of predevelopment concentrations of hydrocarbons and trace metals.

- Five devices for collecting uncontaminated water and uncontaminated and undisturbed sediment samples suitable for chemical analyses were either developed or redesigned from existing "research" devices. The use of such state-of-the-art equipment has demonstrated the practicability of obtaining a chemical data base of sufficient size and quality to resolve regional differences in the chemistry of the Southern California Bight.

- Analytical methodologies were developed which allowed the discrimination of petroleum type hydrocarbons from other hydrocarbons.

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1.0 INTRODUCTION

The "Southern California Baseline Study and Analysis" is one of several marine environmental studies of the Outer Continental Shelves (OCS) of North America sponsored by the Department of Interior, Bureau of Land Management. Selected areas of the Southern California OCS are currently being leased by the Department of Interior to private concerns interested in discovering and extracting petroleum reserves.

This effort consisted of studies of the Offshore and Intertidal environments. The Offshore study was designed to provide an initial descriptive overview of the chemical, biological and sedimentological regimes of the Southern California OCS. The primary purpose of this overview was to describe this environment and the association of the various animal communities, sediments, chemical constituents, water depth, and geographical areas.

The Intertidal study provided a statistical analyses of the floral and faunal communities occupying rocky and sandy beach habitats with emphasis on the associations between organisms, petroliferous and other anthropogenic inputs, substrate type, tidal height, geographic area and seasonal fluctuations. The study was conducted during calendar years 1975-1976 through a contract to Science Applications, Inc. (SAI), La Jolla, California. SAI subcontracted nineteen field sampling and analytical tasks to principal investigators from universities and two tasks to private industries (Table 1-1).

Table I-1. Summary of key personnel, affiliation and project area.

Science Applications, Inc. (SAI)	
Dr. Richard A. Callahan	Program Manager
Dr. John Wilson	Data Synthesis and Analysis
Dr. Victor Orphan	Ba and V analysis by Neutron Activation (with Dr. V. Guinn, UCI)
Mr. Paul Mankiewicz	Hydrocarbon Chemistry Coordinator
Mr. Leonard Cunningham	Logistics
University California, San Diego (Scripps-SIO)	
Dr. Arnold Bainbridge	Hydrographic Sampling and Analysis; Data Base Management (GEOSECS)
Mr. Andrew Soutar	Box Core Development; Geochemical Sampling
Dr. Andrew Benson	Hydrocarbon Analysis - Biota
Dr. Tsaihwa Chow	Sediment Trace Metal Analysis
Dr. Osmund Holm-Hansen	Particulate and Dissolved Organic Carbon, ATP Analysis
University California, Irvine (UCI)	
Dr. Mark Littler	Rocky Intertidal Sampling and Community Analysis
Dr. Victor Guinn	Ba and V Analysis by Neutron Activation (with Dr. V. Orphan, SAI)
University California, Los Angeles (UCLA)	
Dr. Isaac Kaplan	Hydrocarbon Analysis - Sediments
Dr. Walter Reed	Sediment Geochemistry and Characterization

Table I-1. Summary of key personnel, affiliation and project area.

Personnel	Project area
University California, Berkeley (UCB)	
Dr. A. L. Burlingame	Hydrocarbon Characterization (GCMS)
Dr. Robert Risebrough (Bodega)	Hydrocarbon Analysis - Water, Biota
University California, Santa Cruz (UCSC)	
Dr. Kenneth Bruland	Trace Metal Analysis - Suspended Particulate
California Institute of Technology, Pasadena (CIT)	
Dr. Claire Patterson	Trace Metal Lab Calibration
University Southern California (USC)	
Dr. Dale Straughan	Sandy Beach/Slough Sampling and Community Analysis
Dr. Robert Douglas	Microfaunal Sampling and Analysis
Dr. Gilbert Jones	Benthic Sampling and Macrofaunal Analysis
Dr. Kristian Fauchald	Benthic Sampling and Macrofaunal Analysis
California State University-Northridge (CSU-N)	
Dr. Peter Fischer	Sediment Geochemistry and Characterization
San Jose State University (SJSU)	
Dr. John Martin (Moss Landing)	Trace Metal Analysis - Biota
San Diego State University (SDSU)	
Dr. Richard Berry	Sediment Geochemistry and Characterization
Analytical Research Laboratory, Inc. (ARLI)	
Mr. M. L. Moberg	Hydrocarbon Analysis - Sediments and Biota
Escatech, Inc.	
Mr. David Hodder	Aerial Photography and Kelp Bed Analysis

2.0 THE SOUTHERN CALIFORNIA OCS - DESCRIPTION OF THE STUDY AREA

The outer continental shelf of Southern California, is the area within a triangle formed by Point Conception ($\sim$217 km NW of San Diego) the US-Mexico international border and Tanner-Cortes banks (Figures I-1 and I-2). This region is one of the most complex continental margins in the world's oceans. Because of its complexity the area has been known as the Southern California Borderland, recognizing the similarity of its tectonically molded topography to the contiguous coastal lands. The perspective drawing on the cover of this report illustrates the contiguity of the emergent and submerged topography of this region. Due to the concavity of the shoreline south of Point Conception, however, this area has commonly been referred to as the Southern California Bight. Throughout this report the terms Southern California Bight, Southern California Borderland and Southern California OCS are used interchangeably.

Between the mainland California coast and the true continental slope, there are eight islands ranging in size from about 13 km^2 (Santa Barbara and Anacapa) to 258 km^2 (Santa Cruz), each with its own submarine shelf These islands are situated on two major ridge-shelf formations which connect at the northern end of the study area, creating a sort of continuous "wishbone".

Interspersed around the branches of the ridge are 10 basins, all shallower than normal oceanic depressions, but of considerable depth relative to typically defined continental shelves. These basins are considered to be tectonically-associated fault features and in general their axes run parallel to the mainland or island ridges.

The occurrence of basins and troughs is atypical to commonly defined shelf environments and has several consequences: (1) their walls form topographical slopes down which finer grained sediments flow away from the shallow coastal shelves, leaving behind accumulations of relatively coarse material; (2) the irregularity of the bottom topography restricts and channelizes horizontal water movement below the basin sills; (3) the variety of physiographic features provide diverse and changing habitats. The plant and animal communities which have adapted to these habitats are similarly complex and variable.

The inner basins -- those lying between the mainland shelf and the Santa Catalina Island ridge-shelf -- tend to be shallower and accumulate sediments at a faster rate than the more seaward basins. This inner group of depressions (Santa Barbara, Santa Monica and San Pedro Basins) receive most of the terrigenous run-off clay and silts which slump down their walls due to gravitational forces. The outer (more seaward) basins receive almost no terrigenous sediment, their primary source of bottom fill coming from planktonic debris (tests, fecal pellets) raining down from their highly productive surface waters.

It is important to understand that it is the complex physiography just described which has created the collection of diverse environments and ecosystems found within this area. The mainland coast is an intricate combination of rocky shores, sand beaches, and tidal sloughs.

The offshore islands have their own complex coasts and margins. The depressions between the ridges serve to fragment the shelves and to form basins which concentrate most of the sediment in less than 20% of the total area of the Southern California OCS.

3.0 OFFSHORE WATER COLUMN AND BENTHIC STUDIES

3.1 Sampling and Analytical Problems

The acquisition of reliable data which can be successfully used by decisionmakers to manage the use of natural resources requires collection and handling techniques which supply physically intact, uncontaminated and representative samples, as well as analytical techniques which can generate sensitive data. For example, small changes in the concentrations of petroleum or trace metals in the marine environment can not be monitored if predevelopment concentrations have not been reliably estimated. Predevelojnnent concentrations of petroleum in some areas of the Southern California OCS were measured to be as low as $1x10^{-8}$ grams per thousand grams of water, equivalent to one drop of petroleum in 220,000 gallons. Such low concentrations cannot be measured if any contamination of the sample occurs.

At the initiation of this study, especially in the area of low-level chemical sampling, adequate shipboard collection and handling techniques had not been applied to a marine program of this size with similar time constraints. Extensive efforts were made during the first phases of this study to develop practical, cost-effective sampling techniques which would routinely provide reliable chemical data.

3.1.1 Contamination from Sampling Platforms

Figure I-3 illustrates some of the sources of chemical contamination encountered when sampling at sea and describes the major precautions taken in this program to avoid them. Other precautions for trace metal sampling included the use of Teflon-lined, PVC collection bottles, non-metallic line, plastic sheaves, polyethylene-shielded lead weights, Teflon messengers, and an electric/hydraulic winch with a stainless steel drum. The philosophy of excluding contamination when at all practical was extended to every aspect of the chemical sampling program.

3.1.2 Contamination from Sampling Techniques

Three samplers which enable collection of uncontaminated, representative sediment and water samples were developed for routine sampling. Figure I-4 illustrates two of these samplers and how they work. An important aspect of these samplers and their associated techniques is that they not only minimize contamination but also maximize standardization (i.e., sampling reproducibility). Rigorous standardization of sampling and analytical techniques is critical when results will be used to describe chemical changes in space and time.

In addition, an <u>in situ</u> water sampler was developed which promises to allow the quantitative extraction of a wide range of hydrocarbons directly from sea water, avoiding the necessity of collecting large quantities of water for extraction in the laboratory.

3.1.3 Analytical Methods

Developing the capability to measure petroleum in the marine environment was an essential element of this study. A change in petroleum concentrations of from one to two drops per

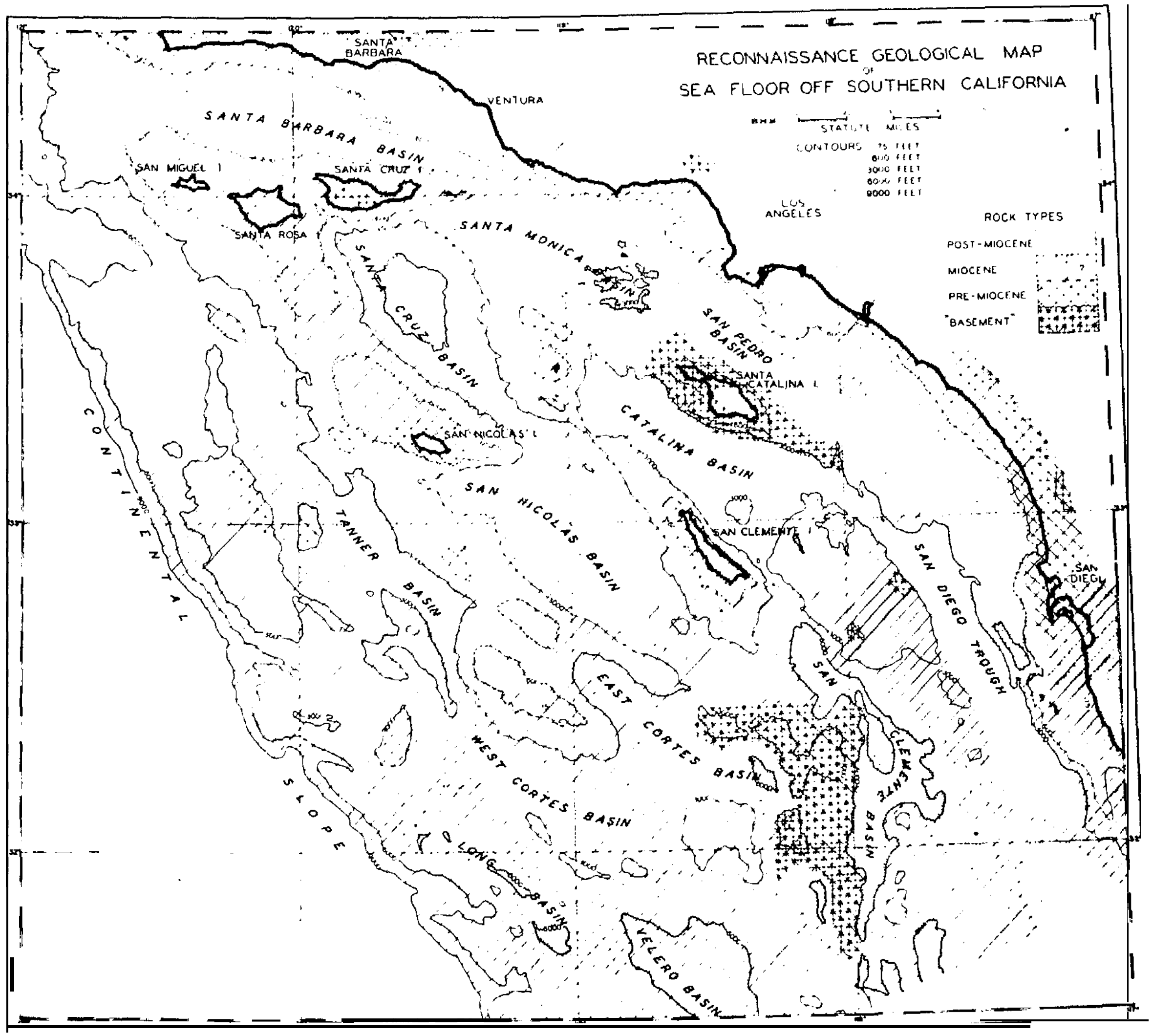


Figure I-1. Geological map of sea floor and adjacent land showing complex topography of the Southern California Borderland. Revised from Emery (1951, 1954d, Fig. 1).

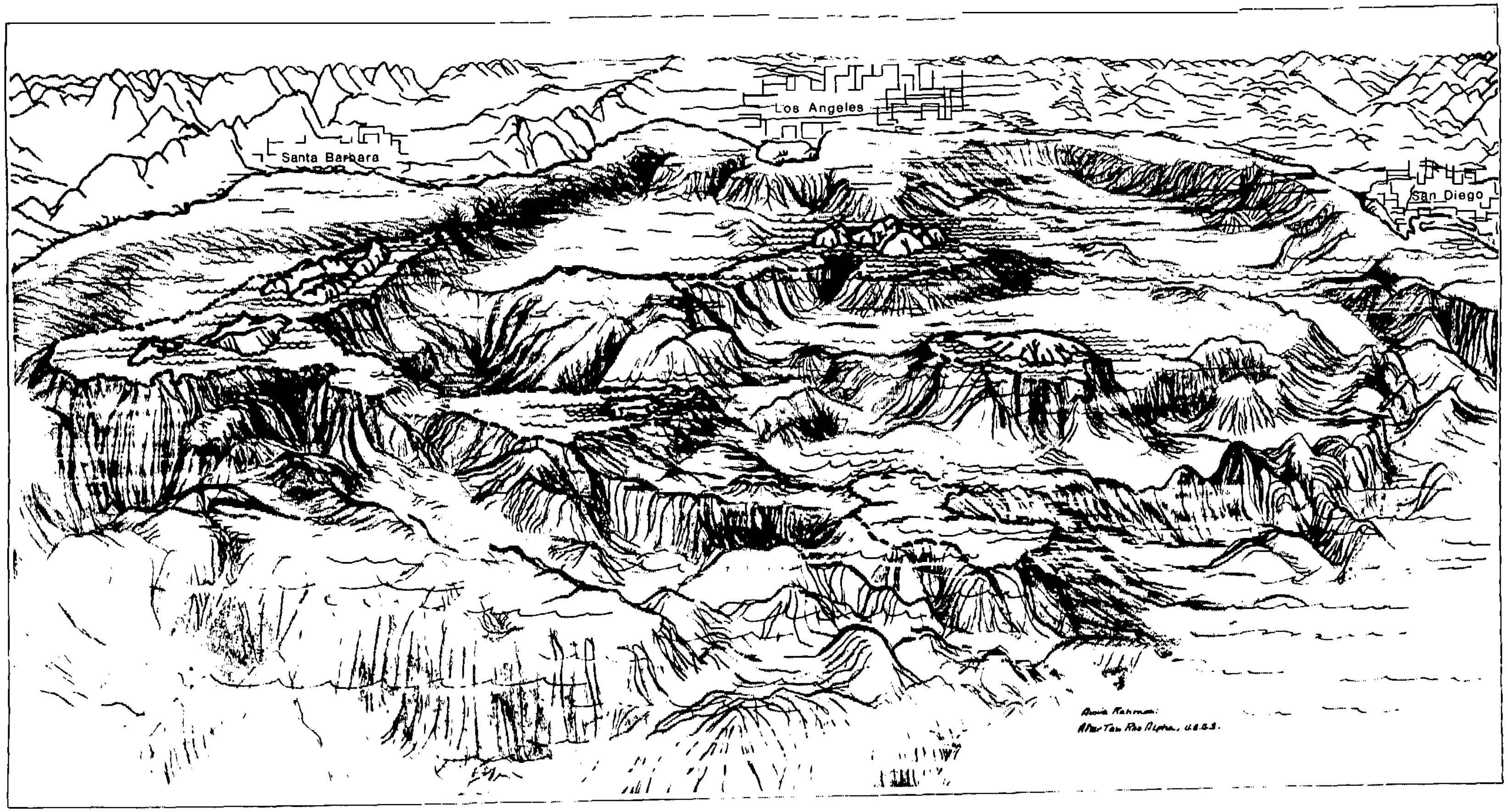


Figure I-2. Southern California Borderland Topographical Relief.

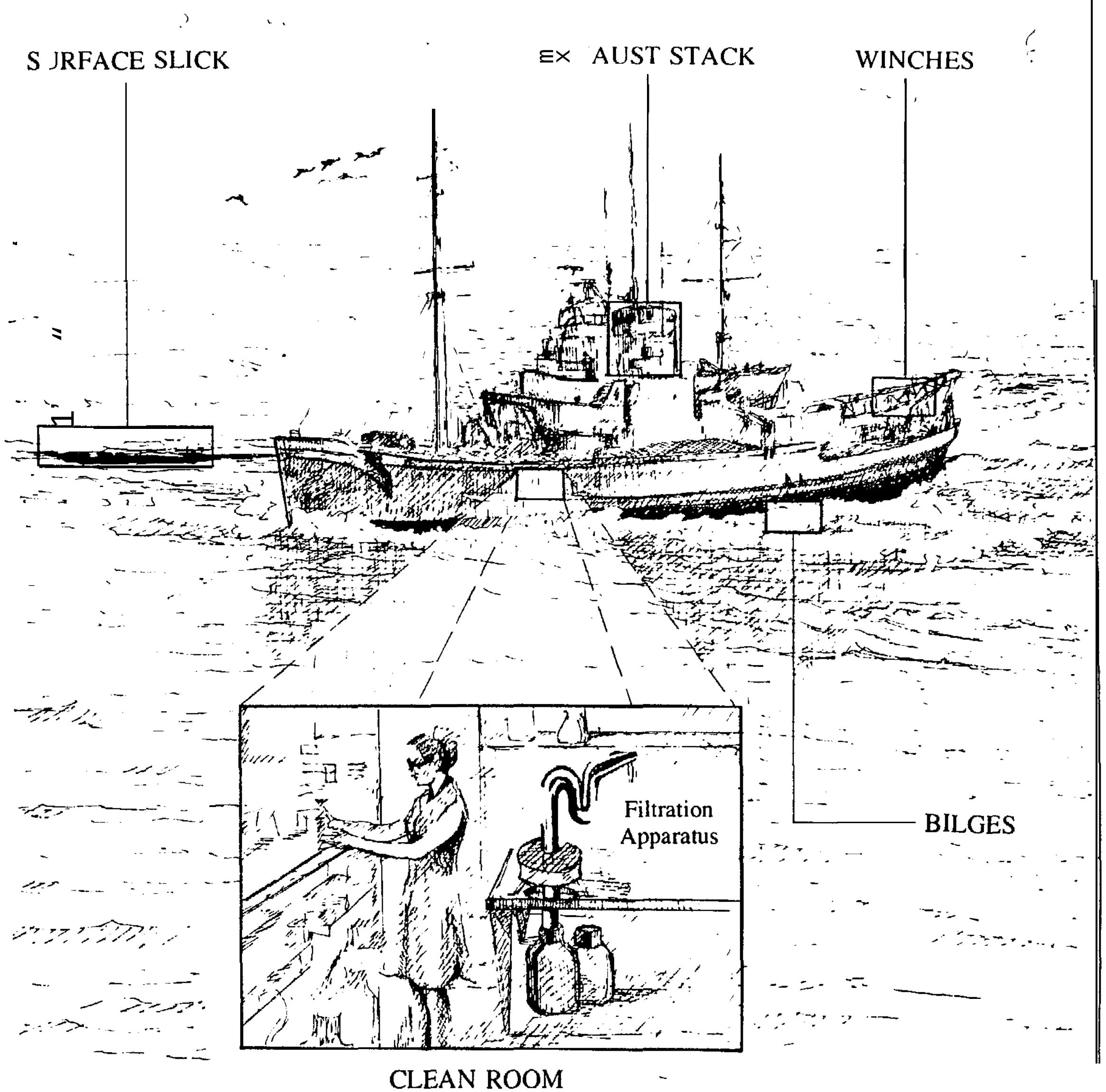


Figure I-3. Sources of contamination at sea.

Sources of Contamination at Sea

A research vessel and its immediate environment is a diffucult place to collect an uncontaminated sample. Hydrocarbons and trace metals are often present in extremely low concentrations in marine samples; while the sampling platform (the ship) is grossly contaminated with oil and is constructed of metals. Common sources of hydrocarbon contamination on board are the diesel exhaust, grease and oils from winches and the oil coated sampling cable.

Fuel oil is commonly spilled on deck, and consequently an oil film is present on all deck surfaces. Sources of trace metal contaminants include the vessel itself, paint pigments, rust, the sampling cable, and the samplers themselves. Bilges contaminate the water immediately surrounding the vessel with oils, metals, garbage and human wastes. Shipboard contamination can only be minimized by providing clean work spaces.

Two such clean rooms were provided for this study, one designed to eliminate metal contamination; the other hydrocarbon contamination. The clean rooms incorporated such features as particulate and carbon air filters, limited personnel access, and noncontaminating paint. Externally contaminated samplers were lashed to the outside of the clean rooms and plumbed through the wall to filtration devices within the rooms. As water was drained from the samplers it was displaced by reagent grade nitrogen.

These and similar techniques protected the samples and samplers from contamination in the shipboard environment. Although similar techniques had been previously used in research programs, they were extensively modified and automated to fulfill the needs of this large survey-oriented study.

220,000 gallons of sea water can represent a doubling of the mean concentrations at the "cleanest" locations sampled off Southern California.

Figure I-5 illustrates the necessity and complexity of discriminating between petroleum-related compounds and other types of hydrocarbons, and between crude and refined petroleum.

Three to four months after initiating this program, the participating scientists and BLM technical representatives became aware that the then-accepted hydrocarbon analytical techniques would not provide data suitable for the needs of this program. The existing methods lacked the sensitivity to determine the low concentrations present, as well as the ability to repeat the results on the same sample and the qualitative resolution to separate crude petroleum from other hydrocarbons. A major effort was made to improve hydrocarbon analytical methods by the chemists in the Southern California OCS study, complementing similar efforts initiated in other BLM OCS programs. Substantial progress was made during the initial year's program. The results of these efforts can be seen in the ability of this study to discriminate petroleum from other types of hydrocarbons present in the Southern California Bight.

3.2 Sampling Design and Results -- Benthic and Water Column

This section summarizes the results of studies concerning the sedimentology, chemistry and biology of the Southern California OCS, touches on the complex regional variations found in all parameters measured, and when possible assesses their biogeochemical relationships.

Benthic sampling was focused within areas of high station density (High Density Sampling Areas, HDSAs) corresponding roughly to areas of high lease interest (Figure I-6). Additional sampling was performed at dispersed stations for broad coverage. This sampling design allowed coverage of the five major subregions of the Southern California OCS as defined on the basis of geographical and environmental criteria: (1) the inner Shelf region, (2) the Inner Basin region, (3) the Outer Shelf region, (4) the Outer Basin region and (5) the Outer Banks region (Figures I-1 to I-2).

3.2.1 Benthic Sedimentology

Three approaches were used to examine the sediment data: (1) Regions were compared by their mean sediment parameter values. In doing so, comparisons between mean grain size, kurtosis and skewness for each sediment sample provided easily visualized relationships. (2) Correlational analyses were used to examine trends between certain sediment characteristics and depth. (3) Trend surface analyses were used to contour the the high density sampling regions for those variables considered significant.

Sediments from the inner shelves are typically coarse, and rich in heavy minerals. These sediments are selectively left behind after their finer-grained components have been moved into the basins by the high energy forces (waves and surf) at work in shallow waters.

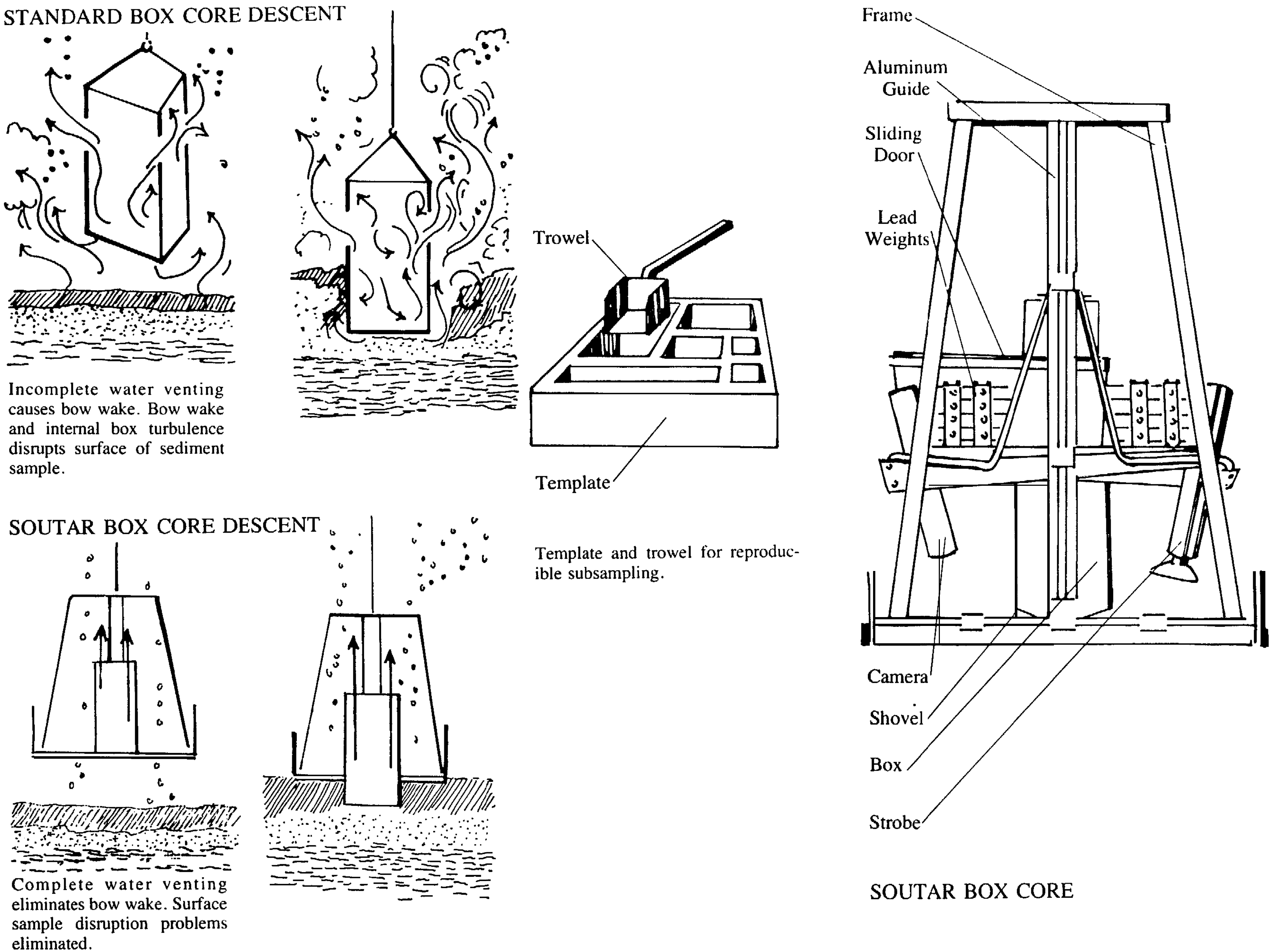
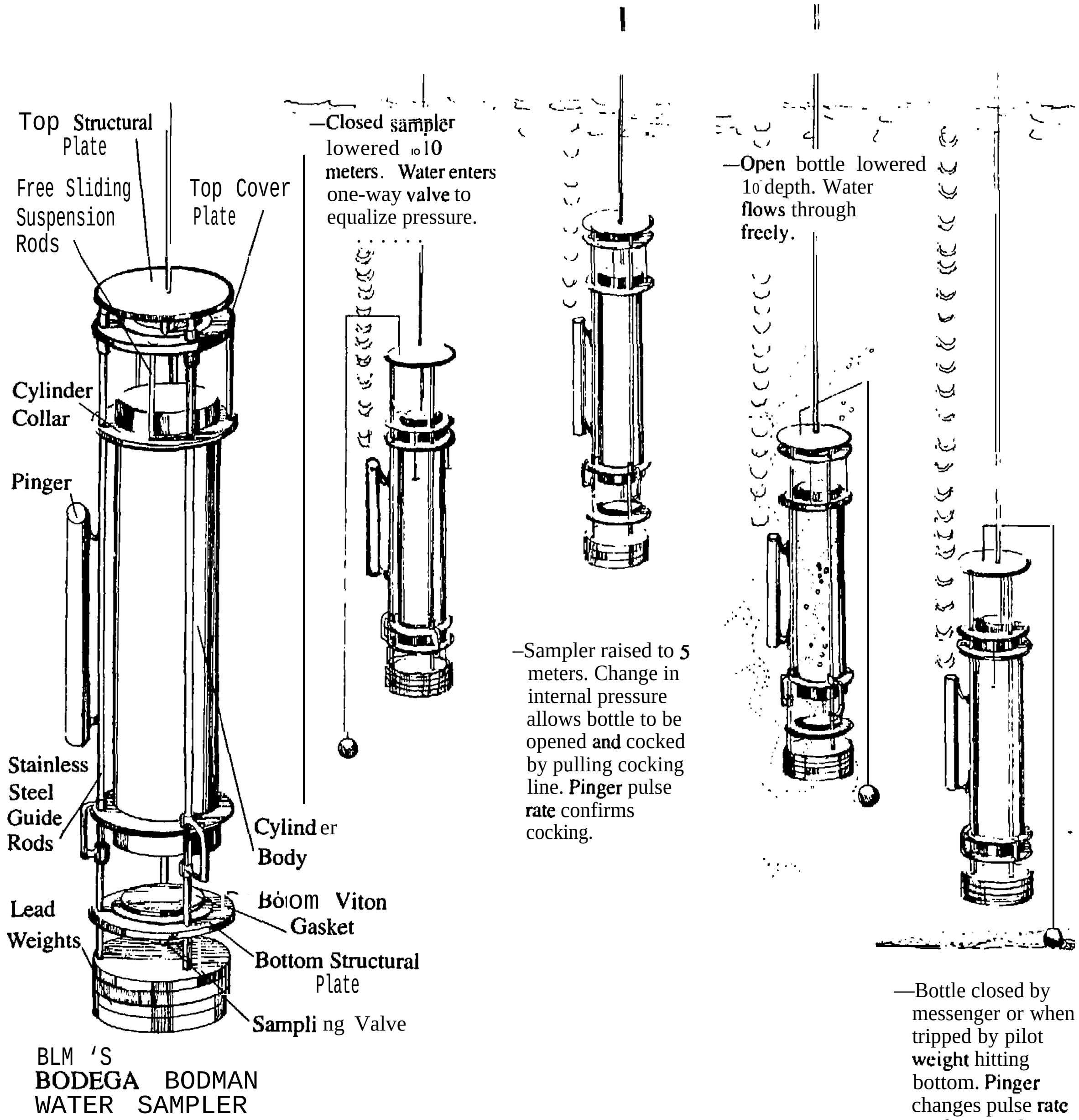


Figure I-4a Sediment sampling.



Sampling Methods

The concentrations of trace metals and petroleum must be precisely determined in the marine environment in order to establ ish predevelopment conditions. These same methods will help determine if changes occur through time. Marine samples fur chemical analysis are often contaminated during sampling. In order to avoid these problems new sampling techniques were developed and exist ing techniques were extensively modified.

Two new sampling devices are illustrated. On the left page is a modified Soutar box corer which collects undisturbed and uncontaminated samples, from soft bottoms. This boxcorer, and a similarly designed Van Veen grab sampler for sandy bottoms (nut shown), descend through the water column as open cylinders. This eliminates surface sediment disruption caused by the bow wave and hydraulic pressure within incompletely vented systems. Both the corer and grab sampler are made of noncontaminating materials which greatly reduce potential sources of hydrocarbon and trace metal contamination. Reproducible subsampling of sediments to uniform depths was accomplished using a template. The template was pressed into the sample; the subsample was removed from within the template guide using a trowel preset to collect the desired depth.

The third chemical sampling device was developed to obtain uncontaminated water samples for hydrocarbon analysis from any depth desired. The sampler is an extensive redesign of Woods Hole's Bodman sampler. The redesign was performed by the Bodega Marine Laboratory and Ocean Industries, Inc. Modifications allow the sampler never to be opened on the deck of the ship and to pass through the air surface interface closed; the sampler opens and closes underwater. BLM "s Bodega Bodman sampler is constructed of non-contaminating materials and is equipped with an automatic bottom closing pilot weight release mechanism. A dual pulse-rate pinger changes frequency when the sampler opens or closes. Quick disconnect nitrogen purge and sample drainage valves ensure efficient connection to filtration and storage bottles housed within a clean room.

Figure I-4b. Water sampling.

Oil Characterization

In order to monitor the presence and assess the significance of oil in the marine environment, scientists must be able to measure both the kinds and amounts of oils present. Chemically speaking, all oils are combinations of carbon and hydrogen atoms known as hydrocarbons. The carbon and hydrogen atoms forming oils can be bonded together in a variety of ways creating over two thousand known hydrocarbon molecules. Petroleum is but one class of hydrocarbon; other hydrocarbons include, plant and animal oil and waxes.

The kind of oil present is determined by measuring the ratios of different molecular structures such as branched, double bonded, ringed structures, etc. The presence of specific combinations of these structures, whether in water, tissues or sediments, can help identify the oils source. For instance, certain compounds are associated with non-petroleum hydrocarbon sources such as plant waxes or industrial wastes. Petroleum consists of a wide range of hydrocarbons including cyclical, aliphatic, branched aliphatic, aromatic and polycyclic compounds.

An analytical technique called gas chromatography separates the various compounds in an oil sample and measures the quantity of each. The product of this analysis, called a chromatogram, is a finger print of the types of compounds present. Note the chromatograms in the third column, the location and height of each peak signifies a kind and quantity of hydrocarbon. These chromatograms are extracts of pristine, seep contaminated and oil spill contaminated sediment.

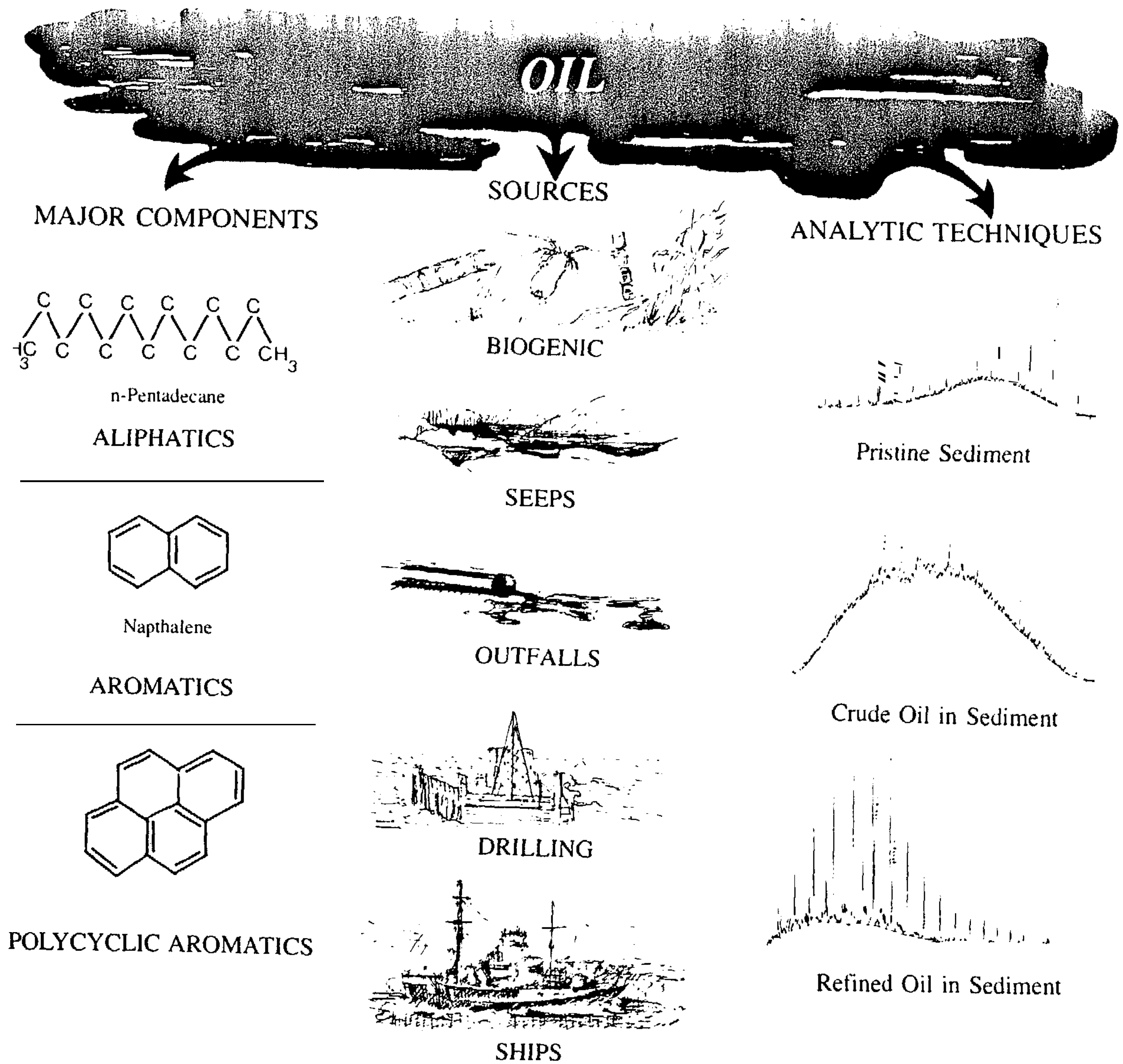


Figure ɪ-5. Factors influencing the measurement of petroleum in the marine environment.

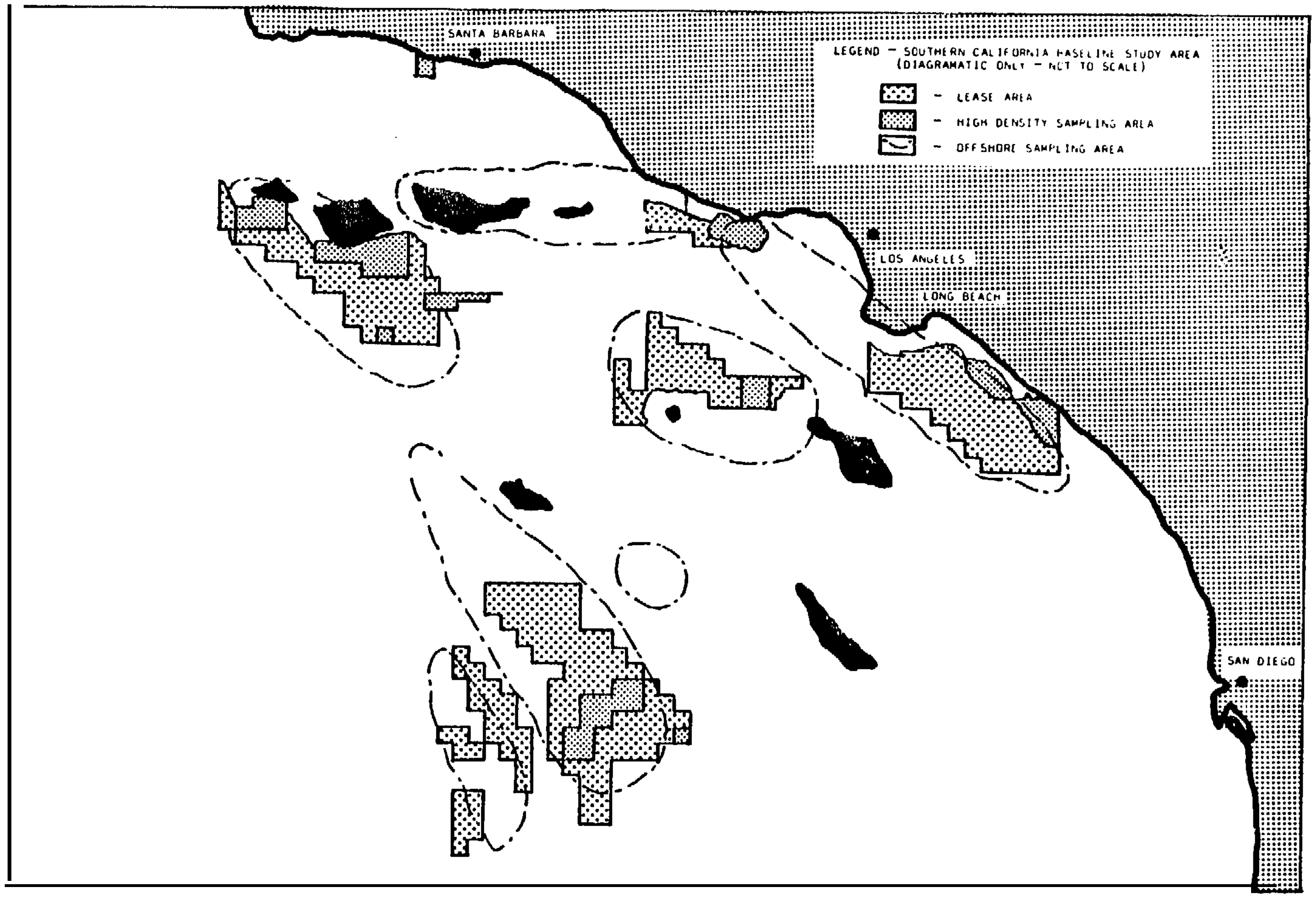


Figure I-6. Southern California Study Area.

Several near-shore locations have unusually fine-grained sediment deposits due to the settling of particulates injected by and flocculated from sewage effluents.

Seaward of both the shallow coast and the island shelves are the slope and basin environments extending below 200 m water depth. These areas are characterized by low-energy bottom waters and fine-grained sediments normally free of significant amounts of heavy minerals. This regime has two distinct settings within the Southern California OCS. The line of basins adjacent to the mainland shelf and inside the first line of islands receives predominantly terrigenous material settling through the water column or being transported by down-slope turbidity and gravity flows.

The outer basins have similar sedimentary characteristics; however, these environments receive very little terrigenous material, relying on water column productivity to supply pelagic debris. As a result, the sediments in the outer basins are slightly coarser and of higher organic content, often being nearly all fecal remains of marine organisms.

3.2.2 Benthic and Water Column Chemistry

Sediments and Biota

Distributions of selected trace metals -- copper, chromium, nickel, zinc, lead, cadmium, barium, vanadium and high molecular weight hydrocarbons were determined in surficial sediments, macrofauna and flora throughout the Southern California OCS. Sediment samples were collected at 145 stations using a Teflon-lined, slowed-entry, completely-vented box corer which carefully preserved the surface layers from mechanical disturbance during coring. The top one cm of sediment was immediately "shaved" from the core, placed into acid-cleaned polyethylene (trace metal samples) or solvent-cleaned glass (hydrocarbon samples) bottles and frozen for transmittal to the analytical laboratory.

Biotal samples were collected by a variety of methods including selection from certain of the biological box cores, from bottom trawling, or by diver (at Tanner and Cortes Banks). All biota samples were handled with the maximum care to prevent contamination, and frozen in polyethylene bags or glass jars for storage and shipment.

The analytical procedures for metals included atomic absorption spectrophotometry (flame and flameless) and neutron activation analysis; gas liquid chromatography supplemented by high resolution mass spectroscopy was utilized for the analysis of hydrocarbons. Preparations for many of these analyses were carried out in filtered-air clean rooms equipped with laminar flow tables or hoods and using procedures designed to minimize contamination.

Water Column

Suspended particulates and water samples were collected at 41 stations throughout the Southern California OCS for the determination of their heavy metal (particulates only) and high molecular weight hydrocarbon burdens. Surface and deep particulate samples were analyzed in such a way as to distinguish between amounts of each metal absorbed on their surfaces and amounts contained within their matrices. This approach was taken in the expectation that any anthropogenic metal alterations would appear in surface coatings. Both surface and near bottom particulate and dissolved samples were analyzed for hydrocarbons.

3.2.3 Benthic and Water Column Chemistry Results

Metals in Sediments and Water Particulate

In general the metal concentrations of water column particulate and bottom sediments from the Southern California OCS reflect the chemistries of their source materials. The waters sampled between the mainland and first set of offshore islands can be expected to contain a preponderance of land-derived materials whose metal contents have in some cases been affected by contact with urban effluents. Surface water from these areas usually contains only fine-grained terrigenous minerals mixed with smaller proportions of planktonic organisms. 'I'he near-bottom waters tend to resuspend various assortments of bottom materials ranging from fine-grained to relatively coarse.

The particulate material suspended in the waters of the outer areas is somewhat different from that found near-shore, being a combination of relatively coarse debris from the islands and outer banks (Tanner and Cortes) and other bodies of living and dead planktonic organisms. The planktonic contribution is particularly evident in the surface waters in the outer edge of the Southern California OCS where upwelling supports an unusually high level of primary productivity.

Although particulate suspended in the water can be considered to be sediments on their way to the bottom, there are observable differences in the metal concentrations measured in settled and unsettled materials. These differences occur because the origins of these settled and unsettled particulate are different. It is interesting to note that both surface and deep particulate and suspended particulate and deposited sediments differ in trace metal chemistry. In most cases throughout the Southern California OCS there are slight elevations in the metal concentrations of deep particulate relative to surface particulate. This is caused either by loss of organic matter as the particles sink or by more extensive adsorption of metals onto the surfaces of the finer-grained deep samples (especially true in the deep basins). Only barium, which decreases in concentration with water depth, and cadmium, which is relatively uniform with depth, depart from this trend.

In most cases, the metal concentrations of suspended particulate from near-bottom waters are elevated relative to the deposited sediments lying beneath. In almost every instance, the disparity in the chemistries of these two phases can be explained by natural physical and chemical processes acting on the deposited sediments and altering their concentration distributions.

Near-shore sediments tend to be highly variable in metal contents, at times exhibiting the effects of local sources of pollution. The deeper water sediments found in the offshore basins are normally enriched in metal concentrations relative to near-shore materials, but these enrichments are typically related more to the finer grain sizes of the deep sediments rather than to metal "pollution."

An important result of this study has been the documentation of highly variable trace heavy metal distributions in sediments and suspended particulates of Southern California OCS environments. Elevations of metal concentrations in materials from one geographical area relative to another are not necessarily related to pollution sources or man-induced affects. Interpretation of metal concentration data has to consider all aspects of the geochemical environments from which samples come when evaluations are being made as to the effects of unnatural chemical impacts.

For example, the fine-grained, clay-rich basin sediments tend to have the highest trace metal content. Exceptions to this would include the relatively shallow sediments collected near sewage outfalls off the Los Angeles metropolitan area, some having very high concentrations of certain metals (especially cadmium, chromium, copper, lead and zinc). Another exception would be sediments from some of the shallow shelves and banks. These settings often were found to have very high chromium (and sometimes vanadium) content resulting from the presence of minerals such as chromite.

Hydrocarbons in Sediments

The contributory sources of hydrocarbons in the sediments of the Southern California OCS are shown in Figure I-8 and can be separated into two general categories:

- Petroleum (crude, refined, petrochemicals), including that from sewage, natural seeps, and petroliferous source rocks
- Recent natural-product or biogenic hydrocarbons (phytoplankton, zooplankton, terrestrial plants).

Most benthic sediment samples contain remnants of more than one hydrocarbon source. The distribution of material from these various sources at a particular location is a function of its distance from each source, rate of microbial degradation, water circulation, water column productivity, wave action, water temperature, bioturbation and oxygen content of the sediment.

A primary objective of the hydrocarbon analyses performed in this study was to document the relative abundances of biogenic and petrogenic compounds in the various components of the marine environment prior to extensive development of petroleum resources. Interpretive methods had to deal with the fact that oils are complex mixtures of molecules. To achieve this, hydrocarbon data were analyzed by systematically separating the components of each sample's gas chromatogram into groups of compounds reflecting its dominant contributory sources.

Based on these groupings of compounds, the relative concentration of each was determined from gas chromatographic data available for each sample. Interestingly, two particular combinations (ratios) of these relative concentrations tend to strongly indicate the contribution of petroleum-related hydrocarbons as compared to other sources. Al though many geographical areas were represented by only a few samples, several generalizations can be inferred from these parameters.

For the inner basins, indications of the presence of petroleum in bottom sediments are greatest in samples from Santa Barbara Basin, the northern part of the south coastal basin, and three stations from Santa Monica Basin. For Santa Barbara Basin the high petroleum levels are likely the result of natural seepage from Coal Oil Point, whereas those for Santa Monica and northern South Coast Basins could result from seepage, sewage (including industrial discharge), shipping, harbor traffic, or any combination of the four. Moderate values observed in San Pedro Basin and the majority of the Santa Monica Basin samples suggest a 'blend' of natural and man-derived contributory sources.

In the outer basins and slopes the greatest indications of petroleum occur in sediments from the Tanner-Cortes and San Nicolas Basins, as well as in those collected from south of San Miguel Island, south of Santa Rosa Island and northwest of Santa Catalina Island. Petroleum burdens in most of these areas can be directly related to known natural seeps, military activities, or proximity to shipping lanes.

In addition to petroleum-related hydrocarbons, those derived from biological processes (e.g., productivity) were also found at various concentrations to some degree in all of the sediments collected in this study. The two main sources of these biogenic hydrocarbons in most near-shore marine areas are (1) run-off from land contributing the remains and products of terrestrial vascular plants and (2) metabolic materials from marine plankton.

Sediments containing materials from terrestrial plant waxes are distributed throughout the Southern California OCS, although in general, locations exhibiting the highest proportions are limited to the near-shore shelf and adjacent basins. Inputs from other hydrocarbon sources often ❑ask the presence of the plant wax component in near-shore areas (e.g., Santa Barbara, Santa Monica and San Pedro Basins and adjacent shelves).

Hydrocarbons derived from both living and dead marine plankton generally increase with distance from the mainland and with coarser sediment grain size. Both of these trends, however, are ultimately related to the characters of sediments generally found underlying waters of high productivity.

Hydrocarbons in the Water Column

The concentrations of hydrocarbons dissolved and suspended in marine waters were found to be very low in all samples not collected in close proximity to outfalls. Concentrations as low as 60 rig/liter (sixty billionths of a gram per liter) were measured in open waters, while more common dissolved fractions varied from 0.15 to 11 µg/l, (eleven millionths of a gram per liter) and those associated with particulate ranged from undetectable to 2.1 µg/l. (An exception of one sample off the Hyperion outfall which had a particulate hydrocarbon load of 81.0 µg/l.) Typically, 10-20 times more dissolved hydrocarbons were present than those associated with particulates.

Biogenic hydrocarbons were found in high concentrations in surface waters distant from the coastline. Petroleum was found in many nearshore samples, especially those from the San Pedro and Santa Monica areas. Offshore, petroleum was found in waters off Tanner and Cortes Banks.

Metals and Hydrocarbons in Benthic Biota

Collection and assay of biological tissues for trace metal content was performed with the goal of surveying a large number of species over a large area. As a result only six benthic species were collected in sufficient numbers to attempt establishing intersite relationships. These included three species of brittle star, two species of sea urchins and a single species of sea star.

Several statistically meaningful conclusions can be drawn from this study. Several species showed enrichment in chromuim, copper, nickel and lead when collected from areas near outfalls (e.g., Palos Verdes and Santa Monica). One species of brittle star had elevated lead levels at Huntington Beach (near a sewage outfall) relative to Coal Oil Point (an area of natural oil seepage). High levels of chromium were associated with proximity to coastal outfalls, and appeared to be especially enriched in one species of sea urchin.

In contrast to the elevation of several metals in organisms associated with mainland outfalls, a few metals were found in high concentrations in tissues from the outer basins and from the banks area. This was especially true for cadmium most likely explained by an association of that metal with highly productive surface waters in which rich planktonic populations extract dissolved metals and then sink to form the bulk component of the sediment. On the banks themselves, elevations of cadmium (and other metals) may result from a similar bioaccumulation process in which the macroorganisms associated with the productive shallow water communities concentrate metals by feeding on the plankton.

Limited interpretations concerning the implications of hydrocarbon levels in benthic biota were possible after this initial survey. While statistically valid interpretations of inter- and intra-species variability and seasonality are not possible, what has been documented is the general range of hydrocarbon types and concentrations within many species residing in a variety of oceanographic and geographic environments characteristic of the Southern California OCS. For example, of five geographical populations of a particular starfish, the north mainland coast samples had significantly higher petroleum-related hydrocarbon contents than those found on the outer banks. This effect is presumably related to urban runoff of man-derived hydrocarbons or to incorporation of natural seep oil.

In general, expected environmental trends were always found. Tissues of animals from the Coal Oil Point area and from the shelves bordering large urban areas or industrial outfalls were found to contain high concentrations of hydrocarbons related to petroleum or industrial sources. Samples from the relatively pristine islands and outer banks were in general low in hydrocarbon concentrations and contained materials which are characteristically biogenic. Organisms living in basins were found to have hydrocarbon concentrations somewhere in the middle to high range. However, their body burdens were of a more balanced petrogenic/biogenic character than were the animals associated with near-shore seeps and outfalls.

3.2.4 Benthic Biology (Macro and Micro Infauna)

The purpose of the benthic community analysis was to define infaunal assemblages -- the communities of animals that live in the bottom sediments -- throughout the study area. Since these animals have very little mobility and live in a relatively stable environment, studying changes in their community structure over time could provide observable indications of the impact of man's activity on a diverse community of marine organisms. Two types of benthic infauna were studied, macroinfauna (animals larger than 1.5 mm) and microinfauna of the class Foraminifera. Foraminifera are small calcareous-shelled animals which can be taxonomically classified by the shells (tests) alone. These shell fragments persist in marine sediments for many thousands of years. Foraminiferal community analyses have been extensively used to provide information concerning environmental conditions in the geological past.

The benthic infaunal study included eleven high density sampling areas (HDSAs) in which concentrated sampling was employed. With one exception these areas were associated with the five lease tract areas proposed by the BLM for offshore resource development (see Figure 1-6).

In additon to the HDSA's, more scattered, broad-coverage "survey" stations were sampled throughout the Southern California OCS.

Boxcores, augmented by trawls and dredges were used for the collection of selected macroinvertebrates for taxonomic and chemical analysis. Box cores were collected from 711 stations; 145 trawl/dredge samples were taken.

Box cores were collected with a standard Naval Electronics Laboratory (NEL) spade corer equipped with a stainless steel sample box of 0.063-m^2 surface area and an underwater-shutter 35 mm camera designed to photograph the sediment to be sampled just prior to penetration. The photographs were used to observe the ocean floor around the boxcore sample. All organisms larger than 1.5 mm were removed from the sediment and preserved for later identification in the laboratory.

Three separate types of analyses were conducted on the macrobiota collected by boxcoring:

1. Preliminary community analysis (coarse-sort) of all 711 box core samples.
2. Rapid Identification Procedure (RIP) of 546 of these samples, and
3. Complete, or detailed, analysis (fine-sort) of 165 of these samples.

The preliminary analysis, or coarse sort, involved separating those organisms retained on the screen into five major groups, and recording the number of individuals and the wet weight of each group. The five major groups designated for this study were polycheatous annelids (a diverse group of worms), molluscs (such as snails and clams), crustaceans (such as crabs and shrimp), echinoderms (such as starfishes and sea urchins), and "minor phyla".

The Rapid Identification Procedure (RIP) carried the analysis one step further. Each major group was assigned to a taxonomist very familiar with the animals of that group. The taxonomist was allowed only ten minutes to identify as many organisms from that group as possible. The RIP analysis resulted in approximately 44% of the organisms being identified to species.

The detailed analysis, or fine-sort, was applied to samples after the preliminary analysis step. Each major group was assigned to the appropriate taxomomic specialist who was given as much time as necessary to identify as many organisms to their species level as possible. This method allowed identification of nearly 70% of the organisms.

Because of the large number of stations in each sample set, the rapid identification procedure (RIP) produced the most valuable data for the principle purpose of this program (i.e., biogeographic community description). The RIP data were sufficient to allow identification of faunal assemblages by both direct inspection and computer classification. The RIP was used also to rank species by frequency and abundance.

The fine-sort data were qualitatively the best data. However, this technique was less useful than the RIP because it included too few samples for adequate statistical characterization. It was used to identify faunal associations and assemblages by both direct inspection and computer classification, and was also used to determine species richness in the calculation of diversity, evenness and dominance.

Computer analysis of community structure was performed using both RIP and fine-sort data. As an ecological tool, such a classification has the advantages of (1) objectivity and (2) the ability to handle very large amounts of data, both of which are lacking in direct inspection analyses. Sampling groups formed by this classification were based on their faunal similarity and were used in ranking the numerically dominant taxa by frequency and abundance.

Diversity was calculated by applying the Shannon and Weaver Index to fine-sort samples. Dominance (a measure of the species with the most individuals and biomass) was measured by the Simpson Index and calculated from the fine-sort data.

Microfaunal assemblages, or communities, were defined on the basis of live, dead and fossil foraminiferan populations. Analysis involved classification of both species and station groups using cluster techniques. Evaluation and interpretation of the computer processed data considered sample quality (particularly for stations previously identified as having low species abundances or diversity) and season of collection. In some instances, the species or sample membership of the resultant cluster was modified when independent assessment of an assemblageindicated more significant ecological relationships than obtained by unabridged statistics. Estimates of foraminifera standing crop and species diversity were determined by counting live and dead individuals.

Analytical methods focused on the possible relationships between changes in the physical environment and in the communities under study. Plots of live/dead ratio, standing crop, species diversity, number of species and number of individuals as functions of water depth, various sediment characteristics and other physical environmental factors were employed. Besides cluster analysis, multiple descriminant analysis was applied.

3.2.5 Benthic Biology Results

Macrofauna

The HDSAS could be separated into three distinct macrofaunal groups: a nearshore group (Huntington Beach-Laguna Beach, Point Dume, Coal Oil Point), an island group (San Miguel and Santa Rosa Islands) and an open water group (Santa Catalina Island, Santa Rosa Ridge, Santa Cruz Basin, and Tanner-Cortes Banks). The communities within each group were generally found not to be statistically interelated. Only the Point Dune and Coal Oil Point HDSAs were found to be statistically similar. Individual stations tend to be similar across geographic groupings on a depth-related basis. However, this relationship is by no means clearcut. Similarly no community alterations could be shown to exist at Coal Oil Point stations where sediments are rich in petroleum. However, this survey was not designed to detect such alterations.

Many new and a few possibly rare species were found, including a snail-like molluscan of the class Monoplacophera, an ancient class of "living fossils"'. Tanner and Cortes banks, located approximately 210 km west of San Diego (Figure I-1 and I-2) appear to constitute an unusual environment where near-shore and open ocean species form unusual associations.

The spatial distribution of benthic macrofauna in the Southern California Borderland is most clearly associated with bathymetry. However some associations also exist between the benthic macrofauna and sediment characteristics. Few cause and effect relationships may be discerned because they are obscured by the complexity of interactions between the biota and their physio-chemical environments. It is extremely difficult to separate the effects of sediment type and bathymetry on benthic assemblages because they are so interdependent.

Some overall patterns of biotal and sediment distributions, however, are apparent. For example, a particular sea cucumber dominates where there are fine sediments with little shell debris in shallow water. Where there is more shell debris, a species of brittle star is co-dominant or dominant. In slightly deeper water with the same sediment characteristics, sea urchins are dominant.

In shallow areas where the ocean bottom consists of soft silts and clays, three families of amphipod crustaceans predominate. Shallow areas with gravel and boulder-strewn bottoms are dominated by tube-dwelling amphipods species. Both types of bottoms (mud and rocky) have large numbers of a burrowing amphipod. In general, amphipod and isopod crustaceans in deep water are uniformly distributed.

In shallow sandy areas, the dominant animals are molluscs (bivalves and snails). Shallow areas with silts and clays contain three different species of bivalves, while deep areas are dominated by a fourth.

Polychaete worms were found to be distinguished by four groups found (1) in shallow sandy areas, (2) in shallow silts and clays, (3) on the slope, and (4) in the basins. Each group was found to be dominated by a number of species.

All groups of animals appeared to be impoverished (reduced populations) in areas of both active sediment transport and rapid deposition. In general, deposit feeders dominate in fine sediments, while filter feeders dominate in areas of coarser sediments.

Microfauna

Three aspects of the benthic microfaunal communities were studied: living communities in the 0 to 1-cm sediment layer, dead communities in the 0 to 1-cm sediment layer, and fossil communities in the 12 to 15-cm sediment layer. Four major living foraminifera communities appear to be present in the Southern California OCS (Figure I-7).

One community (Cassidulina-Hanzawaia) is dominant in water depths of less than 200 m in the outer regions of the Southern California OCS (west of the inner ridges). Many species live attached to a firm, hard substrate in areas subject to strong currents and wave surge and where shell and skeletal debris are common in the sediments.

A second community (Nonionella - Eggerella) is dominant on the inner shelf, being found at nearly all stations between Coal Oil Point and Newport Beach at depths less than 150 m. Deep occurrences (up to 800 m) probably were due to transport by turbidity currents. Some members of this community occur on the shelves of the northern channel islands and the outer banks.

A third community, (Buccella - Cibicides) is generally restricted to depths less than 400 m, and is characteristic of the outer ridges and banks lying between 100 and 400 m.

The fourth community (Epistominella - Seggrunda) is found on the continental slope and basins and is usually characterized by species which inhabit low oxygen environments. Some permanent members of this community appear to be shallow-water forms moved to the basins by turbidity transport.

The ecological assumption that species abundance is a valid measure of species adaptation is probably not viable for many populations of marine foraminifera. Therefore, results based on dead populations are not directly comparable to those based on live populations, although the two are usually related and are often very similar.

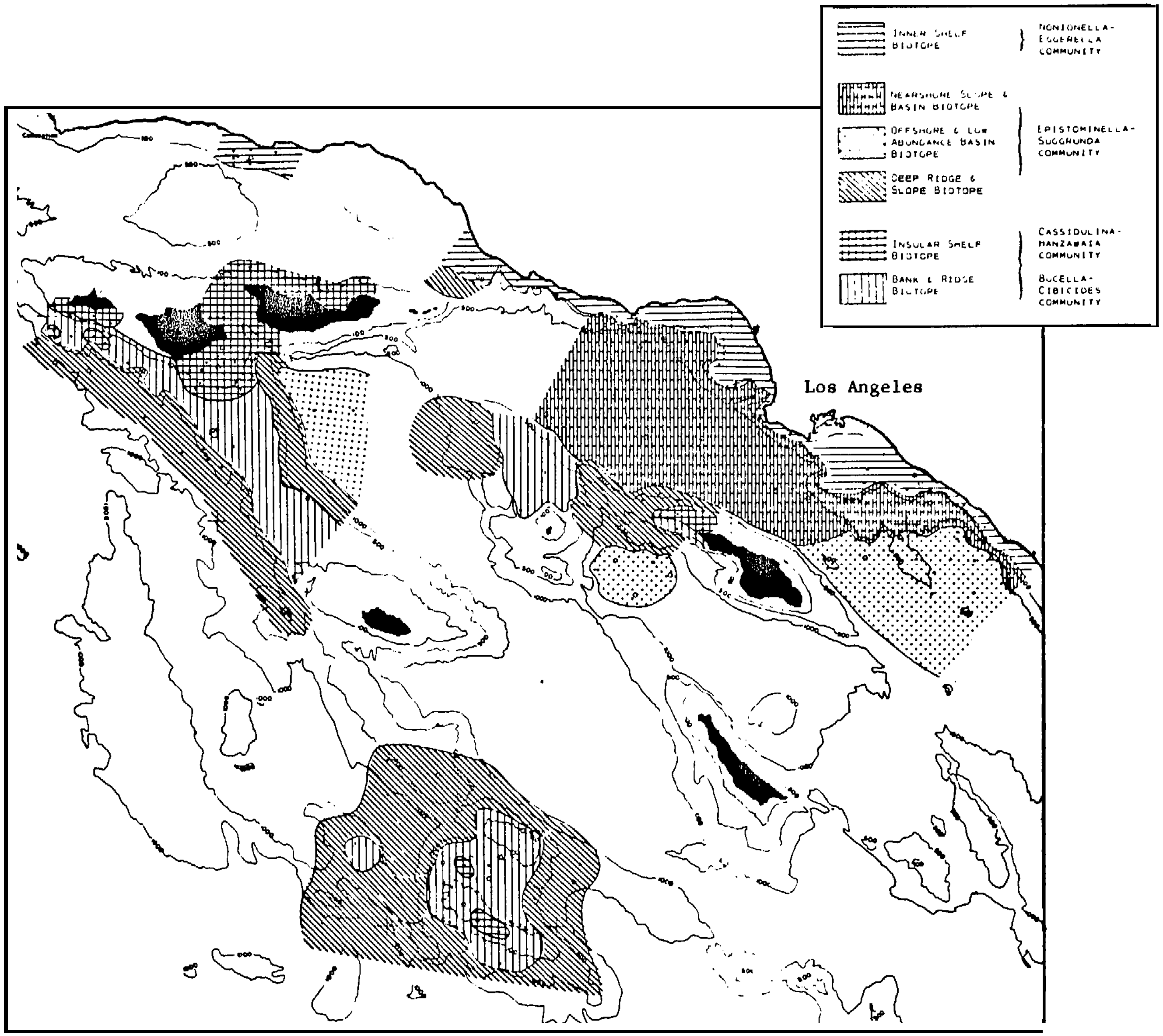


Figure I-7. Existing living foraminiferan communities in the Southern California OCS region determined by cluster analysis.

4.0 INTERTIDAL STUDIES

The intertidal studies (rocky intertidal and sandy beach/slough) consisted of several interdisciplinary approaches including: (1) seasonal community analyses, (2) trace metal and petroleum hydrocarbon analyses of selected biota, (3) a study of mussel community composition and (4) an aerial photographic survey concerning the distribution and seasonal variations of kelp beds. These studies have been summarized in the following sections. Emphasis was placed on characterizing the variations in biological, chemical and physical aspects of the intertidal environments.

4.1 Rocky Intertidal Study

4.1.1 Scope of the Study

Rocky Intertidal Biology (including Mussel and Kelp Surveys)

Three basic sampling approaches were taken in order to characterize the biological distributions and community structures. These included undisturbed, disturbed and aerial photo-survey (for the kelp beds).

Undisturbed sampling was performed at ten sites (Figure I-8) using a photographimetric technique. This sampling approach allowed the quantitative measurement of cover, density and standing crop distributions, and provided permanent records of biotal conditions which can be used to reveal any future changes at each site.

An integral part of the undisturbed technique is that after the photographs were taken a trained taxonomist recorded the taxa, counted the individual invertebrates and visually estimated the cover of each species in a detailed sector-by-sector format. All sites were permanently marked so that the survey could be replicated in the future.

Disturbed sampling was utilized to measure standing crop biomass for further community description. The wet weight, dry weight and ash-free weight data provided by this effort are useful in interpretations similar to those obtained from the cover, density and distributional frequency data derived from the undisturbed method. Quadrats for disturbed sampling were selected for their biological similarity to the photoquadrats. Organisms within each quadrat were harvested quantitatively for subsequent sorting in the laboratory, and the disturbed plots were photographed and harvested within the high, middle and lower intertidal regions. Tidepool finfishes were qualitatively sampled in conjunction with quarterly disturbed and undisturbed sampling.

Small animal communities which exist within the interstitial space of mussel beds were studied at six rocky intertidal areas along the Southern California coast. Mainland localities were sampled twice during the year and island localities four times in order to determine if significant seasonal variation in these communities existed.

Quantitative data relating the distribution of rocky intertidal standing crop to tidal height was obtained. These data were used to determine differences in communities existing at different sites and between seasons at each site.

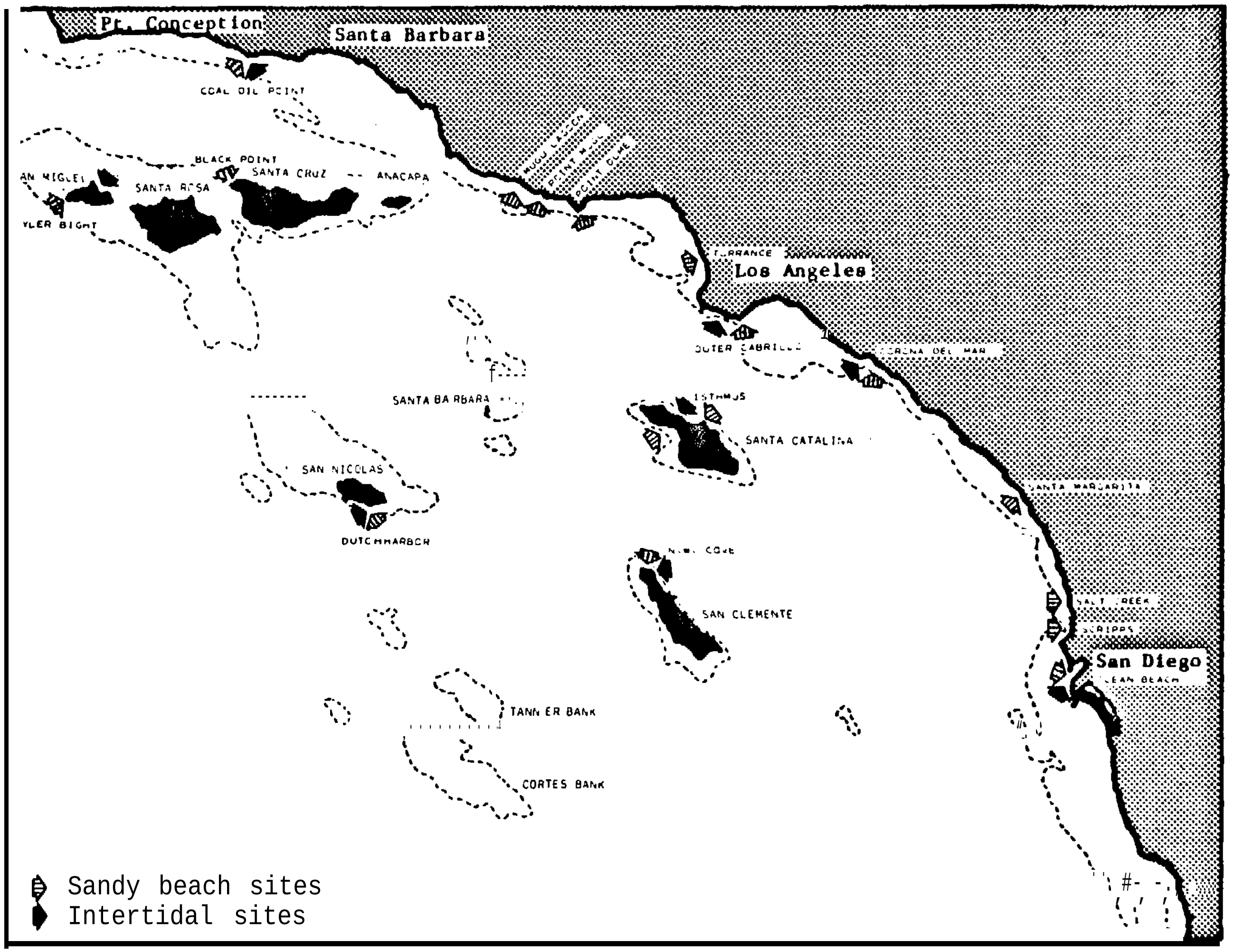


Figure I-8. The Southern California OCS showing the intertidal sampling sites.

Species diversity indices, which are of value in assessing community changes with time, were calculated. Such indices based on cover and biomass were used to quantify seasonal changes in compositional patterns of the biota at each site and to provide intersite comparisons of community structure.

The undisturbed cover samples were analyzed by cluster analyses to objectively evaluate seasonal changes in community structure. The of permanent, undisturbed quadrats were diagrammed to scale for each site and the quadrats contoured according to the community structure. This produced distributional maps illustrating site by site biotal variations with tidal height.

Seasonal changes in the size and coverage of all kelp beds from Point Conception to the US-Mexico Border, including the Channel Islands were calculated statistically and mapped.

The area of each individual kelp patch was determined and compared to the area measured during the previous quarter. Changes in the micro-distribution of kelp were also evaluated graphically by plotting the results of two quarterly surveys onto the same base map.

Rocky Intertidal Chemistry (Biota)

Biota samples were collected at all rocky shore sites (Figure I-8) for tissue concentrations of a set of selected trace metals and high molecular weight hydrocarbons. Copper, chromium, nickel, lead, zinc, cadmium, vanadium and barium were chosen for analysis because of their association with drilling activity or industrial discharges and their potential to have adverse effects on marine organisms. Nineteen different species were collected and analyzed from the ten rocky shore sites and from a sub-tidal location off Coal Oil Point. Of these, five were collected at a sufficient number of sites to allow inter-site comparisons.

Collection of all organisms for chemical analyses was performed in conjunction with the disturbed rocky shore community sampling program described above. Great care was taken in the field to prevent contamination of the samples during collection. After appropriate processing, the trace metal samples were analyzed by flame or flameless atomic absorption spectrophotometry and neutron activation analysis. The samples for petroleum hydrocarbon analysis were analyzed using gas chromatography and mass spectrometry.

4.1.2 Rocky Intertidal Results

The biological and chemical studies conducted in the rocky intertidal program were designed to provide descriptions of ambient, pre-oil development conditions throughout this particular environmental setting. In some cases these studies proved to be of sufficient quality and comprehensiveness to allow the formulation of hypotheses concerning ecosystem interrelationships and parametric cause and effect. In a few cases these postulations have been quantitatively verified. However, in most cases this initial year's data only suggest how the system(s) might be interacting.

Biology

In all, 477 taxa were identified at the 10 sites. Over half of the plant species were red algae and most of the animals were gastropod molluscs (snails).

Three intertidal zones are consistently found on Southern California rocky shores: an upper zone dominated by blue-green algae, a middle zone dominated by barnacles, and a wet, lower zone covered by coralline algae, red algae and kelp. All three of these zones were clearly recognizable at all study sites having continuous rocky slopes.

Seasonal trends were generally lacking except for a general reduction in biomass standing crop during the winter.

Assemblages of organisms were found to be specific to site. This distinctiveness can generally be attributed to variations in substrate material, substrate stability, upwelling exposure, wave exposure, water transparency, natural and man-made disturbances , and available nutrients.

The sites tend to fall into two groups: island sites and mainland sites. This overall trend appears to be due to a lower level of human-induced stress on the island sites. Island sites tend to have higher biomass standing crop than mainland sites. This difference is primarily due to the brown algal standing crops which are more sparse and patchy at the mainland sites. The data suggest that reduction in brown algal biomass may be associated with sewage-induced stress.

in addition to the differences in the brown algae, red algal turf communities tend to be made up of larger and more robust specimens at the island sites. Mainland turf communities were generally found to be lower, more compact, and more epiphytized (plants growing on other plants). Ocean Beach (a mainland site) provided is an important illustration of this characterization. It appears to have received little environmental stress over the last 30 years, since its present biota closely resemble those found in the area in 1947. Interestingly, the turf communities in both cases (1947 and present) resemble the present island turf communities. The observation also suggests that a compact, highly epiphytized turf morphology is characteristic of a "stressed" community.

other parameters which appear suppressed at mainland sites as compared to island sites are number of taxa, richness, evenness and macroinvertebrate species diversity. Macrophyte cover was found to be about the same at each type of setting.

The number of macrophytes (large plants such as kelp) unique to the islands is much higher than the number found only on to the mainland. Also, there are many more macroinvertebrates unique to the islands than to the mainland. These observations suggest that the plant and animal communities on the mainland have been reduced due to environmental stress although they are predicated on the assumption that at some previous time, the island and mainland environments had similar biological compositions.

The implication that environmental stresses have impacted biological community compositions at mainland sites is further supported by the observation that two sites which happen to be in the vicinity of point sources of pollution are distinct from all others. Of the plants which occur at the other nine mainland sites, 66% of these do not occur at Whites Point and 50% do not occur at Coal Oil Point.

In addition, at Coal Oil Point nine plant taxa were found which occur nowhere else. This suggests that the presence of oil from local seeps at Coal Oil Point may eliminate many ubiquitous macrophyte species and in doing so creates a habitat for otherwise noncompetitive and, therefore, less common forms. The data from Whites Point suggest that the nearby sewage outfall has eliminated many plant taxa which appear ubiquitously at the other mainland sites.

Overall, the evidence gathered in this study indicates the following environmental factors as most closely associated with the biological variations in the rocky intertidal environment:

- Urban wastes and other forms of human impact (trampling, sampling)
- Natural environmental stresses, such as wave surge unstable substrate, natural oil seeps
- Habitat variability, primarily in substrate type, roughness, slope, and height above low water
- Ambient water temperature range (related to latitudinal geographic location)

Chemistry

Recognizing the importance of species coverage in this initial effort, the trace heavy metal and hydrocarbon studies were both directed toward determining the ambient concentrations in several forms of macrophytes and macroinvertebrates. In all, 19 species, representing six taxonomic classes were collected and analyzed from the 10 rocky intertidal stations.

Although all of these samples were collected as part of the disturbed biological sampling, practically no relationships between chemical and biological distributions are apparent. There are several reasons for this. Except in the obvious cases of oil inundation, chemical impact on the biota of these environments appear minimal compared to physical impacts (wave action, substrate movement, temperature, desiccation, etc.). Secondly, even if significant cause and effect relationships exist between chemical environment and biological community structure, the data base generated during this initial year's effort did not provide the statistical basis for elucidating them.

Among the noteworthy observations derived from the chemical data are:

- No seasonal differences in the metal contents for any species sampled could be statistically defined.

Because of the broad-brush sampling approach, it cannot be stated with certainty that there are no seasonal variations , only that none were observable.

The sampling and analysis of only a few individuals of any given species was found to result in chemical data of high variability. One hundred percent variation from the mean was found in some cases. These data are of limited use in the establishment of well-defined *'baseline*' conditions; however, they do provide initial indications of the chemical concentrations and variations to be anticipated in subsequent monitoring surveys.

- Comparison of trace metal data derived in this study with those from previous studies of similar systems is in general agreement. Some noticeable differences, such as lower lead concentrations found in some cases in this study, more than likely are the result of utilizing improved sampling and analytical methods which have significantly reduced sample contamination.

- Only the California mussel could be geographically compared along the mainland coast for its metal contents, and they appear relatively constant except for noticeable elevations of lead at Pales Verdes and Corona del Mar. Only cadmium showed significant variation in tissues originating from the islands, being elevated at island sites in both kelp and mussels. Chromium showed some evidence of elevation at mainland sites relative to island sites in the tissues of a small marine snail.

- Relatively large variations were found in body tissue concentrations of hydrocarbons, in rocky intertidal organisms. These variations are due in part to evolving changes and improvements in the analytical methodologies , and in part to the more complex pathways by which these materials are incorporated into tissues, as compared to heavy metals assimilation.

  Bivalves collected at Platform Heidi, an active rig near Coal Oil Point, were found to have relatively low petroleum-type hydrocarbon concentrations with a high fraction of their total hydrocarbons derived from plankton.

- In general, all organisms collected at Coal Oil Point contained significantly higher petroleum-related hydrocarbon burdens than did their counterparts from other mainland and island sites. Unfortunately, the most thoroughly sampled rocky intertidal plant, the Giant Kelp does not occur at Coal Oil Point. For this organism, the highest petroleum hydrocarbon concentrations were found in samples collected at Santa

Catalina Island. Santa Catalina has a significantly higher sediment runoff into the littoral zone than do the other kelp environments examined in this study.

- In general, the quantitative and qualitative assays of high molecular weight hydrocarbons were successful in indicating dominant hydrocarbon sources (seepage, sediment entrainment, planktonic contribution, etc.) in the various rocky intertidal organisms sampled.

4.2 Sandy Beaches/Slough Study

4.2.1 Scope of the Study

As the case in the Rocky Intertidal study, the Sandy Beach/Slough survey consisted of several investigations. Included in this study were seasonal community analyses, substrate (beach sand) characterization and trace metal and petroleum hydrocarbon analyses of the beach sands and selected biota.

Sandy Beach/Slough Biology

Seventeen sites (Figure I-8), including eleven mainland locations and six island beaches, were selected to provide a representative study of the sandy beach and slough environments. Site selection criteria included geography (island vs mainland, north vs south), habitat variety (exposed sandy beach vs protected slough), public use, potential exposure to spilled oil, proximity to sources of fresh-water, natural oil sources (seeps) and industrial effluents. Three sites are particularly interesting because of their proximity to natural and man-derived chemical influences. Coal Oil Point and the collecting site at Torrance are in the vicinity of natural oil seeps; Coal Oil Point being the closer (about 100 meters) to an actual seepage site. While these areas are unique in their proximity to seeps, oil from natural sources periodically contacts many Southern California beaches.

Torrance beach is also located near sources of sewage effluent. A major Los Angeles city sewage outfall lies off Palos Verdes Penninsula between the collecting sites at Torrance and Outer Cabrillo beaches. In addition, both Torrance and Outer Cabrillo are exposed to industrial effluents entering Santa Monica Bay and Los Angeles Harbor, respectively.

<u>Undisturbed data</u> collection included beach profiling, recording occurrences of birds, mammals, kelp and other debris in the area and recording physical parameters. In addition, stranded beach tar was weighed.

<u>Disturbed sampling</u> was conducted by two methods: single-line transects (profile lines) and random stratified quadrats. The transect collection was employed to correlate observed biotic with a biological trends parameters and to examine the adequacy of using such a method as a sole information source for estimating variation in space and time. Randomly-located, stratified quadrats were used to detail species distributions of beach infauna in both local patches and tide height zones.

Sampling along the single-line transects was accomplished by excavating cores at regular intervals from high to low tide levels. Sand was removed in stages to study the distribution of species by depth. Excavated sand was analyzed at each depth for moisture, grain size, and organic carbon content. At each site, three of the cores (designated upper, middle and lower) had additional sediment samples collected for total organic carbon analysis. During the 1976 summer quarter, sediment samples were removed from these same quadrats at Ocean Beach (San Diego) and Coal Oil Point for hydrocarbon and trace heavy metal analyses.

Slough environments were sampled differently than were the exposed sandy beaches due to the unique characteristics of these estuarine sites. A single sampling technique was used combining coverage aspects of both the profile line and random quadrat approaches. This procedure better accommodated the larger species, such as the sand dollar, found in estuarine sites.

Sandy Beach/Slough Sedimentology

In conjunction with the biological and chemical sampling performed at the 17 sandy beach slough sites (see Figure I-8), beach sediments were collected for substrate characterization. The goals of this effort were to (1) provide a sedimentological survey and description of the sandy beaches throughout the Southern California OCS, (2) provide substrate characterization for correlation with biological community distributions and (3) provide correlatable sedimentary data for aiding the interpretation of chemical (hydrocarbon and trace heavy metal) measurements.

During the study, grain size distributions, clay mineral characterizations, and calcium carbonate and total organic carbon determinations were performed on sediment samples selected from eleven mainland and six island beach sites.

Sandy Beach/Slough Chemistry (Sediments and Biota)

beach sands were collected by plastic or stainless steel push cores at seven of the mainland and five of the island sandy beach sites (Figure I-8) for the measurement of ambient levels of petroleum-type hydrocarbons and the several trace heavy metals. Concurrent with these collections, sand crabs were also taken for measurement of these constituents.

Samples were apportioned over several of the beaches in such a way as to provide some information on seasonal, tidal height, and sediment depth effects on chemical distributions. Coal Oil Point, which receives natural petroleum input from nearby seeps, was compared to Ocean Beach (San Diego) which was considered a "petroleum-free" control.

4.2.2 Sandy Beach/Slough Results

Biology

All beaches sampled had distinctive biological communities and no single species was found at all sites. A total of '240 species were identified at the 17 sites; of these, 53 were found at mainland beach sites, 119 at island beach sites and 68 at slough sites. Of the 119 species found on island sites, 96 were found at Twin Harbors and 45 of those were unique to that site.

Four distinct vertical zones were defined at the beach sites: (Figure I-9)

- Uppermost beach zone (+2.7 m and above): dominated by two species of sand hoppers.
- High tide zone (+0.9 to +2.7 m): dominated by the sand crab.
- Mid tide zone (0 to +0.9 m): dominated by polychaetous and nemertean worms.
- Low tide zone (below 0 m): also dominated by polychaetous and nemertean worms.

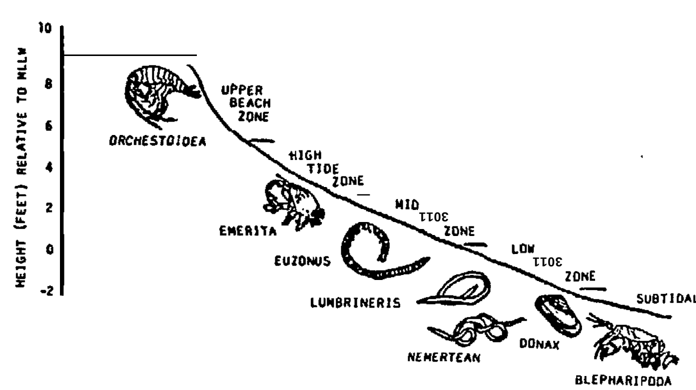


Figure I-9. Schematic profile of a typical exposed sandy beach.

The survey results indicate that variability in the data is related to site differences more than seasonal differences. In only two instances did groups of sites show similar seasonal trends.

In general, the mainland and island site communities were not found to be separable. The inability to separate mainland from island sites more than likely stems from the lack of similarity among mainland sites as a group and among island sites as a group rather than being indicative of similarity between mainland and island animal communities.

If emphasis is placed on the major taxa (crustaceans, molluscs, worms), island sandy beach sites are no more or less diverse than mainland sandy beach sites. Also, northern and southern sites are not distinct relative to each other. Some areas appear to favor development of varying faunas regardless of geographic position. Such patterns usually are explainable by local physical conditions.

The slough sites were found to be different not only from all other sites, but also from one another. The main reason for the observed differences is the occurrence of varying fresh water flow regimes. The two settings which are periodically open to the sea (Salt Creek and Santa Margarita) were found to have several species in common.

Overall, seasonal trends are not well-developed. Several of the sites contained communities which peak numerically in the spring or summer, while in a few cases characteristic communities were found to peak during the fall or winter. None of the other sites were sampled often enough to establish such trends. ALSO> it must be realized that these observed seasonal peaks were usually dominated by increases in a single species, as opposed to prevalent changes in a location's characteristic biological make-up.

Sedimentology

Based on data from this initial year's survey, most intertidal sites follow expected sedimentological trends. Selected sites, however, exhibited unique patterns of variation between seasons and tidal levels. For example, general trends observed for decreasing tidal levels were a decrease in grain size, an increase in calcium carbonate, and a decrease in organic carbon. Also, the mainland sites were found *to* have carbonate comprising less than 3% of the sample weight with a slight increase from north to south. The island beaches contain much more carbonate (average 16%) than the mainland sites due to lower availability of terrigenous sediment.

The general tendency for beaches to erode ***during*** the ***winter*** and acrete during the summer was observed at most of the sites. The departures from this trend which were found during the 1975-1976 sampling period appear paradoxical relative to site locations. During the summer the Southern California OCS receives swells from southern storms and any summer errosion cycle which might occur should be expected to focus on beaches facing south. This did not appear to be the case. In 1975-76 the only two island beaches facing south exhibited summer accretion and others facing west and north were characterized by erosion. These observations may be explained by one of the following factors:

- the 1975-1976 data are atypical,
- sand movement at the island sites is controlled by the nearshore submarine topography rather than by general wave patterns alone,
- beach erosion is controlled by seasonal variations in the directions and strengths of the prevalent current systems operating off Southern California during the different "oceanographic seasons" characteristic of the area.

Chemistry

The relationship between patterns of community variability and levels of trace metals and hydrocarbons in sediments and tissues is of prime interest to this program. The marine environment of the Southern California OCS is by no means pristine, having been subjected to relatively large inputs of domestic and industrial effluents as well as natural and man-induced oil sources. The general increases in levels of pollutants in this environment has been implicated in the documented declines in the number of species and biomass of various groups of organisms.

As anticipated, beach sands from Coal Oil Point contain generally higher total amounts of hydrocarbons than those of Ocean Beach (San Diego). The elevated hydrocarbon levels at Coal Oil Point do not, however, appear to have had inhibitory effects on the development of its sandy beach fauna. Moreover, samples of sand crabs from Coal Oil Point did not show elevated hydrocarbons levels in their tissues despite the presence of extensive natural oil seepage. In fact, sand crab samples from Coal Oil Point, Santa Cruz Island and San Nicolas Island all exhibited only low-to-moderate levels of petroleum-related hydrocarbons. From these results it was concluded that the sand crab as a species is not a sensitive indicator organism for petroleum contamination in the environment.

Trace heavy metal distributions in beach sands and sand crab tissues similarly failed to suggest coherent patterns corresponding to community variability. For example, despite the known impact of the Los Angeles County Sanitation District's waste-water outfall on nearshore benthic sediments, intertidal beach materials did not generally show elevated levels of those metals in the vicinity of the outfall. During this survey, lead levels at Outer Cabrillo were not found to be different from those at Point Dume, Torrance, Scripps/-(San Diego) and San Miguel Island. The highest levels of lead in the sand crab tissues were observed at Scripps/(San Diego); while Outer Cabrillo sand crabs ranked fifth in terms of mean lead concentration (and were equally enriched with respect to other metals). These data suggest that either pollutants from the Whites Point outfall do not ordinarily impinge on the sands of nearby beaches without extensive mixing and dilution, or that sand crabs do not concentrate these chemicals in their tissues.

From the relationships found in this study, several tentative conclusions have been drawn regarding processes affecting hydrocarbons in the beach sands sampled. Changes in diagnostic ratios obtained from the hydrocarbon data indicate that microbial degradation of organics is most intense in the lower tide zones. This is probably best explained by the dominance of finer particle sizes in the lower tidal region and a greater degree of evaporation (and desiccation) in the upper tide zone. These two conditions would tend to enhance microbial activity in the lower relative to the upper tide zones.

Based on the observable trends, it may be hypothesized that hydrocarbons are washed onto shores and then distributed along beach profiles. Once deposited they become weathered, losing volatile components to the air and other compounds to microbial degradation. Eventually the more resistant hydrocarbons are either buried or displaced by wave action to offshore benthic sediments. To support this, a comparison of Coal Oil Point intertidal and benthic sediment samples indicates that the petroleum in the beach sand is much less weathered than that from the benthic sediment.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The initial year of this environmental baseline program was generally successful in its main purpose of describing the chemical, physical and biological assemblages in the Southern California OCS. Significant progress was made in identifying improvements which would enhance future program designs and refinements in sampling and analytical techniques. Programs suggested from the experience of this initial effort promise to further clarify the ambient distributions of chemical and biological constituents in the area.

Information useful to the management of OCS resources includes estimations of the inherent "natural" variations which characterize local biological and chemical parameters. Reliable estimates of these parameters will provide for making sound decisions regarding environmental protection.

An intensive program to study the biology and chemistry of Tanner-Cortes Banks, an unusual habitat, was also recommended and included in the second years program.