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Contract N60ri-111(06)
(Geophysics Branch)

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Contract Nonr-233(22)
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15 February 1955

— ii —

— iii —

— iv —

— 1 —

Introduction

This report describes the results of unclassified research conducted during the quarter, October through December 1954, at the Scripps Institution of Oceanography under contracts with the Earth Sciences Division, office of Naval Research.

Two of these contracts (N60ri-111(06) and Nonr-233(04)) are with the Geophysics Branch; three (Nonr-233(05), Nonr-233(17), and Nonr-233(22)), with the Field Projects Branch.

Waves and Currents

Long-Period Ocean Waves — F. Snodgrass, Munk, Peterson

A cruise to the San Juan Seamount to study long-period ocean waves seaward of the continental borderland was attempted during this quarter, but the ships had to turn back because of heavy seas. the tests there-fore were conducted leeward of San Clemente Island in the Santa Catalina Island Channel. the Vibrotron pressure gage was lowered to the bottom at a depth of 2260 ft and recordings were obtained for a 60-hr period. the gage continued to exhibit a tendency to drift and was returned to the factory to be tested and recalibrated.

The tests at Catalina Channel also indicated that a redesign of recording equipment would be necessary to obtain data equivalent to that obtained by more sensitive gages installed at 60-fm depths on previous cruises. Two new units are being constructed to increase the sensitivity and stability of the recording equipment.

The first unit, which will be used to increase the sensitivity of the recorder, will multiply the output frequency of the Vibrotron gage to an average frequency of about 100 kc. the frequency therefore must be multiplied by eight, which will increase the sensitivity of the gage in proportion. the second unit, which will be used to increase the stability of the recording system, will be a crystal oscillator to replace the RC oscillators previously used. This oscillator provides a heterodyning signal which is used to obtain a beat note with the Vibrotron output. the beat-frequency signal then is measured and recorded by means of a Hewlett Packard Frequency Meter connected to a Speedomax Pen Recorder. Variations in the Vibrotron frequency can be recorded directly by the Speedomax Recorder to obtain the high-frequency signals (5 sec to 1 min). the Speedomax recorder also serves as a monitor for the more accurate digital recorders.

Variations in Sea Level — Groves

A numerical error was discovered in the computations for the determination of weighted averages to eliminate tidal oscillations from hourly data. the error occurred at an unfortunately early stage, and so much of the computation must be done over.

A direct correction for atmospheric pressure has been carried out on the sea-level records for about 25 tide stations over a three-month period. the derived records presumably show how the sea level would have reacted if the air pressure had remained constant, but leaving the existing winds unaltered. the rums value of the corrected records is considerably less than that of the corresponding uncorrected records. the corrected records appear to be related to the winds to a great extent. There is quite a high station-to-station coherence, suggesting that the wind effect does not depend a great deal on the extremely local topography. the fortnightly tide can be seen at some of the stations.

The mysterious four-day oscillations in sea level at Canton Island (mentioned in a previous report) have been found to be related to extremely regular oscillations of the local wind. the mechanism by which the wind effects this sea-level oscillation is still unexplained.

Wind Stress Over Water: A Hypothesis — Munk

A manuscript has been completed and will be submitted for publication in the near future. An abstract follows:

The form drag of wind on an irregular surface is found to equal the product of U^2 (U is anemometer wind speed) and a function of the two-dimensional spectrum of this surface. For a solid surface this function is, of course, independent of U and the form drag is proportional to U^2 , as observed over land. Over water, Neumann's frequency spectrum and the glitter measurements by Cox and Munk make this function proportional to U , and hence the form drag proportional to U^3 . the computed form drag is not far out of line with measurements by Van Dorn and others.

The dependence of form drag on the beam width and frequency spectrum of the surface roughness is discussed. the essential roughness statistics come close to being the mean square slope of the surface, rather than being related to wave height or some other roughness length, as usually assumed. the slope statistics are governed by the high-frequency part of the wave spectrum, and this feature accounts for the pronounced reduction of form drag by surface slicks and the relatively small effect of a limiting fetch. the total drag, $c_1U^2 + c_2U^3$ (skin friction + form drag), must be larger at very high winds than if it followed a U^2 law, as usually assumed.

The Formation of Surface Slicks — Munk

As a by-product of the study mentioned above it now appears that it might be possible that slick streaks formed by winds can be quantitatively accounted for. These slicks have been observed over seas and lakes and they adjust themselves in a matter of minutes to any change in wind direction. They are not associated with any deep convergence to the thermocline. Floats released between slick lines will soon converge upon the slick lines.

— 3 —

Among previous hypotheses it has been suggested that these slick bands may be a result of convection cells in the atmosphere. However, time-lapse motion pictures taken by Stommel indicate a very quick and irregular change in the wind structure whereas these slicks remain in position for some time.

It is here suggested that the selective absorption of the high-frequency waves by the slick band must be such as to cause a directionally skewed spectrum in the immediate vicinity of the slick. It can easily be shown that there is a component of wind drag towards the slick. Some calculations of the magnitude of this component and also considerations concerning the spacing of slicks are now under way.

Motion in the Fluid Core — Revelle, Munk

A symposium on Motion in the Fluid Core which was held during the UGGI meeting in Rome is to be published. Revelle and Munk gave a paper on the evidence derived from the earth's rotation and have now submitted a manuscript dealing with this topic.

Submarine Geology

Changes in Submarine Canyon Heads — Shepard

Difficulties were encountered in making soundings of the canyon during this period, partly due to the fathometer, and also on one survey because a great mass of squid or fish in the canyon blocked out the echoes ([see Fig. 1](#)). On this occasion a Navy jet plane crashed in the vicinity and operations were called off to see what could be done in this connection. The finding that the scattering layer was confined to the canyon head is of interest because the same thing was found three years ago (see ONR Prog. Rept. No. 20, SIO Ref. 51-16, Fig. 1).

The somewhat incomplete survey on 10 November indicated quite clearly that the canyon was still being filled. Observations after the earthquake of 12 November 1954 in an aqua-lung dive indicated that the water in the canyon was somewhat murky, but no clear evidence could be found of a slide. However, a short time later in Summer Branch the divers found a small slide, as shown by fresh escarpments in the sandy sediment.

Instruments For Measuring Sand Movement in Scripps Submarine Canyon — Beal

The "bottom-flow" instruments placed along the floor of Scripps Submarine Canyon to measure sand movement (see Earth Sci. Prog. Rept. No. 33, SIO Ref. 54-34) have been inspected several times during the past quarter. The instruments have not been functioning properly and several of them have been retrieved. Inspection showed that the malfunction resulted from deterioration of insulation on the instrument cables due to abrasion.

A suitable armored cable has been obtained and will be installed at a later date. It is believed that the use of armored cable will prevent future malfunctions due to abrasion.

Boundaries of Boulder Patch off Tijuana River — Moore, Curray

For some years it has been known that there is a roughly circular area lying a half-mile off the Tijuana River (south of San Diego) and having a diameter of about two miles, where the sea floor is entirely made up of cobbles and boulders. Aqua-lung dives have shown that some rather coarse, shelly sand lies in the interstices between these boulders. The area is known to be surrounded by fine sand. However, the boundary had not been investigated until recently. Aqua-lung dives by D. G. Moore and J. R. Curaray showed that at the boundaries of this cobble-boulder area the coarse, shelly sand laps over the boulders. This sand was found to have large ripple marks. The sand is a very thin mass and in places exists only as small dune-like ripples on top of the surrounding fine sand.

Deep-Sea Sedimentation — Bramlette

Most of the work of this period has covered examination of the coccoliths and related microfossils of samples obtained in Europe from the Tertiary type areas, and comparisons with Tertiary sediments in cores from the Pacific Ocean bottom.

Study has been started on the series of recently obtained cores which encounter such Tertiary beds at the surface of topographic highs in the deep sea, and these additional cores may offer an explanation for this very surprising condition.

Observations Using Self-Contained Breathing Apparatus (Scuba) — Inman, Murray, Short, Peterson

Measurement of Sand-Level Changes With Reference Rods

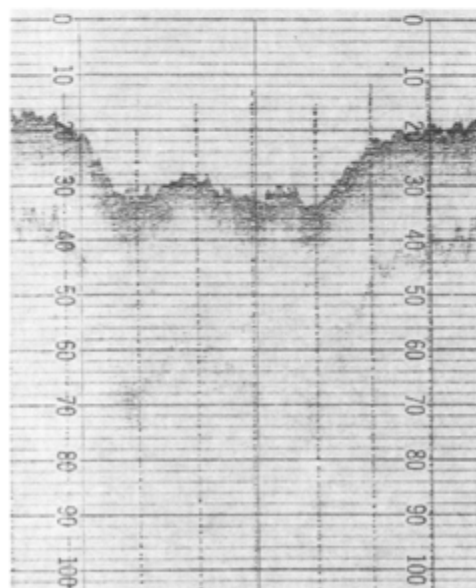
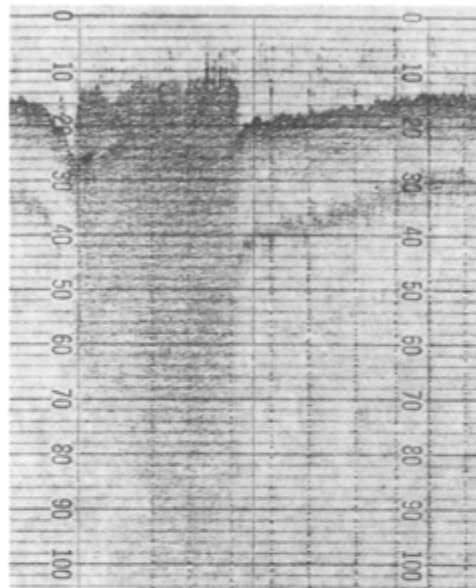
The accurate measurement of the changes in sand level at three stations in the La Jolla area has been continued for 21 months. A maximum cut (increase in depth) for the 21-month period was observed at the 30-ft depth during December and coincided with a period of unusually low, long-period ocean swells.

The maximum changes in level during the entire period of observation are: 0.26, 0.16, and 0.07 ft in areas where the water depth is approximately 30, 52, and 70 ft, respectively. The previous report (SIO Ref. 54-34) of a 0.21-ft change at the 52-ft depth was in error.

Observation of Sand Movement and Ripple Formation

A preliminary paper describing the physical aspects of ripples generated by wave motion in shallow water is in preparation. A summary of this study was presented at the Geological Society of America meeting in Los Angeles in November, and in December results of the field observations were compared with model studies of ripples being conducted by the Department of Engineering at Berkeley.

SCATTERING LAYER IN CANYON DUE TO ORGANISMS



EARLIER
FATHOGRAM

Figure 1.

As reported previously, the majority of the observations have been made in waters in the vicinity of La Jolla. In September a series of observations were made in the vicinity of Point Dume and Santa Catalina Island (SIO Ref. 54–34). During the past quarter, ripples have been studied near the Coronados and Guadalupe Island, Mexico, and off Point Loma, California. Extension of the ripple studies to other environments has strengthened the validity of the findings and indicates that they have a general application.

Ripple size is apparently related to sand size and the rigor of wave action on the bottom. The ripple wave length increases with increasing sand size and with decreasing rigor of bottom agitation. Thus the ripples with greatest wave length commonly occur in coarse sand in deeper water, while the shortest ripples occur in fine sand near the surf zone. The relation between ripple wave length and sand size is shown in figure 2. For ease of illustration, the ripples in this figure are grouped in accordance with the water depth, although depth a priori is not a controlling variable, but rather the orbital motion of wave action which changes with depth.

Fabrication and Development of Equipment — Hetzel

An accurate depth gage for divers has been constructed from a standard rear mount 0 – 100 p.s.i. pressure gage. A O-ring assembly placed between the cover glass and the brass case serves to waterproof the case and maintain the Bourdon unit at atmospheric pressure. Dow-Corning grease inserted into the small orifice of the Bourdon unit keeps sand and salt water from the unit without interfering with the pressure response of the gage. Since pressure is proportional to depth, the dial face is replaced by one reading depth in feet.

Scattering-Layer Investigation — Kampa

The investigation of light-sensitive mechanisms in the various components of the scattering-layer plankton has been continued. So far, only the euphausiids have yielded photosensitive aqueous extracts.

The extracts of euphausiid eyes absorb maximally at 463 to 468 m μ . The maximum change in absorption on exposure to light occurs at about 462m μ . The light-sensitive pigment is decomposed by exposure to temperatures above 70°C and by treatment with absolute alcohol, acetone, or chloroform. After such treatment, the solutions are no longer light-sensitive.

Decomposition of the euphausiid pigment, whether by light, heat, or treatment with organic reagents, results in loss of color and an increased absorption in the ultraviolet, particularly in the region of greatest absorption by vitamin A. Vitamin A has been detected in bleached extracts.

All of the fresh aqueous extracts of the new euphausiid pigment are contaminated with astaxanthin which remains in the solutions after the light-sensitive pigment has been bleached. Until astaxanthin can be eliminated completely from the extracts, it is impossible to be sure whether it is present simply as a contaminant, or whether it constitutes a bleaching product of the light-sensitive material. Attempts to remove astaxanthin from the eyes, by drying them and extracting with petroleum ether before the aqueous extracts are prepared, have been successful to a degree, and it now seems relatively certain that the photosensitive pigment involves vitamin A and a protein rather than an astaxanthin-protein complex.

Meanwhile, attempts are being made to ascertain the role of the photosensitive pigment, "euphausiopsin," in the visual physiology of the euphausiids. We have succeeded in obtaining electroretinograms from the eyes of *Euphausia pacifica*, and the spectral sensitivity of the animals is being determined by this method.

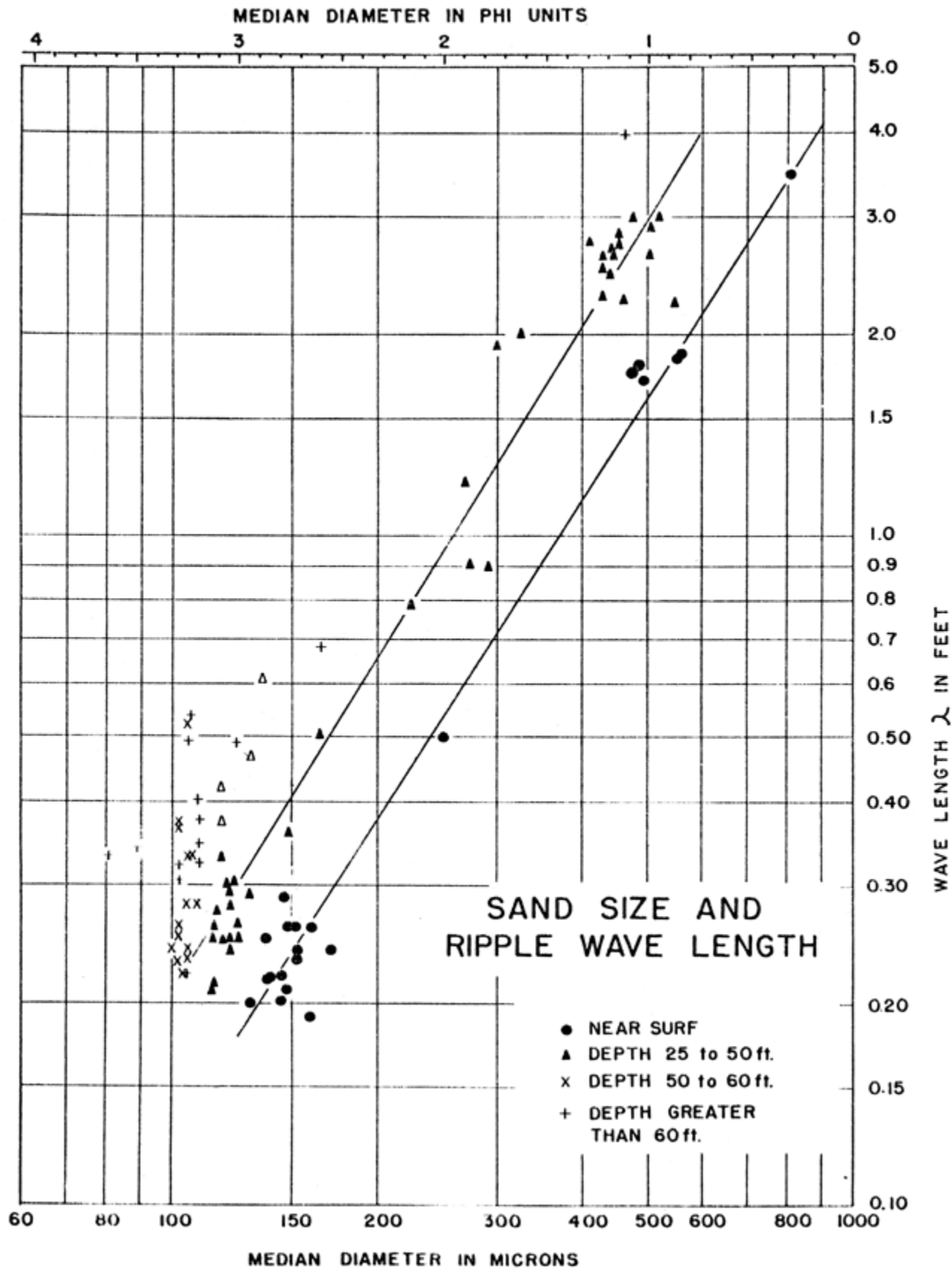
Inasmuch as photosensitivity is known to occur in forms which apparently contain no photolabile pigments, the electrophysiological work is to be extended to include other planktonic groups associated with the scattering layers.

Volcano Studies — Richards

During the quarter reports have been collected from observers of volcanic activity on Isla Isabela in the Archipiélago de Colon (Galapagos Islands). In early 1954 there was an apparent emergence of the shore of Bahia Urvina west of Volcan Alcedo on Isla Isabela. This local upheaval of the sea floor and adjacent land, reported by the masters of several ships, is believed to be due to ascending magma under Volcan Alcedo, which became active with a flank and crateral eruption on 9 November.

On 28 October Photographic Squadron Sixty-one, U. S. Navy, made a flight to San Benedicto and Socorro Islands. Dr. Herbert L. Mason and Mr. Bayard Brattstrom of the University of California, Berkeley and Los Angeles, also participated on the flight to observe the rapid revegetation and increase of the bird population on San Benedicto and to inspect Socorro before the 1955 Scripps cruise to the islands. Photographs were taken of selected areas on the two islands. There has been little erosional change on San Benedicto since the previous flight in early August.

A summary of the paper, "Observations of underwater volcanic acoustics at Boqueron Volcano, San Benedicto Island, Mexico, and in Shelikof Strait, Alaska; a preliminary study," recently prepared (with J. M. Snodgrass), follows:



Underwater audio energy originating from Boqueron Volcano was studied from plane and ship between November, 1952, and November, 1953, and tape-recorded on five different occasions. the recorded sounds are of two kinds: a 125 cps rumble and a higher-frequency hiss. A possible origin of these sounds, which are unlike any of known biological origin, is suggested and tentatively correlated with visible volcanic activity. A triangulation technique consisting of simultaneous recordings from two sonobuoys which was successfully used to locate the source of the sounds emanating from the volcano in November, 1953, is discussed. the inconclusive attempt in August, 1953, to record underwater sounds from an active volcano in the Valley of Ten Thousand Smokes from Shelikof Strait, Alaska, is briefly described to illustrate the technique used.

Analysis of Bathythermograms

Isentropic Analysis of the California Current Region — Cochrane

Analysis based on Cruises 5204 and 5404F was continued. in order to eliminate sigma-t values above which non-isentropic mixing may be considerable, vertical stability at various depths was determined. the permanent stability maximum (permanent thermocline or halocline) occurred at sigma-t values ranging from 25.2 to 25.6. the salinity pattern was charted for surfaces of sigma-t between 25.5 and 27.0. in each of the sigma-t surfaces used, geostrophic flow was determined by means of Montgomery's stream function.

The changes in magnitude and depth of the "permanent" and seasonal thermoclines were studied on the basis of the bathythermograms from Cruises 5204 and 5404F. One interesting point is the increase from north to south in the magnitude of the "permanent" thermocline. in both regions it coincides approximately with the halocline. But in the south the "permanent" stability (increase of sigma-t with depth) is accounted for largely by the change in temperature with depth, while in the north the salinity change dominates.

Seasonal Variation in the Heat Budget of the Oceans — Pattullo

Monthly anomalies in heat content have been computed for all localities analyzed in the previous quarter. Work on this study has been interrupted temporarily, but will be resumed in the coming quarter.

Seasonal Oscillation in Sea Level — Munk, Pattullo, Revelle, Strong

Additional temperature and salinity data have been obtained for localities in various parts of the Pacific Ocean. These are largely averages of Japanese serial observations, computed and tabulated by the U. S. Navy Hydrographic office. These additional data so improve the sampling in the Pacific that we are preparing a revised chart of steric levels in this ocean.

— 8 —

Sea Temperature in the Gulf of Alaska and the Northeast Pacific Ocean, 1941–1952 — Robinson

The manuscript and completed drawings of this report are in the Director's hands for approval.

Most of this quarter has been spent transferring the isotherms from all previously published area studies of bathythermograph temperatures onto pilot charts of the Pacific Ocean. These charts will be used as a base for the temperature distribution of the entire Pacific Ocean, with new areas being added as they are completed. Because there is a change of scale in the redrawing of the isotherms, this is a time-consuming job. It is approximately one-fourth completed at present.

Descriptive Oceanography of Eastern Tropical Pacific — Wooster, Cromwell

A paper entitled "Oceanography of the eastern tropical pacific," by Wooster and Cromwell, was presented before the American Society of Limnology and Oceanography on 29 December 1954. the abstract of this paper follows:

The eastern tropical Pacific, although frequently crossed by merchant and military shipping, remains almost unknown oceanographically. Studies were made in the Gulf of Panama in 1933, and several major expeditions have passed through the area, usually in a direction parallel to the major currents. Not until 1952, on the University of California's Shellback Expedition was a systematic oceanographic survey made with sections of stations relatively perpendicular to the circulation. at the same time numerous stations were occupied by the U. S. Navy Electronics Laboratory and Pacific Oceanic Fishery Investigations.

The region is of particular interest because of the many problems it presents. the general level of productivity appears to be as high as that of other areas in higher latitudes, in contrast to the general concept of low productivity in tropical waters, and the fishery for yellowfin tuna located here is one of the richest of the world. Here the westward-flowing North and South Equatorial Currents are formed, while the Equatorial Countercurrent flowing towards the east reaches the

limit of its course. Below the surface, waters are marked by the lowest dissolved oxygen content found anywhere in the open oceans of the world.

A study is now being made of the oceanography of the area, using Shellback and other pertinent data. New concepts in the treatment of oceanographic data are being used in an attempt to portray the relation between the distributions of various properties. A sample section, from 30°N to 7°S, is presented in a discussion of the principal oceanographic features of the area.

— 9 —

A paper entitled "Water motion and nutrients in the central tropical Pacific," by Cromwell and T. S. Austin (of POFI), was presented on 30 December 1954 before a symposium entitled "Recent advances in biological oceanography" sponsored by the American Society of Limnology and Oceanography and the Ecological Society of America. the abstract of this paper follows:

The basic importance of water motion to marine life is emphasized and it is suggested that if the major currents and turbulent motion were to cease, all marine organisms would die. This dependence of marine life on the water motion is primarily indirect through the renewal of plant nutrients to the upper, lighted layer of the ocean by vertical motion.

A brief history is given of knowledge of the circulation and nutrient distribution in the central tropical Pacific Ocean. By the middle 1800's three major currents, the North and South Equatorial Currents flowing west and, between them, the Equatorial Countercurrent (at 5°–10°N) flowing east, had been described. Recently (1952) an expedition of the Pacific Oceanic Fishery Investigations of the U. S. Fish and Wildlife Service discovered the Equatorial Undercurrent, centered on the equator, flowing east beneath the west-flowing South Equatorial Current.

By the late 1800's it was known that nutrient-laden water "upwelled" from below within the South Equatorial Current and that in this way a large population of marine plants and small animals was maintained in a band along the equator. Recent fishing cruises have revealed that large tuna accumulate in this region.

Oceanographic theory explains that upwelling occurs along the equator because the west-flowing South Equatorial Current, impelled by the tradewinds, moves with a slight northward component in the northern hemisphere and a slight southward component in the southern hemisphere, owing to the influence of the earth's rotation. Thus, the surface current diverges from the equator and a compensatory upward motion of the nutrient-rich water below must develop.

Present investigations by the U. S. Fish and Wildlife Service and by the Scripps Institution of Oceanography in the central and eastern tropical Pacific Ocean are planned to gain new knowledge of the currents, chemistry, and biology.

— 10 —

Geochemical Research — Goldberg and Arrhenius

Chemistry

Zinc has been determined in 25 representative samples from the Pacific Sediment collection. A new method utilizing the X-ray spectrometer has been developed and applied. Zinc shows a similar distribution to copper with a range of 0.003 – 0.05 percent by weight.

An X-ray spectrometric method for the determination of barium and titanium in concentrations greater than 0.01 percent in pelagic clays and oozes has been developed. This method will be applied to studies on the rates of dissolution of calcareous accumulations.

Emission spectroscopic determinations of 28 elements in 400 samples reported in the last progress report are nearing conclusion.

With the cooperation of Dr. E. Picciotto of the Nuclear Institute of Brussels, the Th content of manganese nodules has been determined colorimetrically using the reagent "Thoron." the Th content of the Horizon nodules is 100 parts per million by weight. the methods developed will be used in the studies on the rates of accumulation of manganese nodules as well as of some sedimentary deposits already well-defined chemically and mineralogically.

The carbonate analyses of the East Pacific gravity cores from the Capricorn Expedition have been concluded and the results are being processed. the results will be published with those from the Acapulco Trench Expedition, which complement the Capricorn section through the Equatorial carbonate area.

The calcium content of bottom water and sediment interstitial water from the Capricorn collection has been determined using titration with EDTA. the values obtained differ less than two percent from the average calcium content of sea water.

A seagoing polarograph has been devised for use in the analysis of nitrate in sea water. the only remaining problem before placing the instrument in use is the filtering out of motor vibration which affects the curve of the novel electrode developed. A number of filters are being tested for this purpose.

Petrography

The radioactivity of the phillipsite has been further studied by nuclear emulsion techniques. the results confirm the thesis that the activity is largely bound to the zeolites and the activity of the phillipsite is most probably due to radium.

A comparative X-ray study of monoclinic and orthorhombic pyroxenes has been carried out in order to enable differentiation of andesitic and the Pacific basaltic pyroclastics in the pelagic clays.

The study of soluble silica in standard clay minerals has been concluded and corresponding investigations started on the Capricorn sediments.

Core material enabling stratigraphic control of the geochemistry and mineralogy of the east Pacific pelagic sediments was collected during the first leg of the Acapulco Trench Expedition. This material will also be used for checking the topographic control of the ratio lithogenous/hydrogenous deposition.

Professor Carl W. Correns visited this laboratory as well as other institutions doing geochemical work during the months of November and December. He was brought to this country as a consultant by ONR. While at this Institution he led a number of seminars and colloquia on subjects of interest to the sediment chemistry and mineralogy. A number of problems of mutual interest will be attacked by his laboratory in collaboration with SIO.

Acapulco Trench Expedition

An exploratory geological geophysical investigation, the Acapulco Trench Expedition, was carried out during the last quarter of 1954. R/V Spencer F. Baird sailed from San Diego 11 October and, after a fueling stop at Manzanillo, Mexico, rendezvoused with R/V Horizon 12 November near Maria Cleofa Island, Islas Tres Marias. the ships then worked more or less in company, putting into Acapulco, Mexico, and Puntarenas, Costa Rica, for supplies. After a brief stop at Clipperton Island the ships returned together to San Diego on 20 December. the track of the R/V Spencer F. Baird is shown on figure 3; the Baird steamed about 10,600 miles on the expedition. the Horizon proceeded from San Diego directly to Islas Tres Marias, thereafter closely followed the Baird track, and steamed a total of about 7,000 miles on the expedition.

One-half of the ship charges for the two-ship Acapulco Trench Expedition were allocated to Contract Nonr-233(04), one-half to Contract Nonr-233(05). Salaries of some of the personnel participating in the expedition were paid from other sources.

Special studies on the Acapulco Trench Expedition included detailed echo-sounding, seismic reflection and refraction profiles, bottom and water sampling, heat-flow measurements, measurements of the earth's magnetic field, and shipboard measurements of variation in atmospheric electricity (by Stanley Ruttenger of the Institute of Geophysics, UCLA).

Bathymetry

Throughout the expedition, while at sea, continuous bathymetric records were obtained aboard both vessels by modified EDO echo-sounders.

1. On Leg I, San Diego to Manzanillo, the Baird explored in detail four small areas ([I](#), [II](#), [III](#), [IV](#) on [Fig. 3](#)); the sounding lines have been adjusted and contoured plots of these deep areas prepared for use in interpreting the coring results.
2. Echo-sounding profiles, primarily by R/V Horizon, transverse to the Acapulco Trench, supplement and extend to the southeast the area explored by the U S. Navy Electronics Laboratory Shuttle Expedition (1952) and the SIO Toro Expedition (1953). the Acapulco Trench has now been sounded to reconnaissance detail by continuous-recording echo-sounders along its entire length, from Islas Tres Marias on the northwest 1500 miles southeast to the Cocos Island Ridge.
3. Lines were run by the Baird across the charted positions of Allaire Bank and Ville de Toulouse Rocks. No evidence of shoaling was found in either case. the Horizon explored the environs of Guardian Bank, off Costa Rica, again without finding evidence of shoaling.
4. An irregular ridge, trending between Clipperton Island and Roca Partida and with several sharp peaks shoaler than 1000 fm, was delineated. This ridge appears approximately parallel to the somewhat deeper, broader Albatross Plateau lying between this new range and the Mexican coast.
5. Both ships participated in a detailed bathymetric exploration around Clipperton Island, and a contoured plot was prepared, of immediate use in interpreting the magnetometer data. Clipperton Rock was sampled and mollusks and corals collected on the beach.
6. the Spencer F. Baird ran a series of lines around Roca Partida, in the Revillagigedo Group. One large sample was broken off the rock; it appears to be a porphyritic gabbro (?) high in augite and calcic plagioclase. Roca Partida is probably the core of an old volcano, left as a remnant while the surrounding softer material was eroded by the sea. the steep-sided rock is surrounded to a distance of about 1000 yd by a nearly level platform at about 40 fm.

Seismic Reflection and Refraction Studies

The seismic program, under the general direction of R. W. Raitt and G. G. Shor, was separated into three phases. On phase (1), San Diego to Manzanillo, reflection studies were made while the ship was on coring stations. Refraction and reflection studies were made on phase (2),

— 13 —

Manzanillo to Puntarenas, and phase (3), Puntarenas to San Diego. the refraction station locations are shown on figure 3. On phase (1) a single ship, the R/V Spencer F. Baird, served as firing and receiving vessel. On phases (2) and (3) the R/V Horizon was the firing ship and the Baird was the receiving ship.

Equipment was, in general, the same as used on previous cruises except for the addition of a new model of hydrophone and minor variations in the cable system. The new hydrophones were laboratory-built, with barium titanate receptors, and with preamplifier and batteries carried in the case. Advantages obtained include a lighter-weight cable, less cable drag, and elimination of any noise caused by ground loops and stretching of power-carrying wires in the cables. The lighter (two-conductor) cables permitted the pulling by hand of very long multiple-hydrophone arrays.

Generally there were systematic differences in noise levels between individual hydrophones, and the quietest single hydrophone was usually superior to the others. Nevertheless, use of several hydrophones gave definite advantages in the detection of weak signals over the generally uncorrelatable background. Systematic differences, if any, between the two types of hydrophones were masked by the individual differences within the same class.

Reflection Studies

Reflection shooting was done during the first leg of the trip while cores were being taken for the Eupelagic Area sedimentation studies.

The objectives of the reflection studies of phase (1) were: to test equipment prior to the major work in the trench area, to study variation in thickness of the bottom sediments in an area where rapid lateral facies changes were to be expected, and to attempt to obtain reliable reflection data from horizons below the base of the sediments.

Seventy one-half-pound reflection shots were taken at 35 coring stations. Of these, fifty records show sub-bottom reflections recognizable on amplitude alone. On many of the records the sub-bottom reflections were extremely strong. Shot depth and size were such as to produce 15 cps bubble pulse frequency; sub-bottom echoes contained energy predominantly in the 15–30 cps range but with some energy as high as 100 cps. On all stations except the northernmost and southernmost the sub-bottom echo followed the bottom echo by 0.19 to 0.40 sec. Variations from the mean of 0.29 sec within the central group of stations did not appear strongly related to position, topography, or bottom depth although further detailed study is needed to determine correlation. At the northernmost stations intervals of 0.13 to 0.18 sec were found; at the southernmost station four shots of five on a drift track of 5 miles gave time intervals of 0.47 to 0.54 sec, possibly indicative of an increase of total sediment thickness because of the higher rate of calcareous deposition near the equator.

— 14 —

Assuming a value of 2–12 km/sec for the sound velocity in the sediments, one obtains sediment thicknesses of 250 to 480 m on the central group of stations; at the southernmost station the thickness is about 640 m and at the northernmost about 200 m. Deeper reflections were not consistently strong, but some possible deep reflections were recorded.

Refraction Studies

On the second section of the trip 666 shots were fired during 10 shooting days on seven refraction lines. Station B-I was in the Tres Marias Basin; Stations B-II, B-III, B-V, and B-VII were in the trench; Station B-IV was on the continental shelf, and Station B-VI on the rise seaward of the trench. at Stations B-I, B-IV, and B-V reversed profiles were recorded. the others were standard "split" profiles, consisting of two profiles about 50 miles long at a single receiving position. Rough shipboard plots indicated that normal upper mantle velocity of 8 km/sec was reached on all lines. A greater thickness of the crust in the trench than at typical oceanic stations was found at Station B-VII; the thickening is smaller or absent at the more northern stations. Line B-IV, shot along the edge of the continental shelf, was unusual in comparison with normal continental lines. the crustal thickness under this line (off the Pacific coast of Guatemala) was approximately 15 km, in comparison with normal values of about 6 km in the Pacific Basin and 32 km on the continents.

On the third phase of the expedition 752 shots were fired on nine shooting days at eight refraction stations. Stations B-VIII, B-IX, B-X, and B-XI were deep-water stations between Puntarenas and Clipperton Island. Station B-XII was in shallow water on the southwest flank of Clipperton Island. Stations B-XIII, B-XIV, and B-XV were in deep water between Clipperton Island and San Diego. Reversed profiles were recorded at Stations B-XI and B-XII. at all other stations split profiles of about 50 miles' length were recorded from single receiving positions.

With the exception of Station B-XII, where only short profiles were recorded in order to measure the upper velocities of Clipperton Island, rough shipboard travel-time plots indicated that maximum velocities of the order of 8 km/sec or more were reached at all stations at the outer ends of the profiles. Travel times, corrected roughly for water depth, did not differ strikingly from observations elsewhere in the eastern Pacific Basin, even though the sea depth is significantly less. Two of the stations, B-X and B-XI, are at depths of the order of only 1600 fm. These observations support previous conclusions that there is not a simple correlation between sea depth and the depth of 8 km/sec velocity.

Bottom and Water Sampling

On Leg I, sampling studies under the general direction of Gustaf Arrhenius were made in an area which previous investigation had indicated might provide suitable material for the study of these problems:

- (a) the nature of the marked north equatorial facies boundary between bioliths and clays, and the displacement of the boundary with geological time.
- (b) the details of the Upper Pleistocene stratigraphy, presumably reflecting hydrographic changes.
- (c) Topographic control of deposition.

(d) Mechanism of transfer of solid and dissolved matter from the ocean to the sediment, including radioelements.

(e) Variation in space and time of rate of accumulation of sedimentary components.

A total of 40 gravity cores were collected from stations in a meridional profile at approximately 125°W, extending from 3.5°N to 19°N (see Fig. 3). In the facies transition zone, cores were spaced as closely as ten nautical miles. Three detailed topographic-coring studies were made (I, II, III on Fig. 3), and contoured bathymetric charts of these areas were completed. Successful attempts were made to sample Tertiary sediments outcropping on topographic highs, or covered by abnormally thin Pleistocene and Recent deposits. Fossil and Recent manganese crusts and nodules were encountered in several cases.

In addition to core-sampling, the following tasks were carried out:

(a) Sampling of organically uncontaminated calcareous ooze for the investigation, led by E. D. Goldberg, of the chemical structure of organic compounds in pelagic deposits.

(b) Sampling of inorganic solids suspended in sea water far from land.

(c) Sampling of chlorophyll and particulate iron in a 200-meter-deep profile through the ridge of deep water extending into the euphotic zone at 8–10°N. In spite of the fact that both energy and nutrient sources are available for assimilation, no effect of increased productivity similar to the one found below the Equatorial Divergence is found in the bottom sediments below this zone. Suggested explanations include lack of particulate iron caused by the absence of upwelling, or poisoning of ordinary fossil-producing organisms by dinoflagellates.

— 16 —

(d) Testing of the van Veen grab-sampler in great depths. Lowering and release of the apparatus gave satisfactory results, but torque in the wire and consequent spinning of the sampler made the jaws of the apparatus open up and the sample was lost. Attachment of a swivel above the sampler, or attachment of lead pigs to the jaws is suggested.

On the second and third legs, Manzanillo to San Diego, piston and/or gravity cores were taken aboard the Spencer F. Baird at each seismic receiving station except B–XII and B–XV (see Fig. 3). In addition, a four-core profile normal to the coast off Champerico, Guatemala, was carried out (these are not shown in figure 3). Heat conductivity measurements on most of these cores were made immediately. Each core was logged as packed aboard ship, but laboratory examination ashore has not been completed.

Cores from Stations B–I, B–II, B–III, B–V, and B–V', and B–VI consist of soft green mud, with no layering apparent. The four gravity cores of the Champerico profile, from depths of 105, 205, 400, and 825 fm, consist of coarse green mud and shell fragments, with a higher fine blue-mud

content at the deep end of the profile. Cores from B–VII are short segments of stiff blue-green mud overlain by coarse sand and volcanic (?) rock fragments.

All cores from Stations B–VIII to B–XIV consist of predominantly fine-grained brown to reddish brown mud. Several contain dark specks, probably of manganese oxide, and the short core from B–XI is layered, from foraminiferal red clay on the surface (0–10") to a mottled white clay (ash?) layer (10–12") to a pale brown clay at a depth in the core of 12–55 in.

The hydrographic program on the Acapulco Trench Expedition was carried out by Miles M. Payne.

(a) Three underway bathythermograph profiles (BT's at 25- to 30-mile intervals) were completed:

(1) from Guadalupe Island to 4°N, 125°W.

(2) from about 8°N, 127°W to Manzanillo.

(3) from Clipperton Atoll to Alijos Rocks, off Baja California.

During the latter portion of the third profile two BT's tightly lashed together were lowered each time as a means of checking and correlating the responses of the two styli.

(b) Double hydrographic casts were made at each of the 13 deep-water seismic receiving stations. Vertical density distribution must be known to calculate accurately sound velocities used in the seismic observations, and therefore special effort was made to secure water samples near the bottom. On these casts the average computed distance from the lowest bottle to the bottom was 120 m. the positive temperature gradient with increasing depth due apparently to adiabatic compression was displayed in the measurements obtained near the bottom of the Acapulco Trench. This change appeared most notably on the deepest cast, to a depth of about 6000 m, where the increase as indicated by the raw data was of the order of 0.5°C.

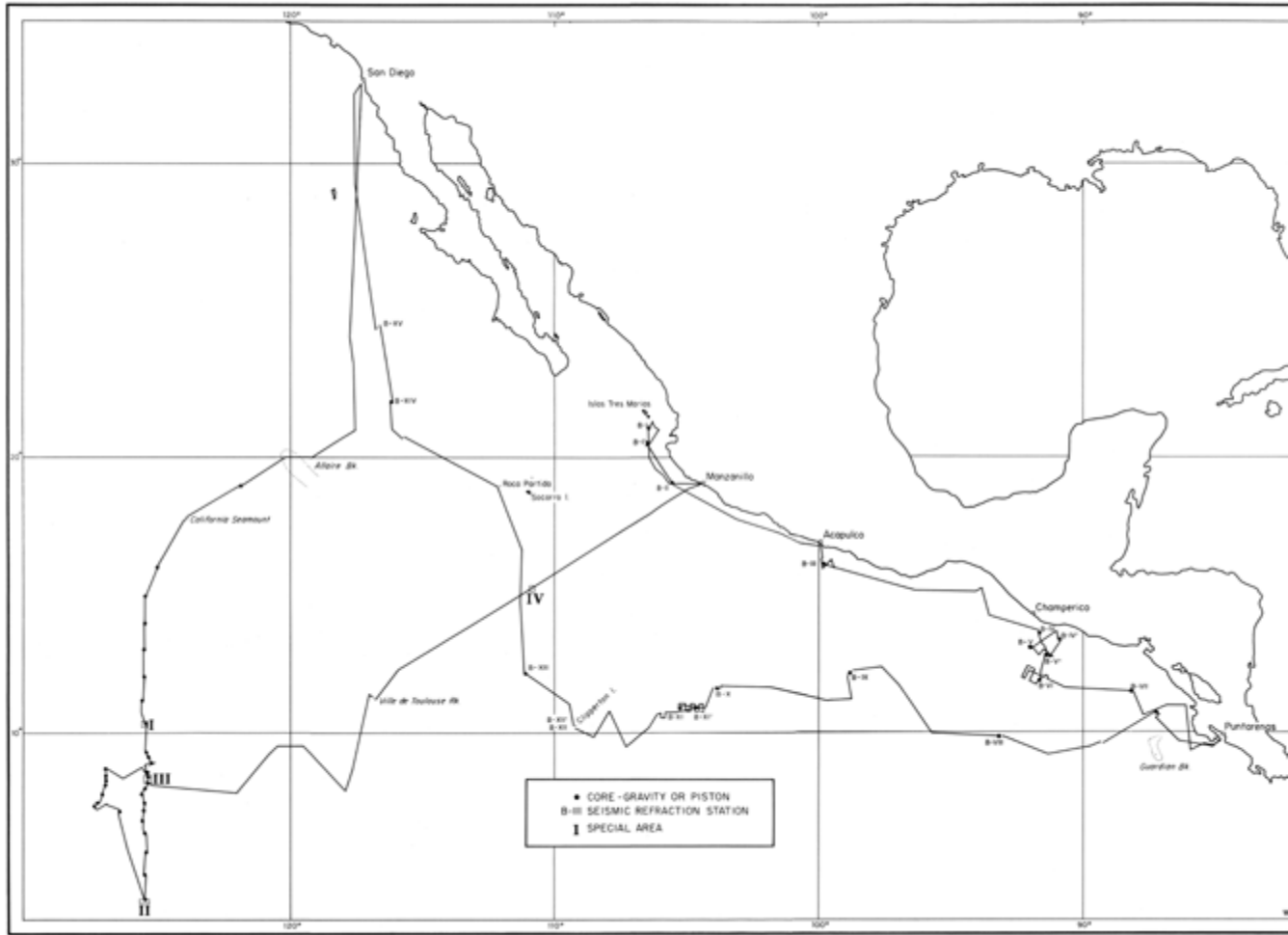


FIGURE 3.

Figure 3.

Heat-Flow Studies — Maxwell

The Division of Special Developments designed and constructed a new instrument to measure the thermal gradient in the sediments.

The instrument was constructed along lines similar to previous equipment, using the experience gained from that equipment to make major improvements. The new instrument worked very satisfactorily after minor difficulties of high-pressure leaks were remedied. Nine successful heat-flow measurements were made during the Acapulco Trench cruise—one value being obtained near the deepest part of the trench. This brings the total number of heat-flow measurements, which extend over a wide area of the Pacific, to 24.

The Acapulco values lie primarily on a line normal to shore, crossing the trench and extending out to sea. A cursory examination of the records shows the heat flow to have a value of only one-

half the average deep-sea value in the trench and to increase proceeding to seaward. They reach a maximum in the vicinity of the Albatross Rise, attaining a value some three times the average. This concurs with earlier results measured on the Albatross Rise some 1500 miles to the south during the Capricorn Expedition of 1952–53. Measurements to the west, or seaward, of the Albatross Rise return to the average value of approximately $1.2 \text{ microcalories cm}^{-2}/\text{sec}^{-1}$ which is also the average continental heat flow.

The significance of these measurements arises in the variation of the heat flow. the variation suggests that the vicinity of high heat flow may be a region of rising convective motions in the earth's mantle, whereas the low heat-flow values would represent the region in which the material has cooled and is sinking.

Magnetic Field Measurements at Sea — Mason

The total-field magnetometer of the fluxgate type which has been under construction for the past year was completed in time for the second leg of the Acapulco Trench Expedition and was operated over 5500 miles of track. This instrument is based upon the AN/ASQ-3 MAD, but is considerably more stable and may be operated for long periods away from a base station. Preliminary measurements indicate that it is capable of measuring the earth's magnetic field to within better than ± 50 gammas. (The value of the earth's field at La Jolla is about 50,000 gammas.)

Close contact has been maintained with Varian Associates of Palo Alto who are developing a magnetometer in which hydrogen atoms of water are made to precess round the earth's magnetic field. the precession frequency is then measured and is proportional to the field, which is thus measured to the same degree of accuracy as the frequency. An absolute accuracy of better than one gamma is easily attainable. the instrument is particularly interesting because of the simplicity of the towed unit and the precision and absolute nature of the reading. It is hoped that a Varian instrument will shortly be available for field tests.

Pelagic Area Studies

Zooplankton — Bieri

At the present time the basic analyses of the chaetognath and euphausiid populations present in the PAS area in May and June 1954 have been completed. Standard statistical tests as well as graphic analyses have been applied to some of this basic data, and we plan to expand this phase of the work in the near future. It is thought that very detailed analyses of these two groups, one representing carnivorous zooplankton and the other herbivorous zooplankton, will serve as models for the work to be carried out on the other zooplankton groups (for instance, the coelenterates, mollusks, tunicates, decapods, copepods, ostracods, and other crustaceans). at the

same time such analyses should: 1) point out deficiencies in present sampling methods; 2) indicate the lines of most profitable research, that is, indicate statistical tests particularly applicable to the material at hand and the smallest combination of samples that will give reliable results; and 3) lead to a better understanding of changes in concentration and size frequency in the zooplankton populations found in the PAS region.

In order to approach the relation between fluctuations in one animal group and fluctuations in another animal group, it is necessary to know the nutritional relationships of the various groups both qualitatively and quantitatively. the qualitative aspects have long been studied but much remains to be done. in this respect the food of the various species is being studied. the quantitative aspects have been little studied. Some analyses of wet, dry, and ash weights of various species have been made in a beginning approach to the quantitative study of nutritional relationships. It is hoped this can be expanded in the future.

Study of Oceanic Slicks — Kittredge

The hydrophyll balance ordered in May was received during this quarter. It is now being standardized and work will soon proceed in measuring the molecular film pressure.

— 19 —

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