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GEOLOGY OF THE CONTINENTAL SLOPE OFF CENTRAL CALIFORNIA

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Introduction

During the summer of 1949 arrangements were made by the Office of Naval Research and the California Academy of Sciences to undertake an exploration from a geological standpoint of the sea bottom off the coast of central California. The project took the form of a contract, No. N9 onr 94400. The net tender, U. S. S. *Mulberry,* Lieutenant James Birtch commanding, was assigned to the work, which was expected to continue for one year. The program provided for at least one week of each month to be spent at sea, a total of 12 weeks. Through urgent need for the *Mulberry* elsewhere, only 24 days were employed in actual exploration. Nevertheless a very considerable amount of material was collected and the present report covers the geological results. Much animal life was obtained incidental to the primary purpose of the exploration and this is expected to be considered in separate reports by various specialists.

Acknowledgments

The officials of the Office of Naval Research were most cooperative throughout the project. For handling the innumerable details we wish to thank especially Messrs. G. F. W. Mulders and J. E. Laurance.

The staff members of the Academy, Dr. R. C. Miller, Mr. W. I. Follett, Dr. Earl Herald, Mr. Robert P. Dempster, Dr. L. G. Hertlein, Mr. J. R.

Slevin, Mr. C. C. Church, Mr. F. L. Rogers, and many others have given advice and help most generously. Mr. Delbert Goodwin took care of records and cataloging of specimens for permanent preservation in a most creditable manner.

Mr. Charles Chesterman of the State Division of Mines undertook the difficult task of accurately identifying the rock specimens collected. His report follows this one.

To all of these the present writer is deeply grateful. Special appreciation is due Lieutenant James Birtch, the other officers, and the crew of the *Mulberry*. In handling the ship and equipping it for this special duty, their enthusiasm and energy were unbounded.

There have been many occasions in the past when close cooperation of the activities of the Academy and various governmental organizations has been most beneficial. In the present instance it is a pleasure to record the assistance given by the U. S. Coast and Geodetic Survey. Through Captain (now Admiral) R. F. A. Studds much information was obtained regarding the offshore topography, and especially, details pertaining to the discovery and survey of the seamounts. Photostatic copies of the original field sheets were supplied to us; they contain the records of many hundreds of depth readings which do not appear on the published sailing charts.

Thanks are also due the U. S. Coast Guard. Commander Henry F. Stolfi of that service made it possible for Mr. Allyn Smith and me to spend a week on the Farallon Islands in June, 1949. This visit was made primarily to secure information regarding the geology of these offshore islands for use in connection with the investigation of the bottom rocks if and when this should be undertaken. Dr. Olaf P. Jenkins of the California State Division of Mines and Mr. M. Vonsen assisted materially in evaluating the results of that investigation.

Finally, the interest which the California Division of Fish and Game has maintained in this work has been invaluable. Details appear later in this report but here it should be stated that during September and October, 1950, it was my privilege to accompany the motor vessel, *N. B. Scofield,* on a trip as far north as Eureka. Arrangements were made through Mr. Richard Croker, chief of the Bureau of Marine Fisheries, and the field work was in charge of Mr. William Ellis Ripley, Mr. Julius B. Phillips, and Mr. Keith W. Cox. Much bottom trawling was done and special efforts were made on many occasions to secure material for the Office of Naval Research Project. The results of this investigation are incorporated in the present report, insofar as they have a bearing on the offshore geology. A preliminary account of this work, supplied by Mr. Ripley but unsigned by him, appeared in Pan-American Fisherman, Vol. 5, No. 6, Dec. 1950, p. 14.

PREVIOUS WORK IN SAME AREA

The Coast and Geodetic Survey came to California soon after the area became a part of the United States and immediately began investigations of offshore waters and bottom conditions. This work was carried on primarily for furnishing aid to mariners and has resulted in continuously improved sailing charts. Many thousands of soundings were made which, until recently, consisted of letting a weight to bottom on a measured line. This gear often brought up samples the nature of which was recorded on the charts in the form of letters or symbols. The later work has been done with sonic equipment, which gives a much more detailed topographic map of the bottom and is much more economical in operation, but gives little if any indication as to the nature of the bottom. The sailing charts used in connection with the present investigation were as follows, listed in order, from Point Sur north to Cape Blanco, Oregon:

1. 5402. Point Sur to San Francisco
2. 5502. San Francisco to Point Arena
3. 5602. Point Arena to Trinidad Head
4. 5702. Trinidad Head to Cape Blanco

At least two surveys were made across the Pacific from California to Hawaii for a submarine cable route. One was by the *Tuscarora* in 1874. The next was by the U. S. S. *Albatross* in 1891–92 (Tanner, 1894, pp. 12–23; Anonymous, 1892). This line extended on the great circle from Moss Landing in Monterey Bay to Oahu. On return a rhumb line was run to the southward. In both surveys many soundings were made and bottom samples were recovered and briefly described.

The U. S. S. *Albatross* also made a biological survey of Monterey Bay in 1904 during the course of which 128 stations were occupied. Details of this work are given by the U. S. Bureau of Fisheries (1906, pp. 1–43). Three stations, D. 4565, D. 4566, and H. 8404, were occupied outside the Golden Gate and 9 miles south of Southeast Farallon Island in 22 and 495–587 fathoms. The bottom was gray sand in the shallow haul and blue and green mud with rock in the deep ones.

In 1912 and 1913 a more detailed survey was made of San Francisco Bay and a few stations were occupied off the Golden Gate. Several publications have appeared on this work. The details of stations occupied are given by the U. S. Bureau of Fisheries (1921, pp. 20–80). Eight stations were occupied outside the Golden Gate in water less than 100 fathoms in depth and in all of which the bottom was reported to be sand. Packard (1918) has described the mollusks obtained. In the same serial the physical conditions are described by Sumner, Louderback, Schmitt, and Johnston (1914).

While the *Albatross* was engaged in survey work primarily concerned with the fisheries of the Pacific, a great deal of time was spent in California or adjacent waters. Dredging, trawling, and sounding were conducted for many years and a wealth of information was secured. Bottom conditions were recorded briefly and in some cases samples were preserved. The disposition of these samples has not been traced.

Many thousands of stations were occupied by the *Albatross* up to 1920. The places where the lists are published are given in detail by MacDonald (1921, pp. 20–21).

The work outlined above has resulted in the accumulation of much valuable information; it is of a generalized nature, however, from a geologic standpoint. So far as I have found none of the samples of bottom collected were examined or reported upon by geologists and most of them almost certainly have been lost.

A long series of submarine geological investigations have been made during recent years in waters off southern California and to the southward under the guidance and inspiration of Dr. F. P. Shepard of the Scripps Institution of Oceanography, La Jolla, California. This work, conducted by highly trained personnel with adequate gear has set new standards and opened up new fields of exploration which have application and implication in many lines of endeavor. A long series of publications have resulted. They are adequately listed and reviewed in two recent documents on submarine geology (Shepard and Emery, 1941, and Shepard, 1948).

While the work just mentioned is of utmost importance, most of the exploration for it was conducted south of Point Conception. The paucity of information pertaining to the offshore geology of northern California had definite bearing upon the schedule outlined for the present undertaking. A very useful reference work on submarine geology was published by Geyer (1948).

I became interested in this subject in 1940 when I was permitted to accompany an expedition along the northern California coast by the California Division of Fish and Game. The vessel used was the *N. B. Scofield.* The objective was primarily the investigation of bottom fishes but light dredges were attached to the trawl to secure bottom samples. Many specimens of rocks were obtained and have been preserved by the California Academy of Sciences. The most interesting perhaps was granodiorite in about 30 fathoms on Cordell Bank west of Point Reyes. In following up this investigation it was learned that there were practically no reliable records concerning the geology of the substratum off northern California.

The literature gave no conclusive answer as to the nature of the rocks on the Farallon Islands themselves. No geologist had apparently ever visited them and records based upon observations by botanists and ornithologists were in conflict.

Resumption of the work was delayed until May, 1948, when arrangements were made with the U. S. Coast Guard Service to spend one week on Southeast Farallon Island in company with Mr. Allyn G. Smith. This is the island upon which the lighthouse establishment is located. Every accessible part of the island was visited and many samples of the rocks were collected. A special report upon the island was prepared for the California State Division of Mines (Hanna, 1951).

It was found that the southeast island with outlying rocks is composed of a highly jointed and fractured granodiorite, very uniform in composition throughout. No dikes of accessory minerals were observed and inclusions are exceedingly rare. This is in marked contrast to the nature of nearest exposures of similar rocks on the mainland, namely Point Montara and Point Reyes. The surface on the island is deeply weathered and shore lines are marked by abrupt cliffs, sea-cut caves, and surge channels. Remnants of at least three elevated terraces are present, the most obvious one being about 50 feet above present sea level. It is possible that the entire island, now 340 feet high was once submerged. Scattered at random all over the surface there are rounded pebbles of foreign rock, mostly jaspers similar to those derived from the Franciscan chert of the mainland. These pebbles vary in size up to four inches in diameter. No thoroughly satisfactory explanation of their presence has been suggested. Possibly one of the following may be the correct one:

1. These pebbles may be remnants of a conglomerate which once covered the island but is now, as such, completely eroded away. In support of this theory there may be cited the presence of a conglomerate containing similar pebbles on the flanks of Cordell Bank to the northward. Abundant evidence of this was obtained in the present investigation. This theory may involve complete submergence of the island.

2. The island was once occupied by a very large colony of fur seals and possibly sea lions. These animals swallow rounded pebbles consistently and often regurgitate them when they go ashore. This is well known to all who have had experience on fur seal rookeries. The pebbles on the Farallon island are usually of about the size such animals would choose.

3. The island has been occupied more or less continuously since about 1800 by man. In connection with some of the modern installations, rock, sand, and cement have been used extensively and nearly all of this has been transported from the mainland. Such operations, however, do not account for the presence of the pebbles in the more distant and inaccessible parts of the island. Early occupants, the fur seal hunters and the egg gatherers, would almost certainly not carry pebbles to such a barren rock as Southeast Farallon and scatter them over the surface.

4. The island is still occupied by a great many sea birds but it is not known that any of the numerous species found there ever carry pebbles from one place to another.

SCOPE OF WORK AND GEOLOGICAL RESULTS

In the original outline of the project it was planned to run cross sections from the 100 fathom curve out to oceanic depths at four places along the central California coast: outwardly from Point Montara across the Guide and Pioneer seamounts; outwardly from Point Bonita past the south end of Farallon Island; and due west from Point Reyes across Cordell Bank. If time permitted similar sections would be run to the northward. As it worked out this schedule could not be followed closely for various reasons and the detail of the ship elsewhere cut the work short.

It took some time to devise the best sort of gear for the task and to learn how to use it. The vicinity of Cordell Bank was believed to be the best location for this experimental study. It offers suitable anchorage at night in good weather and in case of trouble Drakes Bay is close at hand for shelter. Therefore, more details were secured in the vicinity of that bank than elsewhere.

It was found that the top is composed of jagged granodiorite rocks, essentially like those exposed in air on Southeast Farallon Island. The minimum depth is 28 fathoms. The bottom slopes gently to the eastward toward Point Reyes to 70 fathoms, a dredge haul made in 1940 indicating that the bottom in the trough is mud. On the east flank of the bank we obtained large quantities of pebbles and boulders, obviously weathered out of a conglomerate. The rocks consisted of many types foreign to any outcrop now existing on the mainland. It is significant to note that a very extensive conglomerate outcrops at present on the north end of Point Reyes promontory and that this rests on granodiorite also. A comparison of the pebbles we dredged with those of Point Reyes would be instructive.

To the west of Cordell Bank the continental slope is exceedingly steep and descends to oceanic depths in a few miles. We found granitic rocks down to 74 fathoms and lost a dredge in 200–400 fathoms. Green mud was found at 1140–1500 fathoms and again at 2000 fathoms.

On the northwest flank of the bank, however, an excellent dredge haul was made in 400–200 fathoms (Sta. 56) and about 500 pounds of rocks was obtained; these appear to be predominantly phosphate.[1]

1. Dr. Durham of the Museum of Paleontology, University of California, has lately received a piece of hard sandstone which was brought up by a fisherman from Cordell Bank. This rock contains several well preserved specimens of *Thyasira disjuncta* Gabb, and furnishes the first definite evidence of the age of the strata which are closely associated with the granitic rocks of this bank. This fossil is found commonly in Miocene rocks of the west coastal areas.

While our main problem was not the investigation of submarine canyons and we had no intention of discussing them in any way, we found it convenient to make a dredge haul in Bodega Canyon which lies a short distance to the north of Cordell Bank. A position was chosen as nearly in the trough as possible (Sta. 8) in 123–112 fathoms. A large quantity of green mud unaccompanied by rocks was obtained.

Southeast Farallon Island, Middle Farallon, the group of rocks known as North Farallon, and the submerged banks called Noonday Rock, Fanny Shoals, and Cordell Bank, lie on a northwest–southeast line, parallel to the major topographic features of the California coastal region. The discovery that the northern and southern limits were granitic at once raised the question as to the possibility of there being outcrops of similar rocks between the various highs. Several dredge hauls were made to determine this point but in no case did they disclose information which would lead to the belief that such is the case. Some evidence of loose gravel and boulders was obtained but we did not encounter what we could identify as rock in place in any of the attempts. Additional investigation of this feature would be worthwhile.

In this connection an attempt was made to land on one of the North Farallon rocks but this could not be done in safety. At close range from the row boat the rocks appeared to be massive granodiorite. There is a little vegetation on one of them. They are large bird rookeries and a considerable number of sea lions haul out on them.

Immediately to the westward, that is on the continental slope outside of the Farallon Ridge and immediately to the southward, several dredge hauls yielded only sedimentary rocks in place. Excellent Miocene shales and cherts were obtained. The shales contained well-preserved assemblages of foraminifera and diatoms and these rocks extend down to 1150 fathoms (Sta. 62). There was no evidence that these had tumbled down the slope from a higher level; in fact many of the shales were too friable to withstand transport at all.

Farther south on the slope some shales had the appearance of Pliocene outcrops along the coastal shores but the fossils contained in them have not been accurately determined. At one place (Sta. 45) near the head of Pioneer Sea Valley about 200 pounds of dense phosphatic rock was obtained. Some light-colored shale-like material of unknown origin was with it.

When the U. S. Coast and Geodetic Survey announced the discovery of some high submarine mountains about 75 miles southwest of the Golden Gate a few years ago there was considerable comment in the newspapers about them. From a geological standpoint it was important to learn if the rocks found on them were related to those of adjacent continental areas or possibly to submerged land masses to the westward. In any case they do not line up with known topographic features. Some of the strata of the Coast Ranges

of California as young as early Tertiary (San Onofre breccia for instance) contain detrital material which can be traced to no known outcrops. This has caused some to assume that at one time there was land of continental proportions west of what is now California, and from which eastward flowing streams brought these sediments. If these seamounts be remnants of such a land mass corroborative evidence would be at hand. Therefore we made

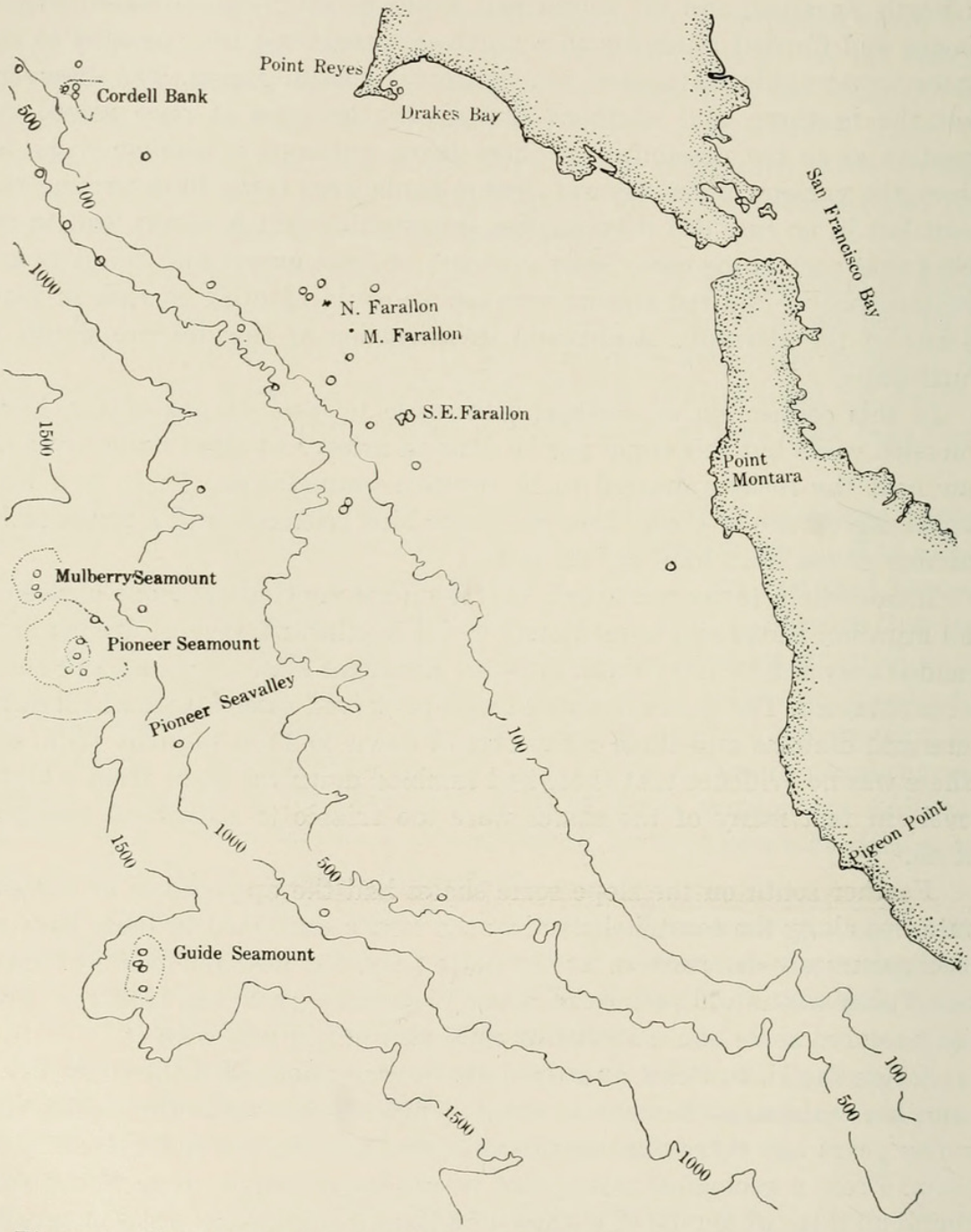

Figure 1. Sketch map of the area off central California where most of the dredging was done. Circles indicate some of the stations. Contour interval, 500 fathoms outside of the 100 fathom line.

numerous dredge hauls on the sides and tops of the mounts and actually anchored one night on one of them in 900 fathoms.

There are really three of these seamounts: Guide to the southward, Pioneer to the northward, and a smaller one which we called "Mulberry" immediately to the north of it. On the Guide we obtained only mud in the dredge; if rock outcrops be present (and they probably are) we failed to locate them. On Pioneer several hundred pounds of basaltic material was dredged. Much of this is altered somewhat, especially in the outer layers. It contains titaniferous augite and in this respect is unlike the volcanic material found in the adjacent coastal mountain ranges. Some large blocks of the material seem to be altered completely or almost completely to phosphatic minerals. This high alteration was not present in the rocks dredged on "Mulberry" Seamount. In fact most of them have a very "fresh" appearance and many are so vesicular that they are scoriaceous. No phosphatic alteration was noticed in hand specimens.

On Pioneer Seamount there were very few living organisms. Large numbers of huge siliceous sponges were obtained but none were living. No adequate explanation of this condition was available; it may simply have been the result of accidental location of the dredge hauls. On "Mulberry" Seamount, on the contrary, every haul yielded a considerable number of living animals, attached to the rocks and otherwise.

It had been hoped that this work might be extended to the northward off Mendocino and Humboldt counties but before it could be undertaken the field work was suspended. However, an opportunity was presented to secure a limited amount of material when the California Division of Fish and Game sent its vessel, the *N. B. Scofield,* to that area in the fall of 1950. The primary objective was the investigation of bottom living fishes with trawls. Since many specimens of biological interest are inevitably obtained in such work, the stations of this trip are included in the tabulation herewith. A haul was made with the dredge in Mattole Canyon off Punta Gorda and it was hoped that material would be secured which would give a clue as to the nature of the great seacliff which extends westward for more than 100 miles offshore. The recovery, however, consisted almost entirely of well-rounded pebbles of sedimentary rocks such as are found on nearby shores in the Cretaceous.

The trawling work off Eureka bar produced numerous pieces of Wildcat (Pliocene) formation and fortunately some of these contained diagnostic megafossils. This formation covers an extensive area in the Eureka district and the present work shows that it extends out to sea at least 30 miles and to the depth of 80-120 fathoms.

Along commercial shipping lanes it is not unusual to dredge up cinders, bottles, cans, and debris of many kinds. Most of this can be readily identified and explained. However, the presence of occasional well-rounded pebbles or boulders generally distributed, even out where the bottom is sand or mud,

COLLECTING STATIONS

Station No.	Haul No.	Date	General Locality	Position N. Lat.	W. Long
1	1	8/23/49	10½ miles west of Point Reyes light	38°–00′	123°–14.7′
1	2	8/23/49	10½ miles west of Point Reyes light	38°–00′	123°–14.7′
1	3	8/23/49	10½ miles west of Point Reyes light	38°–00′	123°–14.7′
2		8/23/49	East side of Cordell Bank; 16¾ miles west of Point Reyes light	38°–00′	123°–22.4′
3		8/23/49	Cordell Bank	37°–59.7′	123°–25.2′
4		8/23/49	Cordell Bank	38°–00′	123°–30.8′
5	1	8/23/49	Cordell Bank bears 180°T., 3½ miles distance	38°–07.5′	123°–26.5′
5	2	8/23/49	Cordell Bank bears 180°T., 3½ miles distance	38°–07.5′	123°–26.5′
6		8/24/49	Cordell Bank bears 90°T., 30 miles distance	38°–00′	124°–04.5′
7	1	8/24/49	Northwest side of Cordell Bank	38°–03.3′	123°–31.2′
7	2	8/24/49	Northwest side of Cordell Bank	38°–03.3′	123°–31.2′
8		8/24/49	Northeast side of Cordell Bank	38°–07.5′	123°–23.6′
9	1	8/24/49	Cordell Bank	38°–02′	123°–24.8′
9	2	8/24/49	Cordell Bank	38°–02′	123°–24.8′
10		8/25/49	Cordell Bank	38°–02.2′	123°–24.8′
11	1	8/25/49	Southwest of Cordell Bank	37°–59.2′	123°–27.0′
11	2	8/25/49	Southwest of Cordell Bank	37°–59.2′	123°–27.0′
12		8/25/49	Cordell Bank bears 14°T., 3¾ miles distance	37°–54′	123°–25.7′
13	1	8/25/49	Northeast of North Farallon	37°–47′	123°–04.6′
13	2	8/25/49	Northeast of North Farallon	37°–47′	123°–04.6′
14		8/26/49	Southeast Farallon light bears 103°T., 9.2 miles distance	37°–43.8′	123°–11.3′
15	1	9/26/49	Cordell Bank	38°–00′–30″	123°–25′–15″
15	2	9/27/49	Cordell Bank	38°–00′–30″	123°–25′–15″
16		9/27/49	Cordell Bank bears 86°T., 31 miles distance	38°–00′–40″	124°–07′–00″
17	1	9/27/49	Cordell Bank	38°–02′–30″	123°–26′–30″
17	2	9/28/49	Cordell Bank	38°–02′–30″	123°–26′–30″
18		9/28/49	Cordell Bank bears 100°T., 8.4 miles distance	38°–02′–30″	123°–36′–15″

* Dredge time is considered as bottom time only.
Double line across chart indicates new trip to location.

COLLECTING STATIONS—(Data continued)

Depth in Fathoms	Duration of Haul*	Net Type	Bottom and Content
60	0700–0715	Rectangular dredge	Dredge lost
60	0740–0745	Round dredge	
60	0910–0930	4′x5′ trawl	
57–50	1015–1035	Round dredge	Much rock; 2 small flatfish
34	1200–1500	Handline	14 rockfish
400–200	1515–1630	Round dredge	Dredge contents lost
35	1645–1800	Handline	24 rockfish
Surface	1900–2200	Night light	Few sauries
—	0900–1100	Observation	Searching for albacore
124–90	1300–1345	Round dredge	1 agonid
90–80	1400–1410	4′x5′ trawl	Net ripped; frame O. K.
123–112	1600–1630	Round dredge	Green mud; small shrimps
28	1635–1830	Handlines	18 rockfish
Surface	1800–2200	Night light	Sauries only
34	0800–0810	Round dredge	Rocks
74	0845–0900	Round dredge	Solid granite
74	0915–1930	Round dredge	Green mud
218–100	1100–1130	Round dredge	Conglomerate and mud
42	1530–1900	Handlines	Many flatfish, 1 lingcod
Surface	1900–2100	Night light	Sauries only
126–70	0905–0930	Round dredge	Sterile green mud
Surface	1930–2200	Dip nets, night light	48 sauries
34	0600–0730	Hook and line	Rockfish
2000	1028–1650	Rectangular dredge	Green mud; 1 tunicate
Surface	1930–2300	Trap and night light	127 sauries; 1 jackmackerel
40	0600–0730	Hook and line	Many rockfish
1000	1140–1500	Round dredge lost; Rectangular dredge used	Green mud; 1 crab, 1 shark sighted

COLLECTING STATIONS—(Continued)

Station No.	Haul No.	Date	General Locality	Position N.Lat.	Position W. Long.
19		9/28/49	Cordell Bank bears 347°T., 6.2 miles distance	37°–55′–15″	123°–24′–05″
20		9/28/49	Cordell Bank bears 320°T., 8.2 miles distance	37°–55′–45″	123°–19′–15″
21		9/29/49	Cordell Bank	38°–00′–15″	123°–26′–00″
22		9/29/49	Fanny Shoal bears 90°T., 8 miles distance	37°–48′–40″	123°–23′–00″
23		9/29/49	Fanny Shoal bears 90°T., 3 miles distance	37°–47′–00″	123°–13′–50″
24			North Farallon bears 178°T., 600 yards distance	37°–46′–30″	123°–06′–00″
25		2/6/50	Pioneer Seamount; Farallon light bears 46°T., 27¾ miles distance	37°–22.8′	123°–25′
26		2/6/50	NE. Pioneer Seamount; Farallon light bears 43°T., 23.2 miles distance	37°–25.2′	123°–20′
27		2/7/50	Pioneer Seamount	37°–24.4′	123°–23.5′
28		2/7/50	Pioneer Seamount	37°–21.0′	123°–25′
29		2/7/50	Pioneer Seamount	37°–21.0′	123°–25.8′
30		2/7/50	Pioneer Seamount Anchorage	37°–22.0′	123°–25.2′
31		2/8/50	Southwest of Pioneer Seamount	37°–18.7′	123°–28.2′
32		2/8/50	Mulberry Seamount	37°–26.5′	123°–28.7′
33		2/8–9/50	1½ miles west of Farallon light	37°–41.9′	123°–2.2′
34		2/9/50	Farallon light bears 12°T., 10.4 miles distance	37°–31.9′	123°–2.8′
35		2/9/50	Farallon light bears 12°T., 10 miles distance	37°–32.3′	123°–2.7′
36		2/9/50	Farallon light bears 180°T., 4.4 miles distance	37°–46.4′	123°–00′
37		2/9/50	Farallon light bears 340°T., 8 miles distance	37°–34.6′	122°–56.5′
38		2/13/50	Mulberry Seamount	37°–26.5′	123°–28.7′
39		2/13–14/50	Mulberry Seamount		

* Dredge time is considered as bottom time only.
Double line across chart indicates new trip to location.

COLLECTING STATIONS—(Data continued)

Depth in Fathoms	Duration of Haul*	Net Type	Bottom and Content
68–70	1624–1700	Rectangular dredge	Rocks; invertebrates; 1 shark and 1 ratfish egg-case
62–60	1715–1755	Rectangular dredge	Rock fragments and mud; invertebrates; 1 ratfish egg-case
28	0600–0700	Hook and line	Rockfish
400	0843–1000	Rectangular dredge	Mud and invertebrates; 3 shark egg-cases
62	1135–1210	4′x5′ trawl	Net ripped; frame O. K.; few box crabs
28	1330–1445	Hook and line	Nothing caught
480–450	1610–1630	12″ round dredge	Rocks and green mud; sponges
800–1000	1905–1950	Fish net	Cable broke, net lost
700–500	0815–0850	15″ round dredge	3 volcanic rocks, new sp. of chiton
600–450	1140–1240	12″ round dredge	Dead sponges
440–540	1340–1430	2½′x4′ dredge	400 lbs. of rocks
460	1930–2200	Setline (vertical)	Hooks wrapped around the cable; no fish
1300–1500	0935–1220	15″ round dredge	Small amount of green mud
1000–700	1700–1850	15″ round dredge	Rocks; skate egg and embryo; gorgonias
33	2145–0700	Handlines, night light	Many invertebrates, 1 starfish
320–250	0900–0935	12″ round dredge	Sack of green mud; *Macoma* sp.
340–120	1015–1110	12″ round dredge	3 pieces of mud; 1 echinoid 1 *Calliostoma platinum* (3rd specimen)
80–65	1130–1230	2½′x4′ dredge	2 sacks of green mud; many shells
55–46	1250–1340	2½′x4′ dredge	Mud; few shells; basket-star
690–800	1500–1630	15″ round dredge	Rocks and shells
800	Overnight	Groundline	No results

COLLECTING STATIONS—(Continued)

Station No.	Haul No.	Date	General Locality	Position N. Lat.	W. Long
40		2/14/50	Guide Seamount		
41		2/14/50	Guide Seamount	37°–01′	123°–20′
42		2/14/50	Top of Guide Seamount	36°–59′–30″	123°–20′
43		2/14/50	Guide Seamount	37°–02′	123°–20′
44		2/15/50	Guide Seamount	37°–01′–30″	123°–20′–30″
45		2/15/50	Guide Seamount bears 256°T., 13 miles distance	37°–04′–30″	123°–04′–30″
46		2/15/50	Guide Seamount bears 258°T., 21 miles distance	37°–05′–30″	122°–55′
47		2/16/50	Pioneer Seamount bears 10°T., 9 miles distance	37°–16′	123°–17′
48		2/16/50	Head of Pioneer Sea Valley	37°–20′	123°–45′
49		2/16/50	Point Montara light bears 30°T., 5½ miles distance	37°–27′–30″	122°–34′–30″
50		2/17/50	Southeast of Farallon, light bears 346°T., 16¾ miles distance	37°–25′–45″	122°–55′
51		2/17/50	16 miles south of Farallon Island	37°–25′	122°
52		3/27/50	Farallon light bears 73°T., 7 miles distance	37°–40′	123°–08.5′
53		3/27/50	Farallon light bears 05°T., 4½ miles distance	37°–37′–25″	123°–00′–25″
54		3/27/50	Farallon light bears 244°T., 3½ miles distance	37°–40′–30″	123°–03′–50″
55		3/28/50	Drakes Bay anchorage	38°–02 –20″	122°–57′–06″
56		3/29/50	Northwest of Cordell Bank	38°–03′–50″	123°–33′–30″
57		3/29/50	Southwest of Cordell Bank		
58		3/29/50	West of Cordell Bank	38°–00′–30″	123°–33′
59		3/29/50	Cordell Bank anchorage	37°–59′–55″	123°–25′

* Dredge time is considered as bottom time only.
Double line across chart indicates new trip to location.

COLLECTING STATIONS—(Data continued)

Depth in Fathoms	Duration of Haul*	Net Type	Bottom and Content
950–1400		15″ round dredge	No results
100+		1 meter tow net	Jelly fish
100	1500–1600	1 meter tow net	Line fouled up; no results
Surface	0800–0900	1 meter tow net; dip net	Many fish, jelly fish
1300–1380	0900–1200	15″ dredge, lost, trawl	Small amount of mud
600–400	1600–1800	15″ round dredge	500 lbs. of rock and mud
Surface	1800–2100	1 meter tow net	Many pelagic organisms
1000–640	0800–1000	15″ round dredge	Mud washed out of dredge
341–100	1000–1300	15″ round dredge	Green mud; gastropods, echinoids
Surface	Overnight	1 meter tow net	Great haul of jelly fish tore the net
200	0800–1000	15″ round dredge	2 gallons of green mud; few pieces of granite
180–80	1030–1150	15″ round dredge	1000 lbs. of rock and sticky blue-green mud
300		15″ round dredge	Sand bottom, 1 crab, 11 *Chrysodomus*
65		Tow net	
45–55		1′ dredge	Crinoids, ophiuroids, gastropods; few rocks of granite and conglomerate mud
5		Tow net, night light, dip net, and hook and line	Starry flounder, asteroids, shrimp, echinoids
400–200		Round dredge	800 lbs. of rock; 1 gorgonian
400		Tow net	2 fish; shrimp
600		Tow net	1 squid, shrimp, few lantern fish, jellyfish
35		Lights, hook, and line	Many fish; young decapods, jellyfish

COLLECTING STATIONS—(Continued)

Station No.	Haul No.	Date	General Locality	Position N. Lat.	Position W. Long
60		3/30/50	Cordell Bank bears 10°T., 7 miles distance	37°–54′–30″	123°–28′
61		3/30/50	Cordell Bank bears 05°T., 10 miles distance	37°–51′	123°–26′
62		3/30/50	Farallon light bears 358°T., 18 miles distance	37°–42′–30″	123°–23′
63		3/31/50	North Farallon anchorage	37°–46′–15″	123°–06′–00″
64		4/6/50	Farallon light bears 53°T., 14¾ miles distance	37°–33′	123°–15′
65		4/6–7/50	Mulberry Seamount anchorage	37°–27′–25″	123°–28′–30″
66		4/7/50	Drakes Bay	38°–00′–30″	122°–58′–00″

* Dredge time is considered as bottom time only.
Double line across chart indicates new trip to location.

COLLECTING STATIONS *(N. B. Scofield)*

Station No.	"N.B.S."* No.	Date	General Locality	Position N. Lat.	Position W. Long
67		7/16/50	Northwest of Middle Farallon heading southeast		
68	1	10/2/50	Off Pescadero Creek on Rocky Reef		
69	2	10/3/50	Off Pescadero Creek between Point Ano Nuevo-Pigeon Point		
70	3	10/5/50	Drakes Bay; From SW. to NW		
71	4	10/6/50	Off Big Flat		
72	5	10/6/50	Off Big Flat between Stillman and Big Creek; E. by S. ½ S.		
73	6	10/6/50	Off Big Flat; due west between Stillman and Big Creek		
74	7	10/6/50	Off Big Flat between Stillman and Big Creek; headed E. SE. ½ S.		

* Station numbers of the Division of Fish and Game M. V. *N. B. Scofield.*

COLLECTING STATIONS—(Data continued)

Depth in Fathoms	Duration of Haul*	Net Type	Bottom and Content
500–400		Two 1′ dredge and net combination	Fish, shrimp, Ctenophora, jellyfish
400–450		Two 1′ dredge and net	Mud; gastropods, shrimp, jellyfish, Ctenophora, fish
1150–1000		Two 1′ dredges	Rocks; mud; shells; coral tunicates, annelids, ophiuroids
25		Hook and line	Rockfish; observed 250; Steller sea lions
1100–1000	1230–1400	Two 1′ dredges	10 lbs. of rock and clay-like shale; Scyphozoa; crustaceans
850–700	1730–0400	Set line; night light dip nets	83 fish
6		Hook and line	Few starry flounder

COLLECTING STATIONS—(Data continued)

Depth in Fathoms	Duration of Haul	Net Type	Bottom and Content
70			Rocks, Bryozoa, corals, pelecypods, annelid tubes
13	1330–1630	Handline	3 cabezones
20	0730–1200	Handline	Flounder and rockfish
10–19	1000–1010	Beam trawl	Mud
15	0824–0915	Beam trawl	Gorgonias, crabs, flatfish
15–21	1030–1102	Beam trawl	Crabs, sole, skates, sand-dabs
35	1132–1216	Beam trawl	Box crabs and flatfish
60–64	1251–1330	Beam trawl	Box crabs, prawns, flatfish, nudibranch

COLLECTING STATIONS—(Continued)

Station No.	"N.B.S."* No.	Date	General Locality	Position N. Lat.	Position W. Long
75	8	10/6/50	Delgada Canyon between Shelter Cove and Big Flats		
76	9	10/8/50	Off Humboldt Bay; west by north ½ north		
77	10	10/8/50	Off Humboldt Bay; west by north ½ north		
78	11	10/8/50	Off Humboldt Bar; north ¾ east		
79	12	10/8/50	West northwest of Eureka Bar		
80	13	10/8/50	Off North end of Humboldt Bay; southwest by south ¼ south		
81	14	10/8/50	Off north end Humboldt Bay; northeast ¾ west		
82	15	10/9/50	Approx. 10 miles north of Blunts Reef Lightship and north of False Cape		
83	16	10/9/50	West of Blunts Reef; west by north		
84	17	10/11/50	Off Punta Gorda in Mattole Canyon		
85	18	10/12/50	Approximately 10 miles southwest of Shelter Cove		
86	19	10/12/50	4 miles north of Fort Bragg; just south of Noyo Canyon		
87	20	10/12/50	Off Fort Bragg; south by ¾ east		
88	21	10/12/50	Off Fort Bragg; north northwest ¼ west		
89	22	10/13/50	Drakes Bay; east northeast ¼ east		
90	23	10/13/50	Drakes Bay, between Block 438 and 448		
91	24	10/13/50	Off Bolinas Bay, E. ½ N.		
92	25	10/13/50	Off Bolinas Bay, E. ½ N.		
93	26	10/15/50	Off Bolinas Bay from south end to Duxbury Reef and Double Point		
94	27	10/15/50	Drakes Bay, just north of Double Point		

* Station numbers of the Division of Fish and Game M. V. *N. B. Scofield.*

COLLECTING STATIONS—(Data continued)

Depth in Fathoms	Duration of Haul	Net Type	Bottom and Content
285–155	1438–1455	12″ round dredge	Many shells, brachiopods, mud
40–52	0915–0947	Beam trawl	Dover sole, echinoids, pectens, hermit crabs, shells
80–120	1013–1044	Beam trawl	Rockfish, octopus, hermit crabs
65	1200–1238	Beam trawl	Annelids, hermit crabs, starfish, heart urchins
68–75	1303–1336	Beam trawl	Heart urchins, flatfish
200	1422–1502	Beam trawl	Teredo logs, hermit crabs, shells
68–50	1527–1600	Beam trawl	Shells, hermit crabs, skates
40–44	0928–1000	Beam trawl	Box crabs, flatfish, ratfish
600	1303–1403	¼ meter tow net 1 meter tow net	Annelids and shrimp
300–100	1515–1615	12″ round dredge	Rocks, mud, shells, coral, shrimp, crabs, anemone, crinoids, Chaetognatha
85–92	0755–0840	Beam trawl	Brachiopods, urchins, starfish, ratfish, egg cases
85–88	1153–1238	Beam trawl	Sea urchins, octopus, annelids, pelecypods, caprellids
100–125	1318–1354	Beam trawl	Prawns, anemones, starfish, hermit crabs, urchins, fish
125–175	1453–1553	Beam trawl	Hermit crabs, sea urchins, flatfish
25–20	0737–0805	Beam trawl	Crabs and fish
15–22	0836–0855	Beam trawl and net # 769	Flatfish, skates, sand-dabs
12	1010–1105	Beam trawl	Sea cucumbers, starfish, sponges, rockfish, ocean perch
12	1023–1045	Beam trawl	Crabs, lingcod, rockfish, dog shark
7–17	0922–1312	Beam trawl and frame	Crabs, flatfish, skates, shark, sole
10–21	1342–1510	Beam trawl and frame	Net snagged; specimens lost

never fails to attract attention. A faultless explanation of their presence is difficult to find. One which perhaps has not received its full share of consideration is the possibility that they were dropped from floating ice during the glacial period. During parts of that period ice reached the sea from points as far south as the Olympic Mountains. There is no assurance that floating bergs reached the latitude of San Francisco but it is a possibility.

BIOLOGICAL RESULTS

Inevitably in such work as this much information and material of interest to biologists will be obtained. While the gear used in the present case was designed to secure rocks in considerable quantity, many living specimens dredged were preserved for study. Much of the sea bottom adjacent to continents is densely populated with animal life and rocks or other bottom material cannot be obtained without a representation of this fauna. Gear designed especially to secure it would be provided with means so that it would skim over the bottom and not cut down into it.

Important results from a biological standpoint will appear elsewhere, but a few observations which were made seem to be significant from a geological viewpoint.

It was expected that the very steep continental slope west of the Farallon Ridge would offer an ideal situation for the growth of bottom organisms. An upwelling from deeper waters might be present and in such places prolific growths have been observed elsewhere. We did not find this to be the case. The slope seems to be swept clean and is relatively barren so far as our dredge hauls offer an indication. In fact active erosion is in process.

One of the principal agents of erosion, perhaps the most important one, is the work of certain rock-boring worms. Several species of these are present but the most striking is the one which choses to bore into hard siliceous cherts and similar rocks. How they do this is unknown but a great many examples were collected which were fairly riddled with them. In some cases the penetration is fully two inches. Rarely did they attack the hard pebbles composed of quartzite or metavolcanic material and this may account for what seems to be the presence of such well rounded boulders in undue abundance; they may be residuals from submarine erosion.

In addition to these borings there were cavities which were practically certain to have been made by boring mollusks such as *Pholadidea*. These were found down to depths of 600 fathoms in some cases but no remains of shells were present. Such species normally live in intertidal areas or just below. Some geologists interpret "pholad borings" as definite evidence of shallow water conditions and unconformities. In this case, in the absence of a better interpretation, it seems that subsidence offers the best explanation.

There is additional evidence of relatively recent subsidence of a lesser magnitude. This consists of the presence of intertidal shells of *Mytilus californianus* at several places down to 50 fathoms. They were especially noticed around Cordell Bank which is 30 miles from the nearest shoreline. All which were recovered were very old "dead" shells but would not be classed as fossils.

NOTES ON THE GEOLOGICALLY SIGNIFICANT STATIONS

The preceding list gives data on all stations occupied during this project. Many of them for various reasons are of no geological significance. Those which did furnish rocks or other noteworthy material are listed below with additional information derived from examination of hand specimens. Exact mineralogical determinations will be found in the report by Mr. Chesterman which follows.

2. N. Lat. 38°00′, W. Long. 123°22.4′, east side of Cordell Bank 16.75 mi. west of Point Reyes light, 57–50 fms.

This station furnished several hundred pounds of rocks, mostly large angular blocks of granodiorite broken from ledges. These, as well as smaller pieces, were encrusted with various organisms and showed evidence of fairly deep weathering. There were several pieces of pebble and boulder conglomerate and a large quantity of well-rounded pebbles and gravel probably derived from the same rock. Some of the boulders were six inches in diameter; most of them were a very hard dark metavolcanic rock which was not bored into by organisms and by hand lens examination showed little evidence of weathering.

7. N. Lat. 38°03.3′, W. Long. 123°31.2′, northwest side of Cordell Bank, 124–90 fms. The dredge secured about 25 pounds of pebbles up to four inches in diameter. Some of these were waxy quartzite, others a green metavolcanic rock. There were a few granitic fragments and pieces of pebbly conglomerate. Weathering was not obvious in hand specimens but many of the boulders and pebbles have innumerable incipient fractures which make them easy to crush with the hammer.

10. N. Lat. 38°02.2′, W. Long. 123°24.8′, Cordell Bank, 34 fms. About 100 pounds of granitic fragments. Most of these were heavily incrusted with organisms and some contained borings up to one inch in diameter. These holes are very old and are exactly like those made by mollusks such as *Pholadidea ovoidea* but in no case was there a trace of shell remaining. This, together with the presence of very old shells of *Mytilus californianus* in the same haul, indicates strongly that at no very distant date Cordell Bank was intertidal. There were a very few pebbles of dark colored rocks which presumably were derived from nearby conglomerate.

11. N. Lat. 37°59.2′, W. Long. 123°27.0′, Cordell Bank, 74 fms. Two dredge hauls were made at this station. In the first there were about 200 pounds of angular fragments of granitic rocks, deeply weathered but not rounded. A few pieces of schistose material were also obtained and some of these contain borings like those made by *Lithophaga*. The other haul contained about 100 pounds of nearly pure foraminifera. These appear to be living forms in the area and were not derived from a fossil bed. It is difficult to account for such a concentration.

12. N. Lat. 37°54′, W. Long. 123°25.7′, off Cordell Bank, 218–100 fms. About 75 pounds of hard, black, banded chert containing abundant cavities of fossil foraminifera. The dark color is due to petroleum residue. Such rocks are typical of the Monterey Miocene of California. In addition there was one large piece and some debris of a soft, gray silty shale which contain abundant beautifully preserved foraminifera and diatoms.

19. N. Lat. 37°55′15″, W. Long. 123°24′05″, Cordell Bank bears 347°T, 6.2 miles distant; 70 fms. About 1000 pounds of cherty Miocene shale and a few fragments of granitic rocks were obtained at this station. The chert is slightly silty and has been greatly bored to a depth of an inch by a species of worm which has not yet been identified. In addition there were numerous borings which were precisely like those made by shallow water mollusks such as *Pholadidea*.

20. N. Lat. 37°55′45″, W. Long. 123°19′15″, Cordell Bank bears 320°T, 8.2 mi. distant, 60 fms. The bottom at this point was a soft dark-colored sand with few organisms. The haul at this station consisted of only a few pounds.

22. N. Lat. 37°48′40″, W. Long. 123°23′00″, Fanny Shoals bear 90°T, 8 mi. distant, 400 fms. The dredge recovered about 100 pounds of soft silty fossiliferous sand containing many foraminifera and sponge spicules. The presence of a species of *Siphogeneroides* indicates that the age is Miocene, probably a part of the Monterey formation.

25. Pioneer Seamount. N. Lat. 37°22.8′, W. Long. 123°25.0′, 41 mi. southwest of San Francisco lightship, 480–450 fms. Many siliceous sponges, some of them 10 inches high, and all dead, were secured in this haul. In the mud among the sponge debris there were large numbers of living foraminifera. About 100 pounds of rocks was obtained. These rocks are mostly volcanic, some being highly altered, presumably by submarine weathering. In the cavities of some of the lavas there is a brilliant blue deposit, probably a phosphate mineral.

27. Pioneer Seamount. N. Lat. 37°24.4′, W. Long. 123°23.5′, 600–500 fms. About 25 pounds of dense black basalt was obtained here. Some pieces were 10 inches across. An altered zone about an inch deep covers each piece.

28. Pioneer Seamount. N. Lat. 37°21.0′, W. Long. 123°25.0′, 600–400 fms. Many siliceous sponges, all dead, were secured.

29. Pioneer Seamount, N. Lat. 37°21.0′, W. Long. 123°25.8′, 440–540 fms. About 200 pounds of vesicular basalt was obtained at this station. The original color was black but some large pieces have been altered and all or nearly all of the original mineral has been replaced. Some of the replacement, perhaps most is a phosphatic mineral and the color is changed to a light brown. Some very large pieces of siliceous sponges were attached to the blocks of basalt.

32. N. Lat. 37°26.5′, W. Long. 123°28.7′, "Mulberry" Seamount, 1000–700 fms. About 300 pounds of dense, black, vesicular basalt was obtained here. The cavities are lined with a secondary mineral, nearly white to bright blue.

34. N. Lat. 37°31.9′, W. Long. 123°2.8′, south of Farallon Islands, 320–250 fms. Recovered about 100 pounds of friable, dark gray siltstone. No fossils were seen in hand lens inspection.

35. N. Lat. 37°32.3′, W. Long. 123°2.7′, 340–120 fms. Hauled toward Point Montara. Only a small quantity of light gray silt was recovered.

36. N. Lat. 37°46.4′, W. Long. 123°00′, toward Sharps Park, 80–65 fms. A few small pieces of light gray sedimentary rock were obtained. These contained fossil foraminifera, very well preserved. With them there were several rounded pieces of granitic rock. In addition, the haul included about 200 pounds of friable dark gray silty mud; this last is firm enough so that it is believed to be older than Recent sediment but no fossils were found in it.

38. "Mulberry" Seamount. N. Lat. 37°26.5′, W. Long. 123°28.7′, 690–800 fms. About 200 pounds of highly vesicular, somewhat scoriaceous volcanic rock was obtained at this station. Weathering and alteration are not readily apparent. One large, erratic rock was dredged; it appears to be a highly altered piece of Monterey siliceous shale with large borings such as shallow water mollusks make.

45. N. Lat. 37°04′30″, W. Long. 123°04′30″, 600–400 fms., on the continental slope. Guide Seamount bears 256°T, 13 miles distant. About 500 pounds of dense phosphate rock and a smaller quantity of a highly altered, light colored, laminated shale like rock were recovered here. The phosphate rock is in the form of large flat masses with the rounded knobs. It contains bones of fishes, foraminifera, and diatoms.

50. N. Lat. 37°25′45″, W. Long. 122°55′, 16.5 mi. south of Farallon Islands, 200 fms. Besides some mud and silty sediment, the only rock obtained was a small piece of light gray, soft, siltstone without fossils.

51. Continuation of Station 50, 180–80 fms. About 1000 pounds of rather tightly cemented silty gray sand was taken. All pieces are highly bored by worms and the nestling mollusk *Saxicava* is common in some of the cavities.

54. N. Lat. 37°40′30″, W. Long. 123°03′50″, Farallon light bears 240T°, 3.5 mi., 45–55 fms. A few small pieces of crystalline rocks were recovered;

these are unlike the granitic rocks of the Farallon Islands but are insufficient to be diagnostic.

56. N. Lat. 38°03′50″, W. Long. 123°33′30″, northwest of Cordell Bank, 400–200 fms. About 800 pounds of black or dark brown rock was dredged. The pieces are two to eight inches across and all appear to be more or less pure phosphatic material. The percentage of sand is very low. Along with this material there was a quantity of pebbles of various composition having a total weight of about 25 pounds. These did not differ especially from those found on the east side of Cordell Bank.

62. N. Lat. 37°42′30″, W. Long. 103°23′, south of Farallon Islands, 1150–1000 fms. This station furnished about 100 pounds of siliceous shale, and some coarse pebbly sandstone. In addition there was about 20 pounds of friable gray silty shale with abundant Miocene diatoms and foraminifera.

64. N. Lat. 37°33′, W. Long. 123°15′, 10 mi. east of "Mulberry" Seamount, 1100–1000 fms. A few pieces of friable, light gray, silty shale were obtained.

67. Northwest of Middle Farallon Island in 70 fms., secured by the Fish and Game vessel, *N. B. Scofield,* July 16, 1950. About 100 pounds of siliceous chert, very greatly bored by worms, was recovered. This material, inside of the altered surface layer resembles much of the Miocene chert of continental areas.

75. Delgada submarine canyon off Buck Creek, Humboldt County, California, 285–155 fms. N. B. S. No. B. 8, Oct. 6, 1950. The haul consisted of a few pounds of friable gray siltstone greatly perforated by boring organisms and a few pebbles of very hard dark gray sedimentary rock. No fossils were found in the siltstone and all that can be determined at present regarding its age or relationship is that lithologically it is very similar to much of the Pliocene found in Humboldt County.

77. Off Eureka Bar, Humboldt County, California, 80–120 fms. N. B. S. Nos. 3, 10, Oct. 8, 1950. A few pounds of typical Wildcat formation, gray siltstone, was obtained. *Pecten caurinus* and other fossils were present.

84. South side of Mattole Canyon, Humboldt County, California, 300–100 fms., Oct. 11, 1950. N. B. S. No. B. 17. About 100 pounds of rocks, mostly well rounded pebbles up to three inches across, were taken at this station. All of these which were examined were formed from hard sedimentary rocks, such as are found on the adjacent mainland. Some of these hard rocks, even well cemented sandstones, have been greatly perforated by boring worms. It was hoped that this station would furnish some clue as to the nature of the great submarine cliff which extends west from Punta Gorda but the only other material in the dredge which was significant in this connection was a quantity of dead calcareous algal stems, which resemble some forms of coral.

NOTES ON GEAR

The U. S. S. *Mulberry* was equipped with adequate power to handle gear of almost any capacity which might be devised. The drums on the winches were of large size and in the regular work of the ship these are spooled with wire line .75″ to 1.50″ in diameter. We made a few hauls with the smaller size but most of the work was done with .375″ wire line which was supplied by the Bureau of Ships from the Navy Yard at Mare Island. Each drum carried enough so that there was no difficulty in reaching bottom in 2000 fathoms. An "A" frame was rigged aft to carry the line above deck.

Several designs of heavy, square and rectangular dredges were tried out but did not dig in among rocks as much as was desired. We, therefore, adopted a dredge which was circular in cross section. The mouth was made of a piece of pipe 18″ or 12″ in diameter and 18″ or 12″ long. The bridle was shackled to this and four .50″ rods were welded over the aperture as a protector. On the back of this piece of tubing either heavy screen wire or expanded metal lath was welded, forming a cylinder about four feet long for the smaller size and six feet long for the larger one. This screen was protected by four rods welded to the pipe. Sometimes a liner of fine wire was put inside of the coarse mesh.

This makes an exceedingly rugged dredge, essentially a "drag line" in commercial practice. Some were lost but in no case was this the result of fouling on bottom. Rocks weighing more than a hundred pounds were broken off of ledges occasionally.

Undoubtedly the ideal dredge for such work would be some sort of clam shell of half a yard capacity or more. With this a sample could be obtained from a single spot whereas with a drag line more or less of the area must necessarily be covered. Thus a mixture of materials is obtained, depending upon length of drag, steepness and direction of slope, and other factors, most of which are beyond the control of the operator. The chief objection to a clam shell is the difficulty of handling it aboard ship, especially in rough weather.

When opportunity offered we used tow nets effectively and sometimes shackled them to the dredge line. Thus a considerable amount of pelagic animal life was obtained, incidental to the main objective.

Very little effort was spent in attempting to get core samples and these were unsuccessful. It was believed that such an operation would take too much time, if carried out systematically, to make it worthwhile. As it turned out, the steepness of the continental slope and presence of outcropping rocks on it probably would have prevented very satisfactory results with a core barrel.

Various forms of strain indicators were used on the dredge line but none of them, in our opinion, were as effective as the simple device originated

by Mr. W. E. Ripley of the California Division of Fish and Game. This consists merely of an ordinary spring balance such as is used for weighing fishes. It is fastened to some part of the ship by one end and the other is hooked over the dredge line with a running sheave. A positive strain is put on the scale before the gear reaches bottom. Subsequently any additional strain shows on the dial.

EXPLANATION OF PLATES

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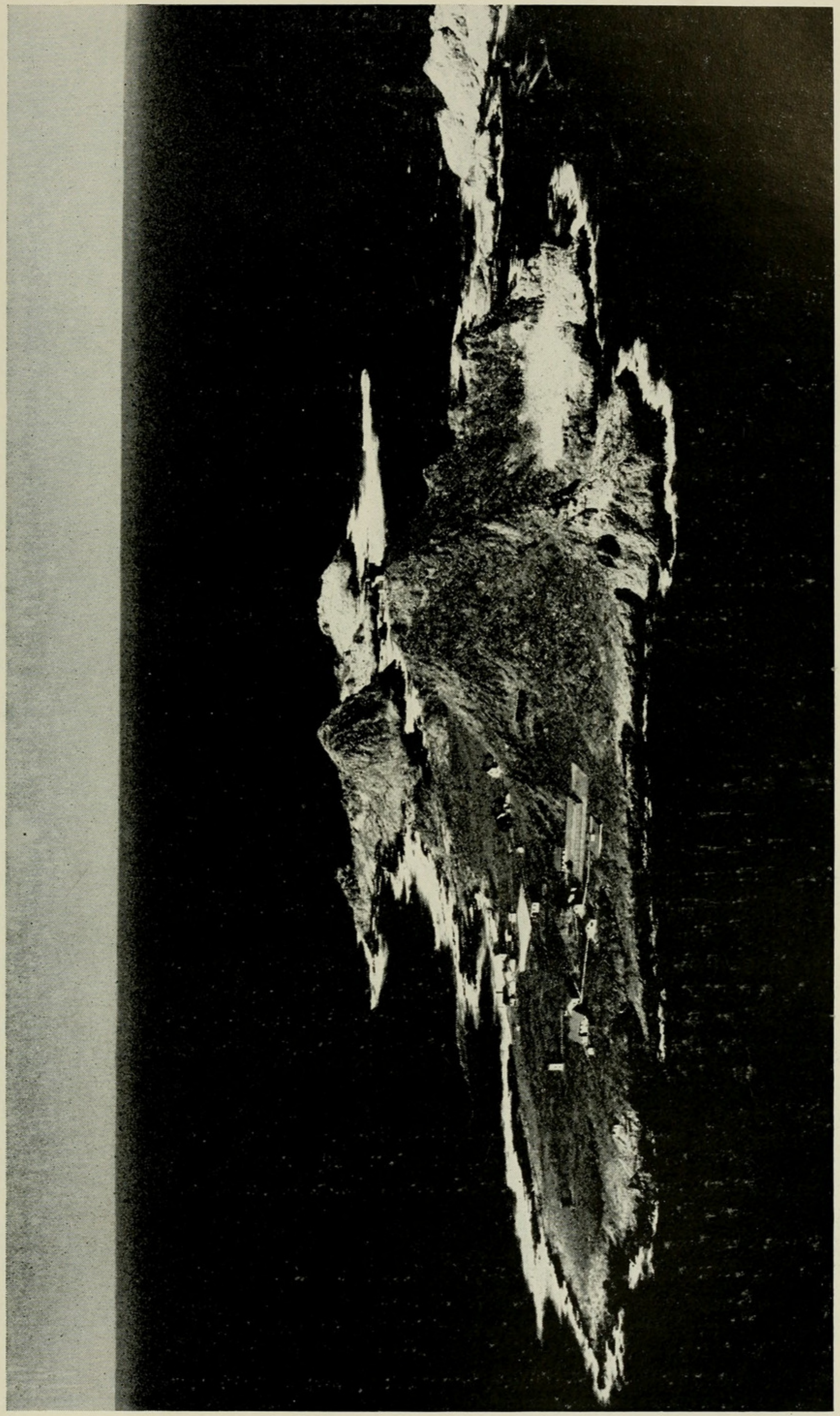
U. S. BUREAU OF FISHERIES

1906. Dredging and hydrographic records of the U. S. fisheries steamer *Albatross* for 1904 and 1905. Rept. and special papers, 1905 (1907), 80 pp. incl. tables. Bureau of Fisheries Doc. 604.

1921. Dredging and hydrographic records of the U. S. fisheries steamer *Albatross*, 1911–1920. Appendix III, Rept., 1920, 190 pp. Bureau of Fisheries Doc. 897.



Southeast Farallon Island showing the terrace upon which the lighthouse maintenance buildings are placed and in the foreground, sea caves made during a former submergence. The highly weathered and fractured nature of the diorite is visible in the original print. The camera was pointed westerly. U. S. Coast Guard photo No. 6,164,917, June, 1949, received from Mr. G. E. Logan.

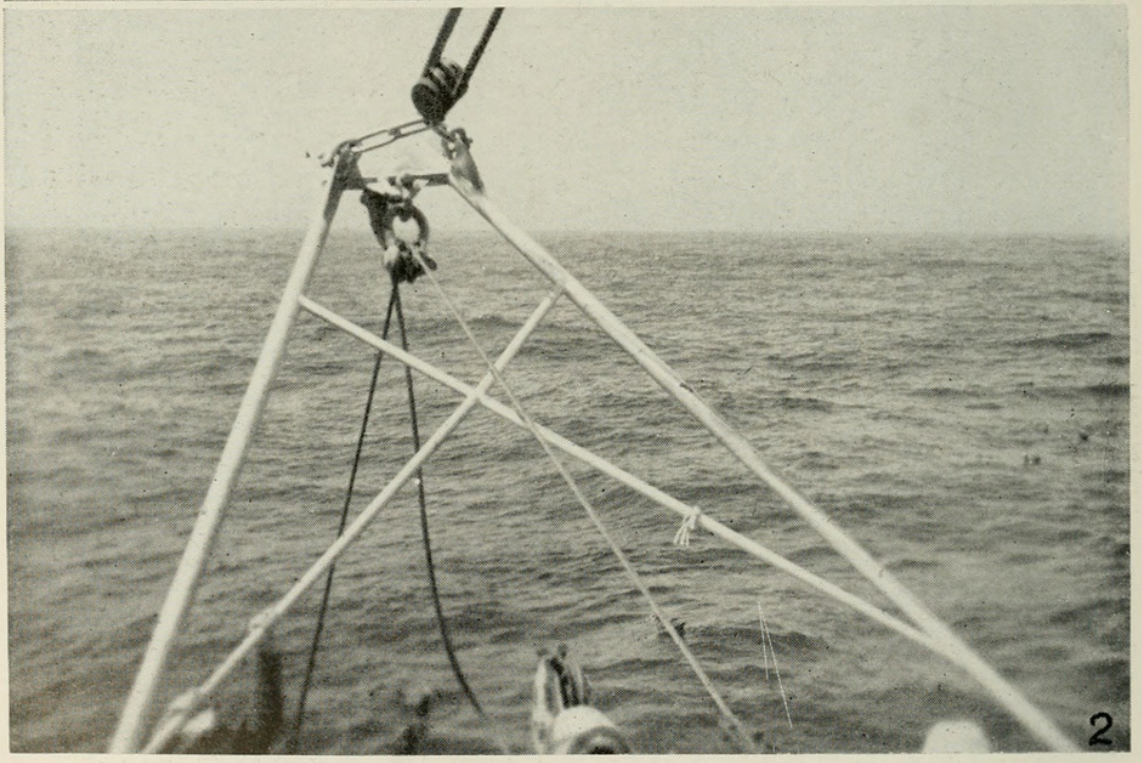
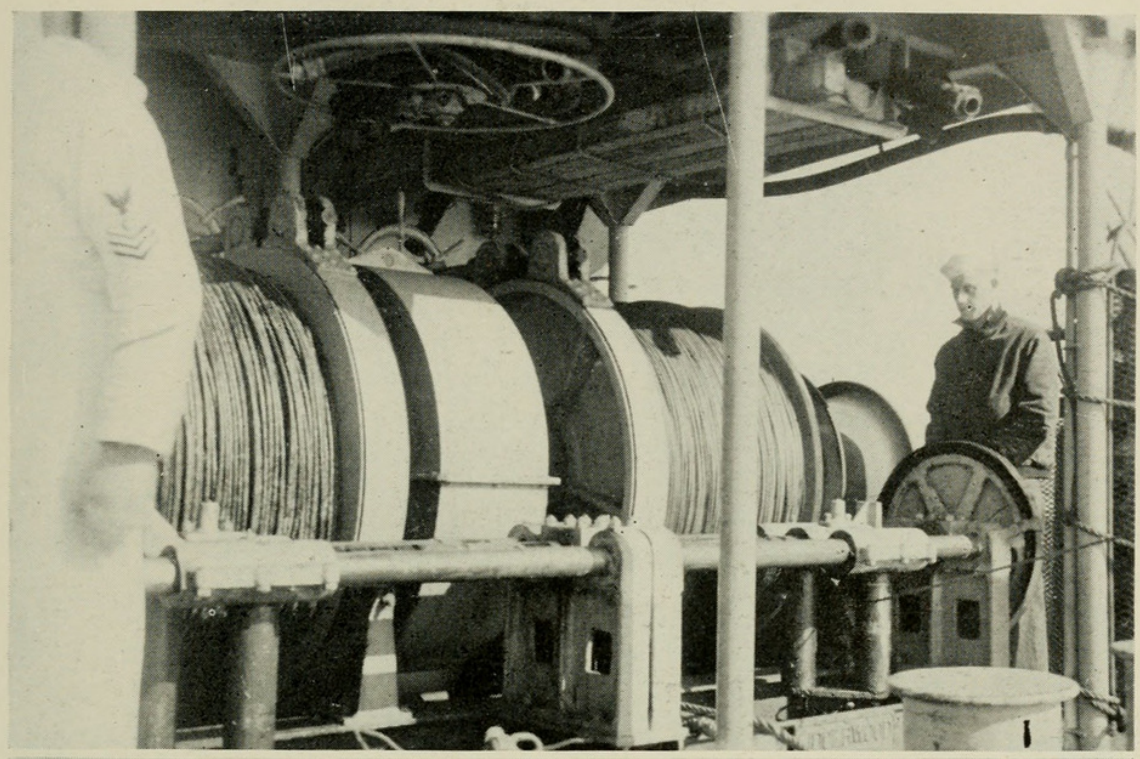


Figure 1. North Farallon Rocks as seen from the northeast. There are five main rocks and several smaller ones.

Figure 2. "A" frame mounted aft on the U. S. S. *Mulberry* for dredging and trawling. This equipment worked satisfactorily in depths as great as 2000 fathoms.



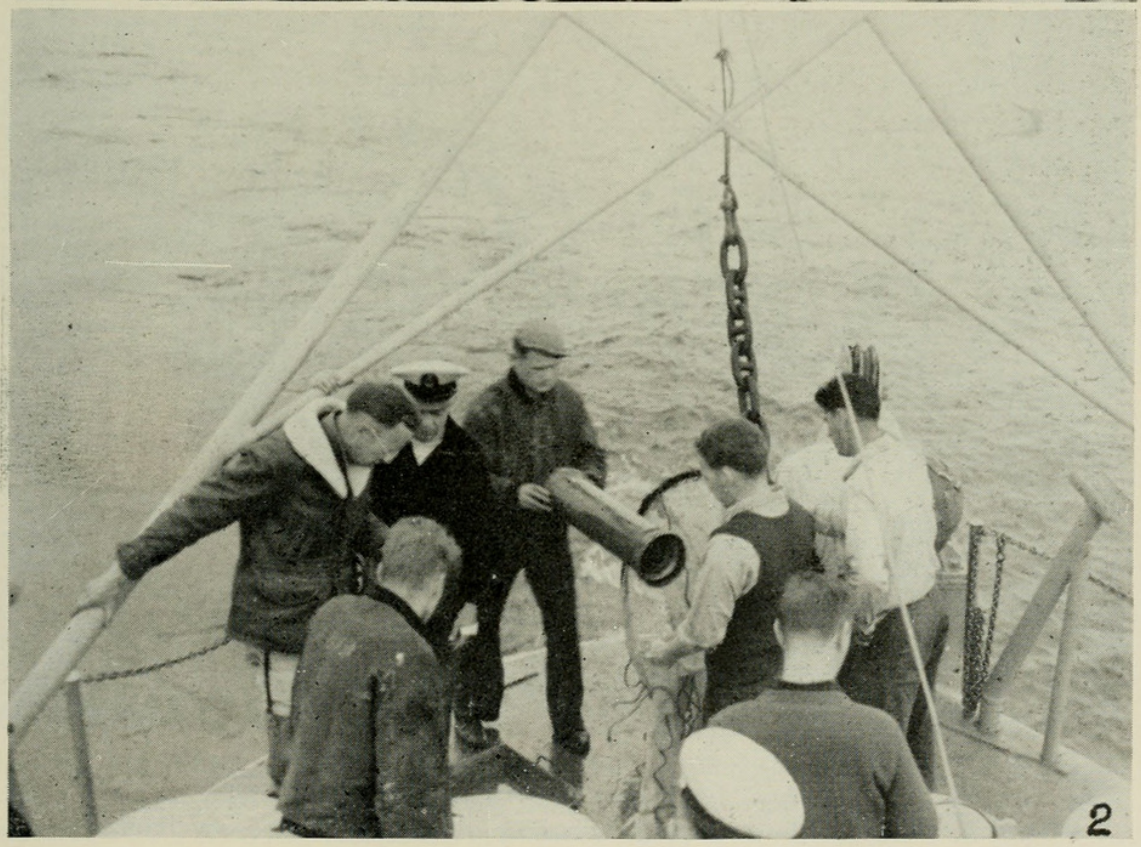
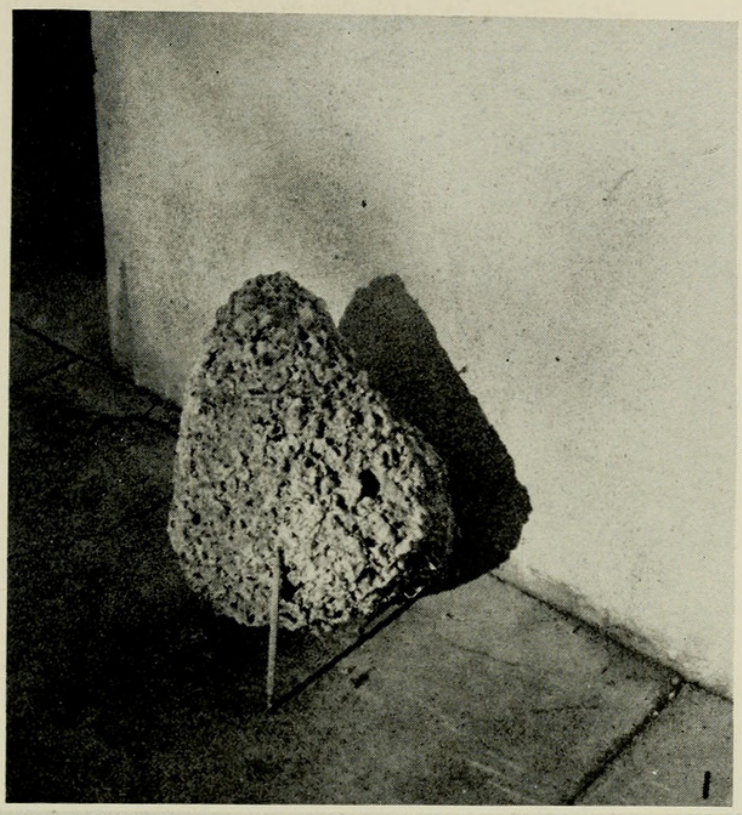


Figure 1. The after winches of the U. S. S. *Mulberry*.
Figure 2. Rigging a tow net to attach to the dredge line on the U. S. S. *Mulberry*.

Figure 1. Dumping a heavy dredge load of rocks obtained on the continental slope, Sta. 56 in 200–400 fms., northwest of Cordell Bank.

Figure 2. Miocene chert, greatly bored by worms, from the continental slope, Sta. 12, in 100–218 fms., Cordell Bank, 3.75 miles, bearing 14° True. Dr. R. C. Miller examining material brought up in the dredge.



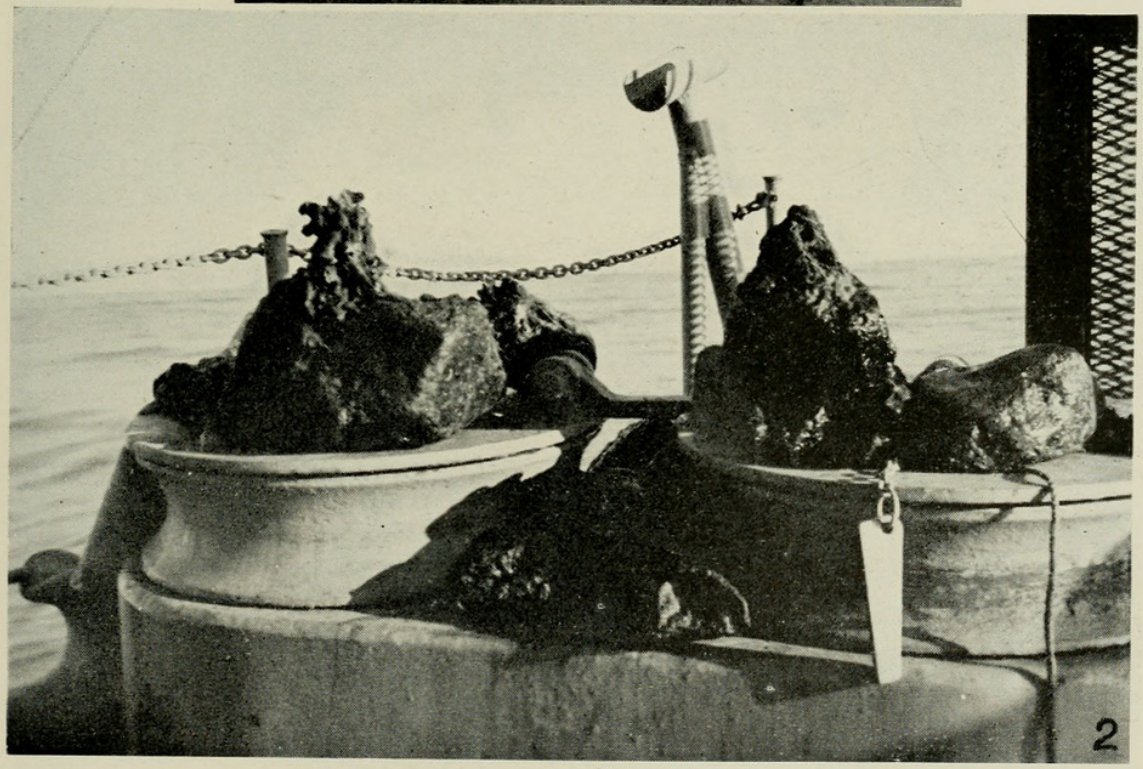


Figure 1. A large piece of Miocene chert greatly bored by marine organisms, mostly worms. The pencil shows the scale. From 70 fms., northwest of Middle Farallon Island July 16, 1950, Fish and Game vessel *N. B. Scofield.*

Figure 2. Representative volcanic rocks from Pioneer Seamount, a siliceous sponge (dead) attached to the rock on the left. Sta. 29, 440–540 fms.

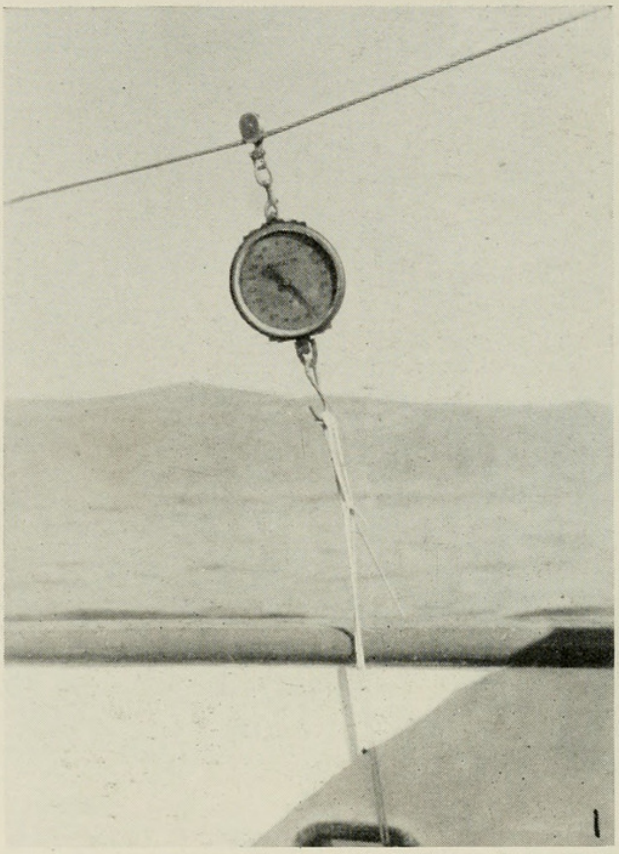


Figure 1. A simple spring balance as used for a strain indicator on the trawl line by Wm. Ripley and associates on the Fish and Game vessel *N. B. Scofield.*

Figure 2. Launching the beam trawl from the deck of the *N. B. Scofield.*

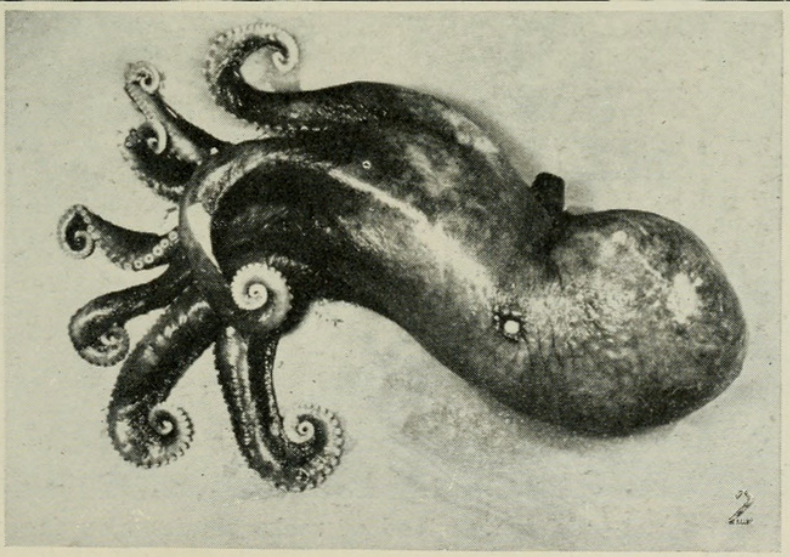
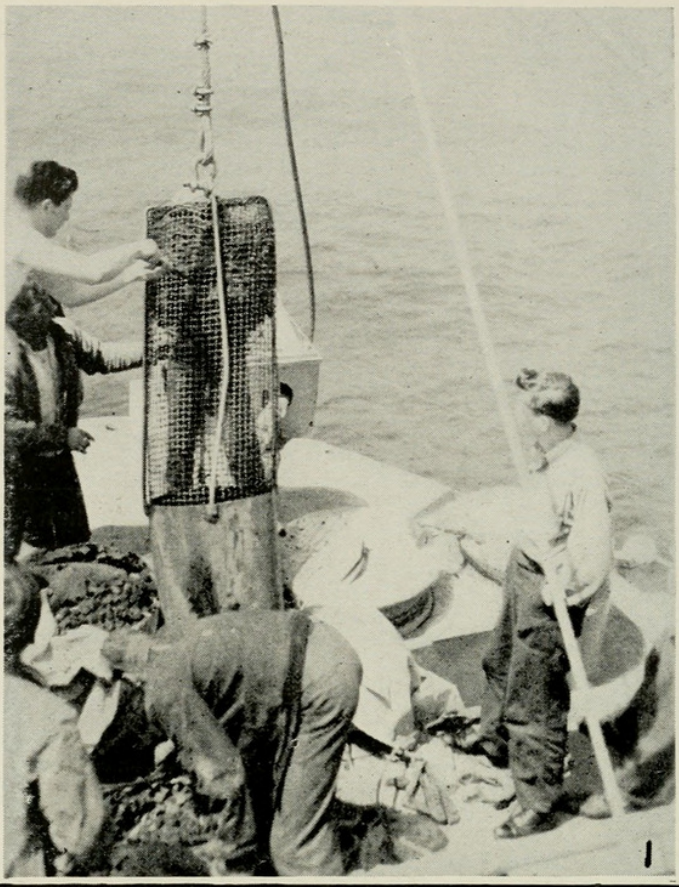


Figure 1. W. I. Follett and Robert Dempster, preparing biological specimens obtained at Cordell Bank by U. S. S. *Mulberry*.

Figure 2. A rare pelagic octopus, *Japetella heathi* (Berry) from Sta. 155 in 700–820 fms., off North Farallon Islands, Nov. 12, 1950, *N. B. Scofield*, No. 50–B–88. This group of cephalopods has only one row of suckers on the arms, whereas the ordinary octopus has two. The species has not been illustrated heretofore. Length as photographed, 235 mm.



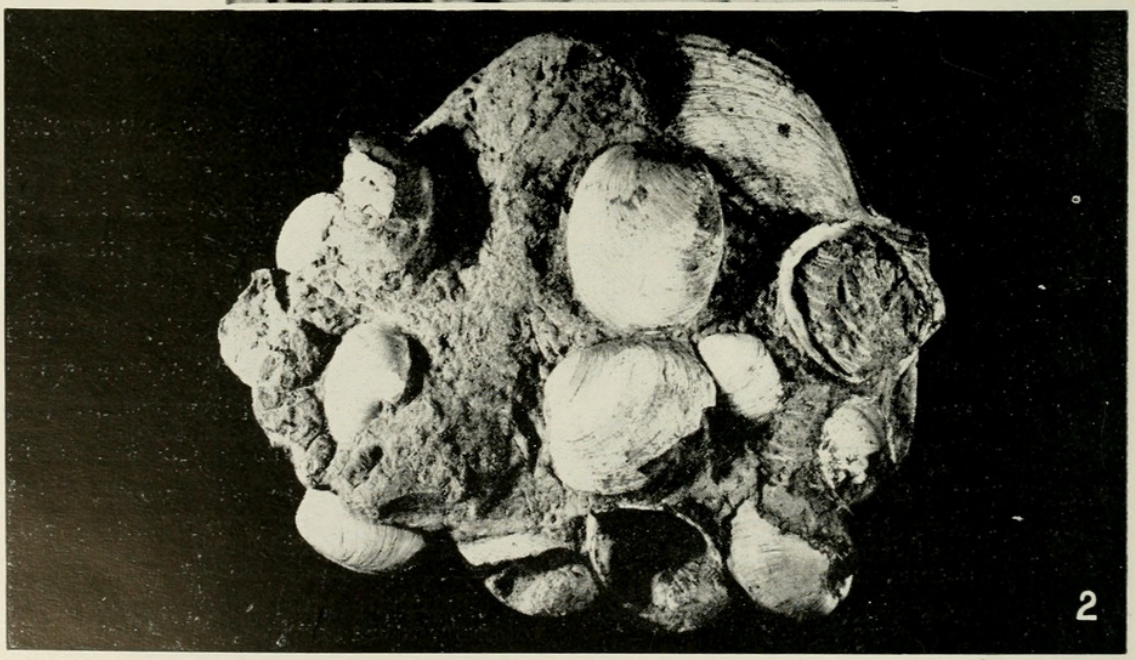


Figure 1. Dumping a heavy dredge load of rocks obtained on the continental slope by U. S. S. *Mulberry*.

Figure 2. A group of Pliocene fossil shells (Wildcat formation), *Compsomyax* and *Pecten caurinus* Gould, Hypotype No. 4284 (Calif. Acad. Sci. Dept. Paleo. Type Coll.), collected by Captain V. Niemi of the fishing boat *Ina* from Loc. 33223 (C. A. S.) from S. W. of Trinidad Head, California, in 96 fathoms. Many similar specimens were dredged off Eureka, Humboldt County, California, as far as 30 miles and as deep as 80–120 fms. (Sta. 77) by the Fish and Game vessel, *N. B. Scofield*, October 8, 1950.