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Coast and Geodetic Survey
Washington 25, D. C.

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In reply refer to:
201-454-20b

INTERNATIONAL INDIAN OCEAN EXPEDITION
Preliminary plans for the
USC&GS Ship PIONEER

General

The USC&GS Ship PIONEER will sail in mid-February of 1964 from San Francisco to take part in the International Indian Ocean Expedition, returning to San Francisco the following September. In addition to underway observations, en route to and from the Indian Ocean, the PIONEER will concentrate on gravity, magnetic, and hydrographic operations in the Andaman Sea and the eastern Bay of Bengal. Three north-south profiles of oceanographic stations are planned from 5°N to 5°S across the Equator south of the Bay of Bengal. The plans for each leg of the expedition are discussed below.

These are only tentative plans covering work on specific Coast and Geodetic projects. It is anticipated that they will be modified and added to as the information from other participants becomes available and as other organizations develop cooperative programs with the PIONEER.

These plans are predicated on the assumption that TRANSIT navigation will be available for determining ship positions throughout the expedition.

Leg I - San Francisco to Singapore

Between San Francisco and Honolulu, the PIONEER will carry out trackline hydrography, gravity, and magnetic observations along one of the lines already laid out as part of the overall scheme for coverage between the west coast and 155°W. All underway observations will also include BT's, surface salinity and temperature, surface weather and upper air observations, visual observations of sea, swell, marine life, etc.; and such underway biological observations as may be programmed by the biologists. From Hawaii to Guam, underway observations will continue along a track planned to cover a route not previously traversed for such observations but sufficiently close to previous tracks that the information will be of greater value than a single trackline.

Over the Mariana Trench, the PIONEER will make three crossings whose actual positions will be worked out with R. L. Fisher (SIO). From Guam to San Bernadino Passage, a similar program will be carried out with three crossings of the Philippine Trench north-east of Samar. Underway observations will be continued to Manila. Through the Philippine Coast and Geodetic Survey, one marine scientist will be invited to ride the PIONEER to Singapore as an observer to obtain training in our underway techniques. From Manila to Singapore, underway operations will continue with one long oblique crossing of the Palawan-North Borneo Trench from 10°N , $116^{\circ} 30'\text{E}$ south of Jesselton, North Borneo. Arrangements will be made with Dr. N. S. Haile, Geologist with the Geological Survey Department, British Territories in Borneo, to have one member of the department travel with the vessel between Jesselton and Singapore. Leaving Jesselton, the ship will make a normal crossing of the trench on a course of approximately 315° to approximately 8°N , 114°W and thence directly to Singapore crossing the westward extension of the trench en route.

Leg II - Singapore to Trincomalee

From Singapore, the track will be northwest through the Malacca Straits into the Andaman Sea. The actual tracklines in the Andaman Sea will depend in part on the results of the work of the ARGO which returns from this area in the early summer of 1963. In general, however, there will be a series of sawtooth crossings of the Andaman Sea carrying out all of the standard underway observations with special attention paid to the bathymetry and the gravity work. Sediment cores and bottom photographs will be taken in the Andaman Sea along these lines. Rock dredgings will be attempted at places where the topography suggests that rock outcrops might be present. Planned tracklines in this area will be modified in the field as dictated by the bottom topography and gravity anomalies encountered. The pattern will include at least two crossings of the Andaman-Nicobar Ridge into depths of at least 3000 meters west of the ridge. These could conceivably be through Ten Degree Channel and Duncan Pass. At the northern end of the Andaman Sea, special lines shall be run to determine if submarine channelling extends seaward of the mouths of the Irrawaddi River.

From the Andaman Sea, the ship will pass into the Bay of Bengal where the underway operations, cores (or dredgings), and bottom photography will continue along a series of East-West lines at approximately two-degree spacing from the coast of Burma out to approximately 88°E . Topographic, gravimetric, or magnetic anomalies found along these lines will be developed more fully. Special care will be taken along the more northerly of these lines to look for any southerly extension of the Ganges Canyon. This has

been surveyed in some detail by the Pakistan Navy as far as the edge of the continental shelf. The GALATHEA's lines showed that it extends south into the Bay of Bengal beyond the shelf, but its extent is not known. It is possible that the valley found by the ALBATROSS east of Ceylon may be the extension of this Ganges Canyon. After a stop at Calcutta, the PIONEER will carry out a detailed survey of the Ganges Submarine Canyon seaward of the continental shelf. The canyon will be traced as far seaward as is possible. Cores will be obtained from the canyon floor where possible and attempts will be made to dredge the canyon walls. Bottom photographs will be obtained where camera lowerings appear feasible. If the canyon terminates well north of the latitude of Ceylon, the east-west lines previously run in the eastern Bay of Bengal shall be continued westward from 88° to the coast of India. If the canyon continues south to or beyond Ceylon, it shall be followed to its termination with cross sections run at frequent intervals.

On the termination of this project, the ship will proceed to Trincomalee, Ceylon.

Leg III - Trincomalee to Djakarta

HO Charts 2523 and 3689 show hard ridges through which has been cut a submarine canyon that heads in Trincomalee and Goddiyar Bays on the northeast coast of Ceylon. The canyon has apparently been cut in quartzite and other hard Pre-Cambrian rocks. The canyon extends seaward to depths of at least 800 fathoms where the soundings terminate. As the ship leaves Trincomalee, this canyon will be traced seaward with a set of profiles, and an attempt will be made to dredge the steep walls. Sediment cores and bottom photographs will be obtained where possible.

Upon the completion of the canyon survey, three north-south sections of oceanographic stations will be occupied from 5°N to 5°S along 84°E , 88°E , and 92°E . Stations will be at 5° , 4° , and 3° , and at $\frac{1}{2}$ -degree intervals to the Equator for a total of 17 stations along each profile. The stations at 5° , 3° and 1°N and S will be deep stations to the bottom, the others will be to 2000 meters. Standard bottle spacing will be used, except that depth of stations and bottle spacing may be modified in the light of other results obtained before the PIONEER sails.

From the southern end of the easternmost line (5°S , 92°E), the track to Djakarta is tentatively planned to accomplish two crossings of the northwestward extension of the trend of the Java Trench. These would be underway observations as described above. The first line would approach the Sumatra coast near Padang and then turn southwest continuing to the latitude of the Sunda Strait, thence due east through the Sunda Strait to Djakarta. The tracklines between the end of the oceanographic stations and

Djakarta are only tentative and will be changed to supplement the work of the ARGO currently operating in this area.

Leg IV - Djakarta to San Francisco

From Djakarta, underway operations will be carried out through the Java Sea, Macassar Strait, Celebes Sea, and thence to the Palau Islands. The Geological Survey has carried out a study of the geology of these islands, and plans for a short study of the underwater portions of the islands' platform will be worked out with the Geological Survey. Most probably this would include hydrography, gravity, magnetics, dredging, coring, and underwater photography. Underway observations would be continued to Guam. On leaving Guam, three more crossings would be made of the Marianas Trench, thence to Honolulu along a line parallel to the track run on the way out. On this leg, any interesting anomalies found on the way out or on this trip would be investigated. From Honolulu to San Francisco, the track would again be along one of the predetermined routes.

Meteorological Program

Space will be made available aboard the PIONEER for two meteorologists. The meteorological program between San Francisco and the Indian Ocean will conform to the needs and desires of the U. S. Weather Bureau. Between Singapore and Djakarta, the program will be an integral part of the Meteorological Program of the International Indian Ocean Expedition. This portion of the PIONEER's operations will be planned in detail with Mr. Shinnors (USWB), Dr. Ramage (U. of Hawaii), and Dr. Portman (U. of Michigan).

Biological Program

The U. S. Coast and Geodetic Survey has neither biologists nor biological sampling equipment. It is, however, willing to cooperate in carrying out the biological program developed for the International Indian Ocean Expedition and will make available aboard space for one or two biologists. This portion of the program will be developed in cooperation with Dr. Ryther (Woods Hole) and the Bureau of Commercial Fisheries.

International Cooperation

Visiting scientists from Manila and Jesselton have been mentioned specifically. When accommodations aboard permit, every effort will be made to have foreign scientists aboard for observation and training. At Manila, Jesselton, Singapore, Rangoon, Calcutta, Trincomalee, Djakarta, and the Palaus, the ship will be open for inspection, and qualified personnel will explain the work of the expedition.

OFFICE OF THE DIRECTOR

U.S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
WASHINGTON 25, D.C.

October 4, 1963

IN REPLY REFER TO:
201

Attached for your information is the present plan for participation by the U. S. Coast and Geodetic Survey Ship PIONEER in the International Indian Ocean Expedition. This is the program as it now stands, although minor changes will undoubtedly be made prior to the February sailing date. I believe we have a good program planned, one that ties in well with both the national and international aims of the IIOE. I will be glad to receive any comments you may wish to make on it!



H. Arnold Karo
Rear Admiral, USC&GS
Director

U. S. DEPARTMENT OF COMMERCE
Coast and Geodetic Survey
Washington 25, D. C.

October 2, 1963

INTERNATIONAL INDIAN OCEAN EXPEDITION
Cruise Plan of USC&GS Ship PIONEER

General

The USC&GS Ship PIONEER sails from San Francisco on Tuesday, February 11, 1964, to take part in the International Indian Ocean Expedition. En route to and from the Indian Ocean routine hydrographic, magnetic, and gravity, observations will be made continuously, and routine meteorological observations as well as plankton tows, productivity measurements, BT observations, and surface salinity measurements will be made on regular schedules. Features of particular interest will be investigated as they are encountered. In the Malacca Straits, Andaman Sea, and Bay of Bengal, work will be concentrated on geological-geophysical investigations of the regional submarine geology with special emphasis on detailed investigations of several submarine canyons. Three north-south profiles of oceanographic stations will be made from 5° N to 5° S across the Equator south of the Bay of Bengal to tie in with the overall physical oceanographic investigations of the IIOE. Biological and meteorological observations are part of and in accord with the IIOE programs in biology and meteorology. Open house aboard the PIONEER for local officials, scientists, and the public will be held at Manila, Calcutta, Colombo, and Djakarta. When possible, shipboard personnel will deliver lectures at these ports to acquaint local scientists with the work of the expedition. On the legs from Djakarta to Guam, lines will be run across the southern Philippine Trench. A detailed investigation of the Palau Trench will be carried out, and crossings made of the Yap Trench and Marianna Trench.

These plans are subject to slight modifications but reflect the PIONEER's program as it has been developed over the past year. The plans for each leg of the expedition are discussed below. Dates of arrival and departure at Manila and subsequent ports are subject to revision after the expedition has started.

Leg I - San Francisco to Honolulu

Leave San Francisco, February 11, 1964, arrive Honolulu February 18.

As during all subsequent underway portions of the trip, there will be continuous trackline hydrography, magnetic and gravity observations, and regular routine meteorological observations. A BT lowering to 300 meters will be made every two hours and salinity determination made of the surface water sample at each

BT station. The track will be offset from previous tracks to extend the area of coverage. Six oceanographic stations for temperature, salinity and dissolved oxygen will be made along this track at the points nearest those similar stations occupied during the PIONEER's 1963 field season. Four stations will be to 2000 meters, two to the bottom. The data from these special stations will be utilized in a continuing program of the Bureau of Commercial Fisheries (Stanford Lab.) aimed at determining the current transport through this section at various times of the year and in different years.

Meteorological observations will be in accordance with standard procedures utilizing the automated shipboard meteorological station provided as part of the IIOE program in meteorology. Biological observations commence after Honolulu. During this leg, trial runs will be made with the Electrosonic Profiler, the deep-sea camera, automated meteorological station, and the heavy-duty deep sea winch to insure that all are functioning properly:

Geophysicist (gravity) C&GS
 Geophysicist (gravity) for training, C&GS
 Mr. Kelvin S. Rodolfo (geologist) Univ. of So. Calif.
 Mr. Austin Weeks (electrosonic profiler), C&GS
 Mr. Reginald Harbison (electrosonic profiler), C&GS
 Meteorologist, Weather Bureau
 Meteorologist, Weather Bureau
 Mr. Byron Hale (deep-sea camera), C&GS

Leg II - Honolulu to Manila

Leave Honolulu February 21, arrive Manila March 7.

At Honolulu two marine biologists from the University of Hawaii will join the expedition. They will handle the productivity work involving at least one stop at 0700 local time each day for a 1/2 hour productivity analysis. They will also carry out special plankton tows for BCF (Honolulu) for which details are not yet available. They will also oversee the collection of plankton samples with the IIOE standard net between Singapore and Djakarta. They will leave the ship on her return to Honolulu.

No specific investigations are planned for this leg other than the standard underway observations which now include plankton and productivity work. Any interesting feature encountered en route will be investigated at the discretion of the Captain and scientists concerned. Insofar as possible the track will be planned to avoid duplication of previous tracks but close enough to others to add to the areal coverage of topography, magnetics, and gravity in this portion of the Pacific.

While at Manila, open house will be held aboard ship to acquaint local officials, scientists, and the public with the work of the expedition:

Additional personnel:

Geophysical (gravity), C&GS
 Mr. Kelvin S. Rodolfo (geologist), U.S.C.
 Meteorologist, Weather Bureau
 Meteorologist, Weather Bureau
 Biologist, University of Hawaii
 Biologist, University of Hawaii

Leg III - Manila to Singapore

Leave Manila March 13, arrive Singapore March 20.

Since no word has been received from scientists or officials at Jesselton, this previously planned stop has been eliminated. In addition to regular underway operations, two extra days of special investigations of the deep and rise northwest of North Borneo are scheduled. Details are being worked out with Dr. Robert Burns (C&GS) and Dr. Robert Fisher (Scripps). The ARGO worked in this area in June 1962, and details of their work must be known before PIONEER's can be fully planned. At least one marine scientist from the Philippines will be aboard to Singapore as an observer. One day of open house will be held at Singapore.

Additional personnel:

Dr. Harris B. Stewart, Jr., C&GS
 Dr. Robert E. Burns, C&GS
 Geophysicist (gravity), C&GS
 Mr. Kelvin S. Rodolfo, U.S.C.
 Meteorologist, Weather Bureau
 Meteorologist, Weather Bureau
 Biologist, University of Hawaii
 Biologist, University of Hawaii
 Marine Scientist, Philippine Islands

Leg IV - Singapore to Calcutta

Leave Singapore March 24, arrive Calcutta April 20.

No word has been received from Mr. H. M. Jeremiah of the National SCOR Committee for Malaya (now Malaysia), but it is possible that one Malaysian scientist may be aboard on this leg.

On leaving Singapore the routine underway observations will be supplemented by routine samplings with the IIOE standard net in accordance with the IIOE Biological Program. In the Malacca Straits there will be a special program of sediment coring and - where practical - rock dredging. This program is planned to determine sediment and rock characteristics in those portions of the Straits not sampled by the Naval Oceanographic Office's work in this area. The detailed track in this area is being planned with Mr. George Keller (NOO) who will join the ship at Singapore specifically for this work in the Malacca Straits.

Profiles with the electrosonic profiler will be made at 5 knots in the Straits, the Andaman Sea, and the Bay of Bengal. This program, coupled with the sediment programs of Mr. Keller in the Straits and of Mr. Rodolfo in the Andaman Sea, and with the hydrographic, magnetic, gravity, heat probe, and camera operations, is directed toward providing data contributing to the solution of several specific problems. In the Straits, the intent is to check on features in a narrow strait which can be traceable to features on the bordering land. In this case it involves possible projection of the Malayan anticlines and synclines into the Straits, the possible extension of the large northeastern Sumatra sedimentary basin, and extension of a possible fault marking the eastward margin of the Andaman Sea basin. This fault is traceable to the Irrawaddy delta from northern Burma and marks the eastern limit of the Burmese oil basin. Sediment studies in the Irrawaddy delta are to determine the basinward variations in sediment characteristics, especially clay mineralogy, and for purposes of comparison with the Ganges delta. It is hoped to trace the continuation of the volcanic belt from the delta through the volcanic Narcondam and Barren Islands to the seaward extension of the Barisan Range of volcanoes of western Sumatra. This volcanic ridge at its northern end is covered by deltaic sediments but apparently is the inner volcanic arc of the island arc complex. This ridge will be investigated together with the parallel trough just east of the Andaman and Nicobar Islands. This trough is probably a northern continuation of the inner trough between Sumatra and the offshore islands to the west. At least two profiles will be made across the Andaman-Nicobar Ridge and into deep water to the west. These crossings will provide sediment samples to delineate the contrast in sedimentary environment between the Andaman Sea and the open ocean. Rock dredging, bottom photography, electrosonic profiling, echo sounding, and gravity and magnetic measurements will all be utilized in attempting to understand the complex geology of the area.

Additional projects will include (1) dredging midway between North Andaman and the headland of the Arakan Range, where a few calcareous sandstone pebbles were recovered from grab samples taken by SERRANO in 1961. (2) Sediment sampling across the ridge through Ten-degree Channel to provide additional data on the foraminifera to correlate with the work of Schwager on samples off Car Nicobar Island taken by the Australian frigate NOVARA in the last century, and (3) sediment sampling in the Gulf of Martaban to permit comparison between Irrawaddy sediments and those from the Sittang and Salween Rivers.

Delineation of the detailed trackline through the Straits of Malacca and Andaman Sea is not now possible. A tentative trackline will be available only after further discussions with Fisher of Scripps on the results of the ARGO's two crossings of the Andaman-Nicobar ridge in 1962. Three weeks are tentatively programmed for the Malacca Straits - Andaman Sea work, and the actual tracklines throughout much of the area will of necessity be determined in the field on the basis on the results being obtained.

From the Andaman Sea, the PIONEER on about April 14 will move into the Bay of Bengal. Underway operations including tows with the IIOE standard net and standard IIOE meteorological observations will continue along 16° N to approximately 88° E, thence north to 18° N and east at least to the 100-fathom curve off the coast of Burma. By sawtooth legs along the slope west of the Burmese coastal islands, PIONEER will proceed northwest to 20° N. On this portion of the track, special attention will be paid to investigating the offshore continuation of structural features of the Arakan arc. Offshore basins are possibly the result of Tertiary or recent faulting. Dredge sampling will be made as appears practical. PIONEER on reaching 20° N will move west across the Ganges Canyon to 88° E, and from there direct to Calcutta.

Any topographic, magnetic, gravity, sub-surface structural or other anomaly found along these tracks will be investigated more fully as deemed practical by the Captain in consultation with the scientists concerned.

Special care will be taken along these east-west lines to look for any indications of the southerly extension of the Ganges Canyon. This feature has been surveyed in some detail by the Pakistan Navy as far as the edge of the continental shelf. Lines run by the GALATHEA showed it to extend beyond the shelf, but its southerly extent is unknown. It is possible that the valley found by the ALBATROSS east of Ceylon and the leveed channel reported by Knauss as having been crossed at the Equator at 87° E may be southerly continuations of this canyon.

At Calcutta the PIONEER will remain from April 20 to 28 for refueling, provisioning, some change of personnel, open house, and a series of lectures and meetings with local scientists. The U. S. Information Service at Calcutta reports that six institutions have already offered to cooperate--the Geological Survey of India, Zoological Survey of India, Calcutta University, Jadavpur University, the Bose Institute, and the Association for the Cultivation of Science. Two days of scientific sessions will be planned in addition to open house on at least two days.

Additional personnel:

Dr. Harris B. Stewart, Jr., C&GS
 Dr. Robert E. Burns, C&GS
 Mr. Reginald Harbison (electrosonic profiler), C&GS
 Mr. Austin Weeks (electrosonic profiler), C&GS
 Mr. Byron Hale (deep-sea camera), C&GS
 Geophysicist (gravity), C&GS
 Mr. George Keller (sediments), NOO
 Mr. Kelvin S. Rodolfo (sediments), U.S.C.
 Meteorologist, Weather Bureau
 Meteorologist, Weather Bureau
 Biologist, University of Hawaii
 Biologist, University of Hawaii
 (?) Marine Scientist, Malaysia

Leg V - Calcutta to Colombo

Leave Calcutta April 28, arrive Colombo May 19.

Standard underway operations will continue as before, but to them will be added special investigations of the Ganges delta and of the Ganges and Trincomalee submarine canyons. Dr. Robert S. Dietz (C&GS) and Dr. Francis P. Shepard of Scripps will board at Calcutta specifically for these studies. Leaving Calcutta, PIONEER will go directly to the Ganges delta. On two east-west lines across the delta, sediment samples will be taken and electrosonic profiles run in an attempt to compare this delta with the Irrawaddy delta. Where the latter delta seems to be building forward rapidly, the Ganges delta on the other hand, is advancing slowly. Following these sections, the ship will move to the Ganges Canyon at about 21° N, 89° E. By a series of crossings, the canyon will be followed south into the central Bay of Bengal. Sediment cores, dredge samples, electrosonic profiles, bottom photographs, and detailed development of features found by the standard underway measurements will be undertaken as decided upon in the field by the Captain in consultation with the scientists concerned. If this canyon terminates well north of the latitude

of Ceylon, the east-west lines previously run in the eastern Bay of Bengal shall be continued westward from 88° E to the coast of India. In this event, it might be possible to investigate in detail Krishna, Mahadevon, and Andhra submarine canyons (17° 54' N, 84° 16' E to 17° 44' N, 84° 02' E) discovered earlier in the IIOE.

Upon reaching the southern termination of the Ganges Canyon or after completing the east-west lines, PIONEER will head for Trincomalee on the northeast coast of Ceylon. H. O. charts 2523 and 3689 show hard ridges through which has been cut a submarine canyon that heads in Trincomalee and Goddiyar Bays. The canyon has apparently been cut in quartzite and other hard Pre-Cambrian rocks and extends seaward to depths of at least 800 fathoms where the existing soundings terminate.

In shallow depths, divers will investigate the canyon head using SCUBA gear. All equipment which can provide data on this canyon will be utilized in an investigation of which the details will be planned in the field by the Captain in consultation with Drs. Shepard, Dietz, Stewart, and Burns.

Following this canyon study, the ship will go directly to Colombo for fuel, resupply, and open house. It is possible that one marine scientist from India and one from Ceylon will take part on the leg from Calcutta to Colombo. At Colombo all plankton samples collected with the IIOE standard net will be forwarded together with the location of each sample to the Indian Ocean Biological Center, CSIR, University Oceanographic Laboratories, Ernakulam, Cochin, India. The official IIOE stencil should be used on all such shipments. At Cochin, determination will be made of displacement volume, and sorting will be accomplished for distribution to specialists in the various zooplankton groups.

Additional personnel:

Dr. Harris B. Stewart, Jr., C&GS
 Dr. Robert S. Dietz, C&GS
 Geophysicist (gravity), C&GS
 Mr. Austin Weeks, C&GS
 Mr. Reginald Harbison, C&GS
 Mr. Byron Hale (deep-sea camera), C&GS
 Dr. Francis P. Shepard, SIO
 Mr. Kelvin S. Rodolfo, U.S.C.
 Meteorologist, Weather Bureau
 Meteorologist, Weather Bureau
 Biologist, University of Hawaii
 Biologist, University of Hawaii
 Marine Scientist, India
 Marine Scientist, Ceylon

Leg VI - Colombo to Djarkarta

Leave Colombo May 25, arrive Djarkarta June 23.

If the southern limits of the Ganges Canyon were not found prior to the work in Trincomalee Canyon, the Ganges Canyon investigation will be continued southward until the terminus is reached. Otherwise PIONEER will go directly to 5° N, 84° E to start the first of three north-south profiles of oceanographic stations from 5° N to 5° south along 84° E, 88° E, and 92° E. Standard underway observations will be run to the start of these profiles and - where practical - between stations and between profiles. Oceanographic stations will be occupied for temperature, salinity, dissolved oxygen and phosphate along each profile at 5° , 4° , and 3° , and at $1/2$ degree intervals to the Equator for a total of 17 stations along each profile. The stations at 5° , 3° , and 1° N and S will be deep stations to the bottom, the others will be to 2000 meters. After the station at the Equator and 92° E, the ship will move due west to 90° S. The IIOE has designated 0° at 90° E as a standard station to be occupied by all ships in the area. At this point an oceanographic station will be observed to 2000 meters with bottles at standard depths. The ship will then return to the profile at 0° $30'$ S, 92° E and continue station observations as planned. Work done on the LUSIAD expedition under Dr. Knauss showed that the salinity structure in the region of the thermocline necessitated a 10-meter bottle spacing in that region for adequate definition. For this reason it is planned that PIONEER will use 36 bottles between the surface and 1200 meters at the nine stations between 2° N and 2° S. Bottle spacing below 1200 meters will be at standard depths.

Upon completion of these three sections of oceanographic stations PIONEER will make three crossings of the northwestward extension of the trend of the Java Trench. The first will be from 5° S, 92° E to Sumatra in the general area of Padang (1° S, 100° $30'$ E), from thence SSW across the trend to the latitude of the Sunda Strait, thence due east through the Sunda Strait to Djakarta. The purpose of these profiles is to determine the features of the inner and outer troughs on opposite sides of the Mentawai Island Chain. Supplementing the standard underway investigations will be heat probe, dredging, coring, deep-sea camera, and electrosonic profile studies as deemed worthwhile by the Captain in consultation with the pertinent scientists.

Upon arrival at Djakarta, open house will be held aboard PIONEER and local lectures will be arranged through USIA. In addition, a one-day trip out of Djakarta will be planned to acquaint Indonesian scientists with the work of the PIONEER. The number of guest scientists that can be accommodated will be determined by the Captain. A one-day trip to Krakatoa and the eastern flank of the Java Trench is tentatively planned. At Djakarta those biological samples obtained with the IIOE standard net will be shipped to the Indian Ocean Biological Center at Cochin, India.

Additional personnel:

Geophysicist (ESP), C&GS
 Geophysicist (gravity), C&GS
 Mr. Ronald K. Reed (Oceanographer), C&GS
 Mr. Richard B. Perry (Geological Oceanographer), C&GS
 Oceanographer, C&GS
 Oceanographer, C&GS
 Mr. Mark Schuldt (Deep-sea camera), C&GS
 Mr. Kelvin S. Rodolfo, U.S.C.
 Meteorologist, Weather Bureau
 Meteorologist, Weather Bureau
 Biologist, University of Hawaii
 Biologist, University of Hawaii

Leg VII - Djakarta to Palau

Leave Djakarta June 29, arrive Palau (Koror) July 6.

Standard underway observations will be made along the most direct route to the southern end of the Philippine Trench at approximately 6° N, 128° E. In this general area, three crossings will be made of the trench with standard underway techniques. On the third crossing, an attempt will be made to dredge the deep slope and to obtain photographic coverage of the bottom and sides of the trench. The electrosonic profiler, corer, and other available equipment will be utilized as seems practicable.

Following the Philippine Trench work, PIONEER will go directly to Koror in the Palau Islands.

Additional personnel:

Geophysicist (ESP), C&GS
 Geophysicist (gravity), C&GS
 Mr. John W. Kofoed (Geological Oceanographer), C&GS
 Mr. Mark Schuldt (Deep-sea camera), C&GS
 Mr. Ronald K. Reed (Oceanographer), C&GS
 Meteorologist, Weather Bureau
 Meteorologist, Weather Bureau
 Biologist, University of Hawaii
 Biologist, University of Hawaii

Leg VIII- Palau (Koror) to Guam

Leave Koror July 7, arrive Guam July 18.

This leg involves a fairly detailed investigation of the Palau Trench and limited crossings of the Yap and Marianna Trenches. At Koror, Dr. Joshua Tracey and Mr. Gilbert Corwin of the Geological Survey will come aboard to take part in these trench investigations.

The Geological Survey has carried out extensive studies of the emergent portions of the Palau Islands. Scripps geologists aboard the BAIRD in 1962 did some work in the Palau Trench, but gravity and magnetic data were not obtained. This trench is quite complex due to recent (?) volcanism, and detailed studies here could be quite significant.

The PIONEER will undertake gravity, magnetic, and hydrographic profiles along the south and east sides of the island group, at least three crossings of the trench, and a profile along the western side of the group, including if possible a profile up into the lagoon approaching Koror from the west. The electrosonic profiler will be used on at least one crossing of the trench and elsewhere where its use appears justified. Similarly the deep dredge, heat flow probe, and deep-sea camera would also be used. Details of the BAIRD work have been requested and will be considered in the detailed planning of this work.

The Yap Trench will be crossed once southeast of Ngulu Atoll to provide gravity, magnetic and PDR profiles to tie in with the earlier BAIRD work.

The PIONEER will then make at least three crossings of the Marianna Trench in the area of the Challenger Deep in a program coordinated with the earlier work of the BAIRD and MAURY. As in the Palau Trench, decisions on the extent to which the heat probe, electrosonic profiler, and deep-sea camera will be used will be made in the field, but an attempt will be made to dredge rock samples from the side of this trench. Upon completion of this work the ship will move directly to Guam for fuel and supplies.

Additional personnel:

Geophysicist (ESP), C&GS
Geophysicist (gravity), C&GS
Mr. John W. Kofoed (Geological Oceanography), C&GS
Mr. Mark Schuldt (Deep-sea camera), C&GS
Mr. Ronald K. Reed (Oceanographer), C&GS
Dr. Joshua Tracey, Geological Survey
Mr. Gilbert Corwin, Geological Survey

Meteorologist, Weather Bureau
 Meteorologist, Weather Bureau
 Biologist, University of Hawaii
 Biologist, University of Hawaii

Leg IX - Guam to Honolulu

Leave Guam July 20, arrive Honolulu July 31.

This leg will entail one crossing of the Marianna Trench on a straight run from Guam to Honolulu. All standard underway observations will be made along a track offset from previous ones through this area. At the discretion of the Captain in consultation with the pertinent scientists, at least one seamount along this leg will be developed and an attempt made to dredge rock samples from the crest. A guyot should be picked for this investigation if one is encountered.

The marine biologists, their equipment, and the samples for BCF (Honolulu) will be disembarked on arrival at Honolulu.

Additional personnel:

Geophysicist (gravity), C&GS
 Meteorologist, Weather Bureau
 Meteorologist, Weather Bureau
 Biologist, University of Hawaii
 Biologist, University of Hawaii

Leg X - Honolulu to San Francisco

This will be a straight run with all underway observations except the biological ones. The track will be slightly offset to cover a new line while adding to the areal coverage of hydrographic, gravity, and magnetic data.

Additional personnel:

Geophysicist (gravity), C&GS
 Meteorologist, Weather Bureau
 Meteorologist, Weather Bureau

Navigation

Operational shipboard equipment for TRANSIT navigation will not be available for this expedition. Navigation will be limited to Loran-A and Loran-C where reception is possible, and elsewhere by standard celestial and dead reckoning techniques.