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Cruise Report, INDOPAC Expedition, Legs 9 through 16 January 12–July 31, 1977

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Edited by

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F. N. Spiess, Director Marine Physical Laboratory 23 November 1977

ABSTRACT

In the first half of 1977, the R/V *Thomas Washington* of the Scripps Institution of Oceanography continued work on INDOPAC Expedition, starting from Guam, Marianas, and ending in San Diego. Geophysical and geological programs were carried out in the marginal seas of southeast Asia; biological and physical oceanographic programs were carried out near Guam, and in the central and eastern Pacific. This report includes a brief summary of the work on each cruise leg, a chronology, cruise tracks, and lists of stations, samples, and observations. Work on leg 13 was in cooperation with the K/M *Samudera* of the Indonesian Institute of Sciences.

INTRODUCTION

INDOPAC Expedition started in March, 1976, when the R/V *Thomas Washington* left San Diego and headed across the Pacific carrying out programs in physical oceanography that terminated at Guam in June, 1976. Programs in marine geology and geophysics, mostly part of the SEATAR cooperative program of study of the tectonics and resources of southeast Asia offshore areas, were carried out from June to September, 1976 concluding at Guam. The ship went into lay-up status in Guam, in October, pending resumption of the work. A cruise report (SIO Reference 77-5) was issued covering the work on INDOPAC Legs 4 through 8.

Commencing in January, 1977, work resumed. The first program was one in benthic biology carried out in the Mariana Trench by Aristides Yayanos. In addition to the primary work, geophysical staff carried out tests of a newly installed 24-channel seismic reflection system to be used on later cruise legs. After returning to Guam, the ship proceeded to the Molucca Sea for geophysical work under Eli Silver and Russell Raitt, continuing the cooperative program of study (with Indonesia) of the structure of the Molucca collision zone, and then went on to Singapore. The following leg, under Joseph Curray, carried out work in the Andaman Sea in cooperation with the governments of Thailand and Burma, with concentration on multi-channel seismic reflection work and seismic refraction work. The leg ended at Phuket, Thailand.

Legs 12 and 13 were carried out in cooperation with the government of Indonesia, as part of the Sunda Transect of the IDOE SEATAR program. Curray and Daniel Karig were in charge on leg 12, which was

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devoted to sampling, heat flow, and single-and multi-channel seismic reflection work. Curray and George Shor were in charge on leg 13, which was primarily two-ship refraction work with the Indonesian research vessel *Samudera*. After completion of this, the *Washington* returned to Honolulu on leg 14, with some work in the Banda Sea en route to complete work started on leg 8, and carried out a program of XBT measurements in the north Equatorial current.

Leg 15, in a concentrated study area north of Honolulu, was an ecological study in the North Pacific gyre, under Kenneth Smith. Leg 16, which returned the ship to San Diego, combine biological and physical oceanographic studies en route under Michael Mullin.

Ancillary observations

In order to make maximum use of available time and facilities, various ancillary operations are made from SIO ships whenever they do not conflict with the primary purpose of the cruise leg. On this cruise, these included echo sounding, magnetic observations, and gravity measurements underway on most cruise legs. Neuston tows were made nearly every time that the ship slowed down for a station or got underway after a station, and XBT drops were made in conjuction with all refraction stations as well as on cruise legs with physical oceanography programs. Echo sounding was carried out primarily with a 3.5 kHz system, with a 12 kHz echo sounder operated in addition some of the time. Weather observations are made routinely four times a day by the bridge watch. Dipnetting was carried out on some stations.

INDOPAC LEG 9
CHIEF SCIENTIST: A. ARISTIDES

YAYANOS
Physiological Research Laboratory
Scripps Institution of Oceanography
12–23 January (Guam to Guam) 1977

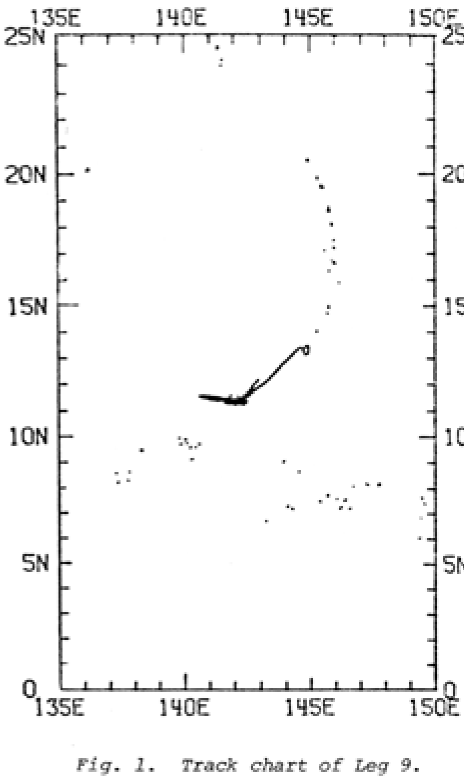

Fig. 1. *Track chart of Leg 9.*

The objectives of Leg 9 were mainly biological but in part geophysical. The objectives of the biology program were to determine the approximate density of amphipods in the Marianas Trench with the use of baited cameras, to sample the bottom of the trench at different depths for amphipods, to sample the deep water of the trench with trawls, to evaluate freeze drying as a technique for preserving deep sea samples thus possibly replacing the need for storage at high pressure, and to retrieve amphipods alive in a pressure-retaining free-vehicle amphipod trap. All objectives except the last were realized. It is noteworthy, however, that the pressure-retaining amphipod traps (after a few explainable mistrials) did function as pressure-retaining devices as demonstrated by the recovery of a sample of water at a pressure of more than 1,000 bars. The camera and all traps were free vehicles.

The geophysicists successfully tested the multi-channel seismic reflection system used on Legs 11 and 12. Bathymetric measurements were recorded continually on this leg.

Chronology

January 11. In harbor, Agana, Guam, balancing the multi-channel reflection system streamer for proper buoyancy.

January 12. En route to the Challenger Deep, Marianas Trench. Began bathymetric profiling. Rigged biological gear for use.

January 13. Dropped a free vehicle 35 mm still camera in 10,663 meters of water to be recovered after approximately 50 hours. The camera was focused on bait intended to attract amphipods. A pressure-retaining amphipod trap (PRAT 1) was dropped in 10,196 meters of water and also two free traps designed for amphipod population studies. A Tucker trawl for midwater organisms was completed and a second trawl was started.

January 14. When the second trawl was recovered it was found that the trawl had been damaged, so repairs were started. PRAT 1 was recovered. It contained amphipods, confirming their presence in the trench, and had a partial retention of the trench bottom pressure. PRAT 1 was put down again and an Isaacs-Kidd midwater trawl (IKMT) was started.

January 15. Brought in the midwater trawl and its catch and recovered the camera put down January 13. It had a flooded strobe light housing. This was repaired and the camera was put down a second time. PART 2 was put in. PRAT 1 was recovered and contained many amphipods but had not retained any pressure.

Originally there had been a design flaw in PRAT 1. This was corrected and PRAT 1 was used successfully on Expedition EURYDICE (1974–5). Later in this expedition (INDOPAC Leg 15), it was discovered that the correction had not been permanent. This explains why the pressure traps were not working properly at this earlier time. The flaw was then permanently corrected and the traps were very successful on Leg 15.

A population study trap was put in and an Isaacs-Kidd midwater trawl was taken.

January 16. The multi-channel seismic reflection system was successfully tested. PRAT 2 was recovered. There were no amphipods in it but it had retained pressure close to that at the bottom of the

trench. The population study trap was also empty when it was recovered. Catching no amphipods is unusual but it happens occasionally for no known reasons. Another population study trap was put down in a shallower part of the trench (ca. 7,353 meters) and an Isaacs-Kidd midwater trawl was started.

January 17. Unfortunately the midwater trawl was lost but the dredge wire was not lost or damaged. The camera was recovered with excellent pictures of amphipods in the Marianas

Trench at 10,559 meters. PRAT 1 was dropped in 10,592 meters of water. The camera was put down for the third time.

January 18. The Tucker trawl was repaired. Many improvisations had to be made but it was tried again. The attempt to use it was unsuccessful and ended trawling operations. PRAT 1 was recovered and contained amphipods but none of them were in the pressure-retaining part of the trap and no pressure had been retained. PRAT 2 was put down.

January 19. A free-vehicle line with baited hooks was put out. PRAT 2 was recovered and contained amphipods although none were in the pressure-retaining chamber. The pressure in the chamber was over 1000 bars which is within a few percent of the pressure calculated for the trench bottom. The population study trap was recovered with a large catch of amphipods. Laboratory studies of these samples began at once. As it was time for the camera to come up, a search for it was started.

January 20–23. PART 1 was put down and recovered with a large catch of amphipods. This provided good samples for microbiological studies and work on amphipod biology. More time was spent searching for the free camera but it was never found. On the way back to Guam the multi-channel seismic reflection system was successfully tested a second time.

INDOPAC LEG 10
CO-CHIEF SCIENTISTS:
ELI SILVER
Earth Sciences Board
University of California, Santa Cruz
and
R. W. RAITT
Marine Physical Laboratory
Scripps Institution of Oceanography
25 January (Guam) to
21 February (Singapore) 1977

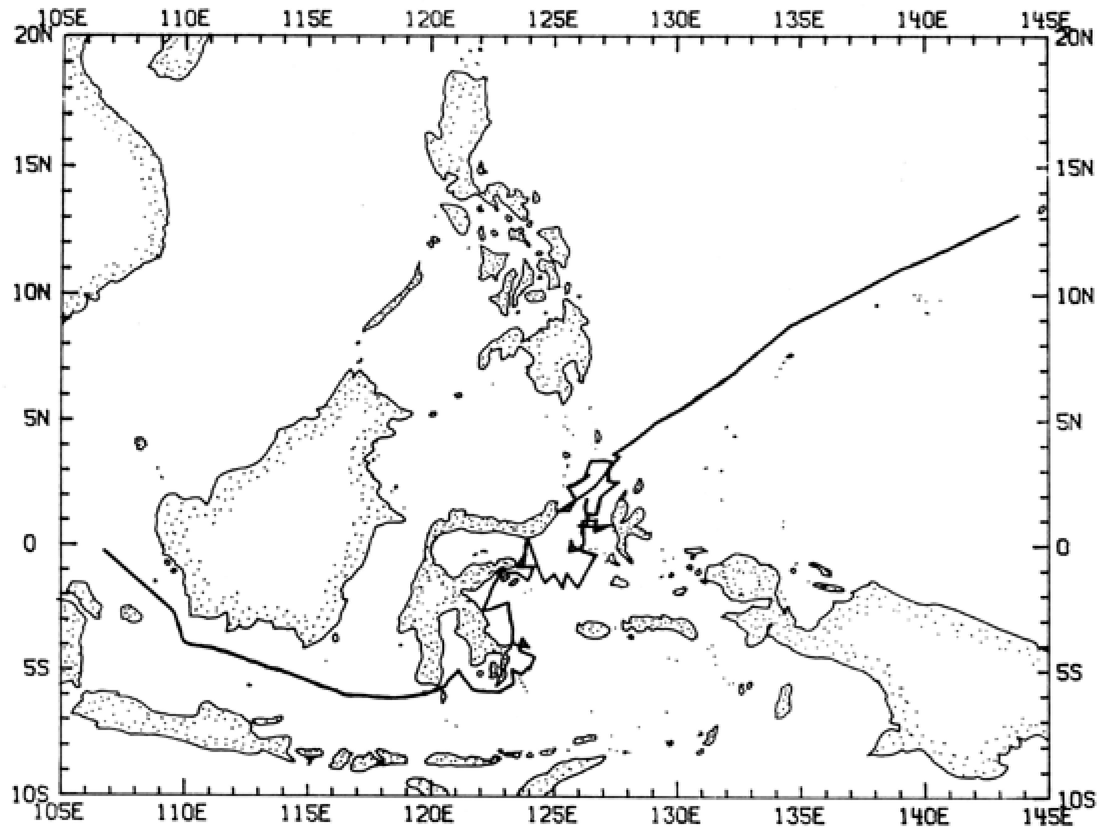

Fig. 2. Track chart of Leg 10.

Fig. 2. *Track chart of Leg 10.*

The combined data from INDOPAC Legs 7, 8 and 10 in the Molucca Sea region consist of a regional seismic reflection and gravity survey, 13 seismic refraction profiles, 7 dredge hauls, plus onshore observations on several of the islands. These data confirm the suggestion that the Molucca Sea is a collision zone between facing island arcs, and provide valuable insight into the collision process. Our seismic reflection data show that the Halmahera and Sangihe arcs are separated from the Molucca Sea deposits by bounding thrusts which dip at low angles away from the arcs, in toward the Molucca Sea. Between the thrusts the deformation is too intense to be resolved by single-channel reflection techniques and is designated the collision complex. Narrow troughs as deep as 3 km mark the surface outcrops of the thrusts. The western thrust can be traced north to Mindanao and south to the Sula Islands. The eastern thrust extends from the south end of Halmahera north past Snellius Ridge to intersect the Philippine Trench west of southernmost Mindanao. The south boundary of the collision complex is a low-angle thrust just north of the Sula Islands separating gently north-dipping Mesozoic and younger strata of the Sula Islands from the overriding collision complex. This finding is in sharp disagreement with most previous suggestions

of transform faulting in this area.

Gravity over the Molucca Sea collision complex is very low, with negative anomalies in excess of -250 mgal in water depths as shallow as 2 km, indicating a very great thickness of low-density material. Models indicate thickness in excess of 10 km in parts of the collision complex.

Dredge hauls in the Molucca Sea and geologic observations on Mayu and Tifore Islands indicate that at least part of the collision complex is a melange. Tertiary sediments are highly deformed and shales are pervasively sheared. Peridotite and schist crop out on Mayu, sandstone and highly sheared basalt on Tifore. Serpentine is a common dredge product and gabbro was found in one dredge haul.

Seismic refraction data confirm the great thickness and melange nature of the collision complex, but these factors make interpretation difficult. Seismic attenuation is very high and quite often energy from shots up to 261 1b is highly attenuated in 30 seconds of direct-wave travel time (45 to 50 km). Several profiles reach a layer of velocity 5 to 6.8 km/sec at depths of 8 km or greater. One profile showed good evidence of significant lateral variations in velocity.

Chronology

January 25. Loaded explosives and left Guam.

January 26–28. En route to the Molucca Sea.

January 28. Ran a test refraction line with drifting sonobuoys while underway in the Philippine Sea area west of the Palau Islands.

January 29–30. En route to the Molucca Sea.

January 31. Went into Bitung Harbor, Sulawesi, Indonesia, and picked up three Indonesian participants in the expedition. After leaving Bitung, ran refraction station 10-1 using drifting sonobuoys. Later started dredge 11.

February 1. Completed dredge 11 and ran refraction stations 10-2 and 10-3 west and east of Talaud Ridge. They are roughly parallel and used drifting sonobuoys. Station 10-2 is poor as the buoys failed after about one hour. There is a good sediment velocity but not much evidence of basement. No airgun records were taken as information from them is dubious in the melange. Station 10-3 gives excellent sediment and basement arrivals (5 km/sec). The buoys lasted only 1 to 2 hours. The magnetometer and airgun reflection system were secured during station 10-3 with only the shot break streamer out. The gravimeter was working but having some navigation-logging problems. Dredge 12 was taken about four hours after the end of station 10-3. Both stations 10-2 and 10-3 are north-trending.

February 2. Ran refraction station 10-4. This is also a north-trending station and is located off northern Halmahera. It is a reverse with two moored buoys. The outgoing run is good. The moored buoys were quieter than the drifting sonobuoys. The refractions were very low frequency; it has been suggested that there might be attenuation of the high frequencies in the melange.

February 3. Dr. Silver and two of the Indonesian participants went ashore at Mayu Island. Their small boat overturned in the surf but was righted without damage. After they had collected rock samples ashore, they returned to the ship, and dredge 13 and neuston tow 1 were taken. During this time, batteries for the moored buoys were being charged. Refraction station 10-5, a reverse with two moored buoys, was started. It is a north-trending station located off the northern end of sulawesi in the Molucca Sea.

February 3–4. Launching the second buoy for this station, buoy B, had to be delayed until the batteries for the buoy were charged. It was moored within sight of Mayu Island. After the station ended there was some difficulty retrieving the first buoy due to currents in the area.

February 4. Took dredge 14.

February 5. Took neuston tow 2 and ran refraction station 10-6 off central Halmahera. It is a north-trending reverse using two moored buoys. There was trouble with low-frequency noise on buoy A, possibly something banging on something. Buoy A was retrieved and relaunched. It recorded good water-wave arrivals as there was a 70-m mixed layer and also recorded sediment and basement arrivals. There was some difficulty launching buoy B. At the time it was not sure that it was anchored but it was. This appears to be a good station and both buoys were retrieved without much trouble in spite of rain.

February 6. Members of the scientific party went ashore at Tifore Island to collect rock samples. After their return, seven hours were spent taking dredge 15. Neuston tow 3 was then taken.

February 7. Ran refraction station 10-7 between northern Halmahera and Mayu Ridge, south of station 10-5. It is a north-trending reverse using two moored buoys. The outgoing run from buoy A showed thick sediments and high attenuation; there was a velocity of 3.5 km/sec out to a water-wave time of 24 seconds. While buoy B was launched smoothly, the hydrophone was noisy after launching. When the buoy was retrieved it was found that two floats from the surface string were tangled around the weight. This may have caused the noise. The reverse run was much like the first run with high attenuation and no velocity greater than 3.5 km/sec.

February 7–8. Took dredge 16.

February 8. Ran refraction station 10–8 off southern Halmahera, an east-west-trending line just south of the equator. It is a reverse with two moored buoys. There was high attenuation again on both runs. On the first run there was a velocity of 3.5 km/sec and on the reversing run possibly 4.5 to 5 km/sec as well. The last shot caused a bioluminescent light show.

February 9. Underway gravity and reflection profiling off the Sula Islands.

February 10. Ran refraction station 10-9, a north-trending line, in the Gorontalo Basin south of the north arm of Sulawesi. This is a drifting sonobuoy station. About the last third of the station was run going up the south wall of the basin. Basement arrivals were received but no mantle arrivals.

February 11. Ran refraction station 10-10, an east-west line east of the east arm of Sulawesi. It is a reverse using two moored sonobuoys. There are good sediment and basement arrivals and a strong intermediate-frequency arrival about three minutes after the shot went off. This intermediate-frequency arrival may be a water-wave reflection from the north arm of Sulawesi across the basin. A large seaquake was recorded on both buoys on the second line. Neuston tow 4 was taken while the anchor line for buoy B was being recovered.

February 12. Ran refraction station 10-11. This a northeast-southwest line in Selat Peleng, between the east arm of Sulawesi and Peleng Island. Drifting sonobuoys were used. The station crosses a large ridge going from 500 fms to 200 fms to 400 fms. There were good arrivals on 20-1b shots for most of the run. The sonobuoys died after about an hour. A basement velocity of 5 km/sec was received.

February 13. Gravity and reflection profiling off the southeast and southern arms of Sulawesi.

February 14. The buoy tapes were played back and it was discovered that the recorded signal was greatly attenuated compared to the telemetered signal. It was decided to lower the input impedance of the tape recorders.

February 15. Standard watch standing.

February 16. The ship reached the continental shelf en route to Singapore and the underway watch was secured. Work on reducing data was continued as far as the weather would allow. It was quite rough with strong currents.

February 17–18. En route to Singapore.

February 19. A test station for the modified seismic recording buoys was run. Two buoys were launched about one-half mile from each other and a run of about one-half hour was made and the buoys were picked up.

February 20. En route to Singapore.

February 21. Arrived at Singapore.

INDOPAC LEG 11
CO-CHIEF SCIENTISTS:

J. R. CURRAY
Geological Research Division
Scripps Institution of Oceanography
and
D. G. MOORE
Deep Sea Drilling Project
Scripps Institution of Oceanography
1 March (Singapore) to 21 March (Phuket, Thailand) 1977

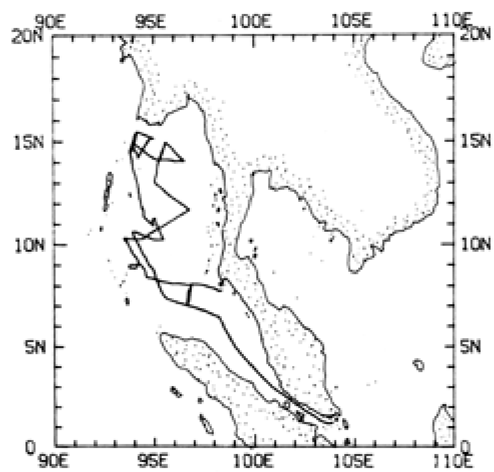

Fig. 3. Track chart of Leg 11.

Fig. 3. *Track chart of Leg 11.*

The objective of Leg 11 was a geological and geophysical study of the Andaman Sea. Previous studies, conducted largely on TASADAY and EURYDICE Expeditions, (on the R/V *Thomas Washington* in 1973 and 1974–75), had shown that the Andaman Sea is an extensional basin, opening in a northwest-southeast direction behind the oblique subduction zone of the northwestern Sunda Arc. In contrast to many extensional basins of the western Pacific, identifiable oceanic magnetic anomalies had been discovered in the Andaman Sea. The plate edge between the "China" plate lying to the east, including the Malay Peninsula, eastern Burma highlands, and most of Sumatra, and the small Burma plate on the west is a complex system of short segments of spreading rifts and transform faults. Our objectives were to further delineate magnetic anomalies to date the present phase of opening, to delineate the plate edge and eastern margin in better detail as an example of an early stage of evolution of a rift-type continental margin, and to determine the nature of the crust underlying marginal portions of the sea.

We were joined in these attempts by two geologists from the Thailand Bureau of Mineral Resources, Mr. Suvit Sampattavanija and Mr. Chiramit Rasrikriengkrai. A visit by Curray to Rangoon immediately prior to the departure of the ship from Singapore concluded arrangements for a cooperative study of crustal structure underlying the continental shelf at the north end of the Andaman Sea with scientists of MYANMA Oil Co., Rangoon, Burma. Mr. Aung Tin U, Chief Geophysicist of M.O.C., accompanied us on the ship, and Mr. Paul O'Neill worked with an M.O.C. shore party, receiving our refraction shots with a 24-channel array at two sites on the shores of Irrawaddy Delta.

All tracks included complete underway geophysical work, including 3.5 kHz echo sounding, magnetics, gravity, and seismic reflection with two sweeps and frequency bands of analog single-channel recording, and some also with 24-channel digital recording.

For the latter, we were the first users of Scripps' new 24-channel digital seismic reflection system, assembled from components donated to the institution by the Exxon Corporation, integrated with a high-density format tape recording system of our own design, and made operative by Scripps personnel with funding from Scripps Industrial Associates and Mr. Cecil Green, of La Jolla, California.

The expedition work was very successful. Three long reversed refraction lines were run on the Burma shelf, with shots received from 150 to 200 km away by the M.O.C. shore party on land, and one was run in the Mergui-North Sumatra Basin. About 2700 km of multi-channel seismic reflection and about 1800 km of single-channel analog seismic reflection were run. Several successful heat-flow stations were taken, and one rock dredge haul was recovered from Alcock Seamount. An average of four XBT's were taken daily.

Chronology

March 1. Underway from Singapore, 27 hours late, en route to Andaman Sea.

March 2. En route through the Malacca Strait to the Andaman Sea. Started complete underway geophysical surveying.

March 3–6. The multi-channel reflection system was put out as soon as deeper water was reached and records were taken on it until March 7, when the heat-flow station was reached. Three airgun-sonobuoy stations were run, one on March 4 (11-1), and two on March 6 (11-2, 11-3).

March 7. A gravity core (38) was taken and heat-flow stations (1 and 2) were taken with neuston tow 11-1 taken between them. Underway geophysical work was resumed with single-channel analog reflection, and two airgun-sonobuoy runs (11-4, 11-5) were made.

March 8. Dredge 17 was taken, recovering volcanic rocks from Alcock Seamount, and the ship continued towards the Irrawaddy Delta. An airgun-sonobuoy refraction station (11-5) was run.

March 9. The first of three explosive seismic refraction stations off the Irrawaddy Delta (11-6) was run with recording buoys and sonobuoys. These buoys were also used for airgun wide-angle reflection and refraction studies. Large shots from this station were monitored by a MYANMA Oil Corp. shore station.

March 10. The recovery of the second moored buoy was completed, and neuston tow 11-2 was taken. An airgun-sonobuoy refraction station (11-7) was run. The second moored buoy explosive refraction station (11-8) was run. The moored buoys and sonobuoys were again used for airgun wide-angle reflection/refraction runs and large shots were monitored by the M.O.C. shore station.

March 11. After the recovery of the moored buoys, the multi-channel reflection system was put out.

March 12. En route to the third moored buoy station running the multi-channel reflection system.

March 13–14. Neuston tow 11-3 was taken while the multi-channel reflection system was being brought in. Then two moored tape-recording buoys for the third explosive refraction station (11-9) were launched, with sonobuoys (for airgun wide-angle reflection/refraction studies) in between. Large shots from this station were monitored at a second M.O.C. shore station. After the shooting run for this reversed refraction line, the moored buoys were recovered, and the multi-channel reflection system was put out again to continue reflection surveying. An additional airgun-sonobuoy station (11-10) was run later on the 14th.

March 15–20. Continual multi-channel reflection surveying. There was one airgun-sonobuoy station March 15 (11-11), two March 16 (11-12, 11-13), one March 17 (11-14), and two March 19 (11-15, 11-16). The multi-channel reflection system was brought aboard late on March 19, and neuston tow 11-4 was taken.

March 20. A moored tape-recording buoy for a north-south explosive refraction line (11-17) in the Mergui-North Sumatra Basin was launched. The moored buoy was at the north end of the line with sonobuoys along the line and at the south end. After shooting the line and picking up the moored buoy, the ship continued to Phuket, Thailand, doing normal underway geophysical work to the 12-mile limit.

March 21. Arrival at Phuket, Thailand.

INDOPAC LEG 12

CO-CHIEF SCIENTISTS:
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Geological Research Division
Scripps Institution of Oceanography
and
D. E. KARIG
Department of Geological Sciences
Cornell University

24 March (Phuket, Thailand) to
10 April (Padang, Indonesia) 1977

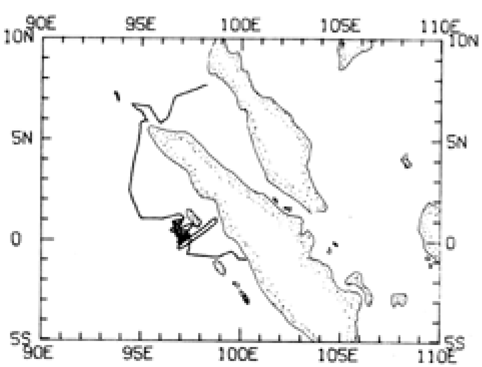

Fig. 4. Track chart of Leg 12.

Fig. 4. *Track chart of Leg 12.*

The objective of Leg 12 was a study of the structure, morphology, and sedimentary and tectonic processes along a transect of the western Sunda Arc, passing from the deep-sea floor southwest of Sumatra, through Nias Island, to the shoreline of central Sumatra. This is one of the transects of the CCOP/IDOE/SEATAR Program, selected at the 1973 Bangkok Workshop. Karig and his graduate student, Gregory Moore, have been studying the geology on Nias Island and adjacent areas for the last few years. Work on this leg and Leg 13 of INDOPAC Expedition was to provide the marine data to be incorporated into a land and sea, geological-geophysical study of this transect.

Oblique subduction occurs in this area, with the Indian plate underthrusting the adjacent China plate along the trace of the Sunda Trench. Shallow and intermediate focus earthquakes occur beneath Sumatra, but no deep focus earthquakes. Normal arc volcanism occurs on Sumatra. The underthrusting Indian plate here contains the extinct eastern lobe of the Bengal Deep-Sea Fan, the Nicobar Fan, and hence an abnormally thick section of sediments is passing into the subduction zone. Some of this is offscraped at the subduction zone, and a large volume of accreted sediment in the fore-arc region has formed the melange mass which outcrops in the Mentawai Island chain, the outer nonvolcanic ridge of the Sunda Arc, and including Nias Island. The fore-arc basin lying between this nonvolcanic ridge and Sumatra is a subsiding zone, containing a very thick section of Neogene sediment.

The ships departed Phuket, Thailand, on 24 March 1977 and proceeded almost directly to Sabang on the northwest tip of Sumatra, where we were joined by one Indonesian Naval Officer, Major Syaifuddin, and two Indonesian scientists, Sugiarta and Juliar. From Sabang, we proceeded directly to the transect area and, on the completion of our investigations, went into port in Padang.

All tracks except short segments between coring stations included complete underway geophysical work, including 3.5 kHz echo sounding, magnetics, gravity, and seismic reflection with two sweeps of analog single-channel recording and some also with 24-channel digital recordings. About 800 km of multi-channel seismic data were recorded, and about 3100 km of single-channel analog seismic reflection data were taken.

Chronology

March 24. Departed Phuket, Thailand, doing underway geophysical surveying.

March 25. Ran two airgun-sonobuoy lines (12-1 and 12-2).

March 26. Went into Sabang, Sumatra, picked up three Indonesian participants, and proceeded to Nias Island area, doing underway geophysical surveying.

March 27. Ran an airgun-sonobuoy line (12-3) and a single explosive refraction line using sonobuoys (12-4) and did heat-flow station 3.

March 28. Took neuston tow 12-1 and put in the multi-channel reflection system.

March 29–30. Continued the multi-channel reflection surveying until late on the 30th. Pulled in the multi-channel reflection system, took a neuston tow 12-2 close inshore and did airgun-sonobuoy line 12-5.

March 31. Surveyed out to the trench, ran airgun-sonobuoy line 12-6 and took heat-flow station 4 in deep water.

April 1–2. Continued a detailed survey of the landward side of the trench wall. Ran two airgun-sonobuoy lines on April 2 (12-7, 12-8).

April 3–4. Took three piston cores (39, 40, 41 and 42, 43, 44) each day and one heat-flow measurement April 3 (5) and two April 4 (6 and 7).

April 5. Took three piston cores (45, 46, 47) and two heat-flow measurements (8 and 9).

April 6. Took one heat-flow measurement (10) and started a moored buoy explosive seismic refraction station (12–9), a NW-SE line in the Sunda Trench along the axis. Launched the first buoy and surveyed out from it. Launched the second buoy and shot back to the first and picked it up. There was considerable interference on the records from frequent lightning flashes.

April 7. Ran back to the second buoy, picked it up and did heat-flow measurement 11 at the same site.

April 8. Did heat-flow measurement 12 in the trench and later an airgun-sonobuoy line (12–10).

April 9. Did two airgun-sonobuoy lines (12–11, 12–12) en route to Padang, Indonesia.

April 10. Arrived Padang, Indonesia.

INDOPAC LEG 13
CO-CHIEF SCIENTISTS:
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Scripps Institution of Oceanography
and
J. R. CURRAY
Geological Research Division
Scripps Institution of Oceanography

12–24 April (Padang-Padang, Indonesia) 1977

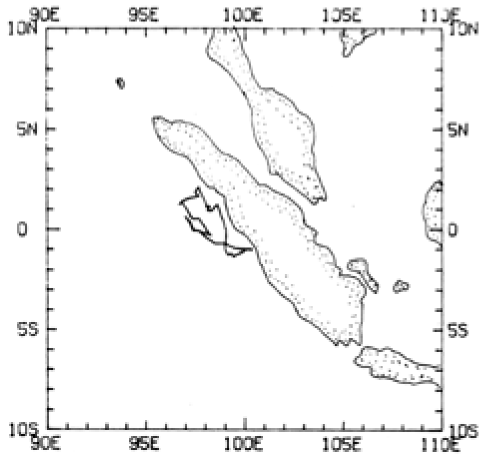

Fig. 5. Track chart of Leg 13.

Fig. 5. *Track chart of Leg 13.*

The primary program on Leg 13 was a two-ship seismic refraction program, using somewhat unconventional methods. A long array of individual hydrophones on separate suspensions was used; the R/V *Thomas Washington* towed the array at slow speed between shots, and stopped for each shot to let the hydrophones quiet to the maximum degree possible. One unit was wired directly to the ship; the other units telemetered signals using modified sonobuoy transmitters in towable cases. The research vessel K/M *Samudera* of the Indonesian Institute of Sciences acted as a shooting ship for the program. The purpose of the multiple hydrophone array was to provide records at sufficiently close spacing to make it possible to trace second arrivals (if any) from record to record, and to detect possibly discontinuous or masked layers in the complex structure of the accretionary zone. Experimental playbacks using "velocity stacking" have shown that this goal is attainable. The orginal design of the array was for 12 units spaced at 500-meter intervals. We quickly shifted to 250-meter spacing to eliminate problems with "spatial aliasing". Since the *Samudera* was available for only 12 days, it was necessary to concentrate all of the refraction work using the system into an extremely short time period, leaving little time to repair broken equipment between stations. As a result, most of the data were taken with 5- or 6-unit operational, and some with as few as three operational units. Data were digitized using a PDP-8 computer, which permitted post-station playback, filtering, and velocity-stacking.

Two reversed profiles were made on the bench on the trench slope, west of Nias; one reversed profile was made on the ridge south of Nias at the edge of the trench; one reversed profile and a one-way profile were made in the basin east of Nias; and one reversed profile with a short, unreversed line close to the coast of Sumatra southeast from Sibolga. A preliminary analysis of data using conventional methods shows a large thickness of low-velocity material overlying basement, increasing steadily in thickness from the Sumatra coast to the trench slope. Oceanic crustal velocities were detected as far inshore as the ridge south of Nias Island, and possibly beneath the basin between Nias and Sumatra. Mantle velocity was normal, and mantle arrivals were detected on most of the profiles.

During the last two stations, extensive lightning displays were seen over the mountains of Sumatra; these were accompanied by severe disturbance on the records from hydrophones radio-telemetered to the ship. Otherwise, data were quite good, and refracted arrivals were detected to very long distances.

Chronology

April 12. Transferred people, equipment, and supplies to the K/M *Samudera* of the Indonesian Institute of Sciences to start a two-ship refraction program using the long array refraction system. Left Padang and took neuston tow 13–1 in the outer harbor and later ran airgun-sonobuoy line 13–01.

April 13–14. Both ships proceeded to the work area southwest of Nias Island. The *Samudera* put in a marker buoy. Both ships continued on to a position where a second marker buoy was put in. *Washington* took neuston tow 13–2, heat-flow measurement 13 and put out the long refraction array for refraction station 13–02. The *Samudera* dropped shots abeam of the second marker buoy while the *Washington* towed the array away to the northwest. At the end of the line the *Washington* stopped, pulled in the array, and took heat-flow

measurement 14 and a gravity core (48) while the *Samudera* picked up the marker buoy and proceeded to the *Washington*. There were radio transmission difficulties and problems with the fuse for the explosives on this station.

April 15. O'Neill went from the *Washington* to the *Samudera* to adjust the refraction radio equipment and the *Samudera* put in a marker buoy. There were some difficulties with it and it had to be taken in and fixed and put out a second time. A reverse of the first line was shot, station 13–03, with the *Samudera* shooting in place at the buoy and the *Washington* towing the array away back to the southeast. When the array was pulled in at the end of the line, it was discovered that units 5, 6, and 7 had been crushed. Apparently unit 7 leaked, sank and collapsed and dragged down units 5 and 6. On all three units the telemetry units were completely destroyed, the batteries were crushed, the cases were wrecked and the hydrophone floats were flattened. It was thought that the hydrophones might be salvageable. The *Samudera* picked up the marker buoy and both ships proceeded to a position near Tanahbala Island along a ridge southeast of Nias Island.

April 16. The *Samudera* had put in a marker buoy in this area on April 13 but the *Washington* was not able to find it. They stopped and put out hydrophones, and took neuston tow 13–3. The *Samudera* came up to them and then shot a standard line, station 13–04, out from the *Washington* to the northwest. Dip-netting was done from the *Washington* while on this station. Large shots in shallow water shook the *Samudera* badly. The shooter was requested to use longer fuses. *Samudera* put in a marker buoy at the position of the last shot.

April 17. There were problems on both ships, on the *Washington* with leaking array units, on the *Samudera* with the engine. After these problems were fixed, the *Washington* couldn't get the refraction computer started so they did station 13–05 without it. The *Samudera* shot in the vicinity of the marker buoy and the *Washington* towed the refraction array in to it going southeast to northwest. Neuston tow 13–4 was taken before starting the station. After finishing the line, the *Washington* pulled in the refraction array and did a slow run for magnetics and reflection to a new location on the slope. The *Samudera* picked up the marker buoy, which had broken its mooring line and drifted, and joined the *Washington* in moving to the next position.

April 18–19. The *Washington* put out hydrophones, drifting on station, and the *Samudera* shot station 13–06 away from them to the northwest. This station was upslope from the first refraction station and southwest of Nias Ridge. After the last shot, personnel on the *Samudera* observed a partial solar eclipse at sunset and moored a marker buoy. The *Washington* took neuston tow 13–5. *Washington* then put out the long refraction array and towed it northwest toward the *Samudera* which was shooting in the vicinity of the marker buoy for station 13–07. The *Samudera* had difficulty with the AC generator which blew a fuse as it had done on April 17. A new fuse was made and a short discovered in the wiring. This was repaired causing a delay of about one hour. When the line was completed, the *Samudera* picked up the marker buoy and proceeded to the next refraction station position.

April 19. While the *Samudera* proceeded to the next station position, *Washington* did reflection surveying and a heat-flow measurement (15) on the trench slope, repaired array units, and went on to the next refraction station position.

April 20–21. The ships met in the basin between Nias Island and Sumatra. A marker buoy was put in by the *Samudera* which shot near it while the *Washington* towed the refraction array to the southeast for station 13–08. The *Samudera* then picked up the buoy and shot station 13–09 to the *Washington* and out past it. The *Washington* was having difficulties with the array units and the *Samudera* had another AC generator failure so after several stops and starts extension of the outgoing run was abandoned and the *Washington* did reflection surveying during the night.

April 22. The final refraction stations 13–10 and 13–11 were a reversed pair approximately 10 miles southwest of the west coast of Sumatra, with the northwest end of the line near Sibolga. For the station 13–10, the *Washington* received on station while the *Samudera* shot up to the *Washington* and away from it to the southeast. Then the *Samudera* put in a marker buoy and shot in place at the end of the first line while the *Washington* towed the long refraction array toward it receiving station 13–11.

April 23–24. En route to Padang, Indonesia, with the *Washington* doing a wide-angle reflection run (13–12) on the way. After arrival in port, remaining explosives and equipment were transferred back from the *Samudera* to the *Washington*.

INDOPAC LEG 14
CHIEF SCIENTIST: GEORGE G. SHOR JR.
Marine Physical Laboratory
Scripps Institution of Oceanography
24 April (Padang, Indonesia) to
28 May (Honlulu, Hawaii) 1977

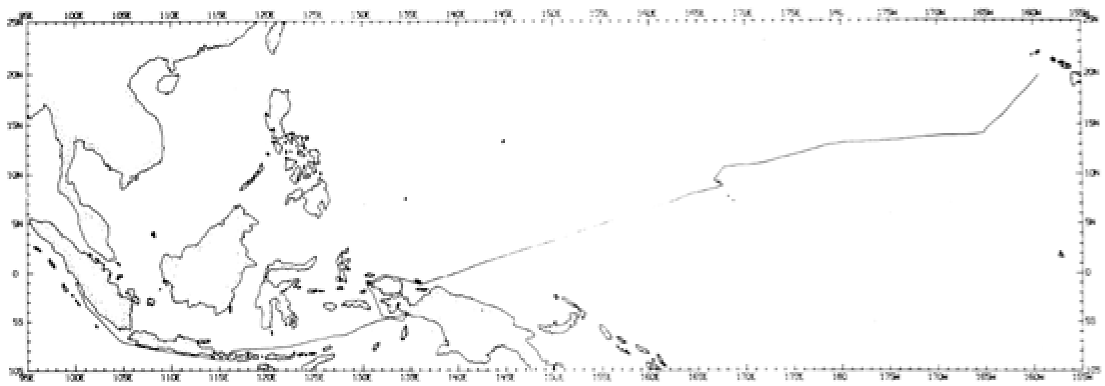

Fig. 6. Track chart of Leg 14.

Fig. 6. *Track chart of Leg 14.*

A considerable part of this cruise leg was a transiting run, to get the ship back from the work area off Sumatra to Honolulu for the next program. The ship departed Padang, one day late because of fueling problems, with less than a full load of fuel. Two Indonesian participants continued with us on this leg, to depart at Biak, West Irian. No underway measurements other than echo-sounding and magnetometer measurements were made while the ship followed close along the south side of Sumatra and Java; on passing through Lombok Strait, airgun operations were commenced. The track was laid out through the central part of the Banda Sea east as far as the north tip of the Aru Basin, to fill in needed data for the Banda Sea IDOE program that had been carried out on Leg 8. Airgun runs across an area of suggested diapiric intrusions in the western part of the South Banda Basin failed to show any structures which could be interpreted as diapirs. A piston core was taken in the South Banda Basin and a gravity core in the Aru Basin for use by Professor Kaplan of UCLA in studies of hydrocarbon maturation; another gravity core attempted in the Weber Deep penetrated but came up empty. A short survey around the junction of the Aru Basin and the Ceram Trough indicated that the two are probably separate, intersecting structures rather than a single continuous arcuate structure. After crossing the Ceram Trough for the third time, we pulled in the airgun and magnetometer for a shallow-water run around the west end of the island of New Guinea, and relaunched equipment on the north coast of New Guinea for a short run to Biak. At Biak, we disembarked our Indonesian participants, and resumed underway geophysical measurements for a crossing of the New Guinea Trench and the Eauripik Rise. Thick sediments are seen in the zone between the New Guinea coast and Biak, and again beneath the New Guinea Trench. A final short refraction run was made on the Eauripik Rise, to use up remaining explosives.

A stop at Kwajalein was considered necessary to obtain sufficient fuel to make the run to Honolulu. After departing Kwajalein, we commenced a profile of XBTs every hour (18 km interval) along the North Equatorial Current, for a program planned by Robert Bernstein, NORPAX, Scripps Institution of Oceanography. An XBT section was made along the current, from the longitude of Kwajalein to 165°W. XBT data quality was excellent. Preliminary results indicate surpringly weak mesoscale (200–500 km) variability in the subsurface thermal structure of the North Equatorial Current.

Chronology

April 24. Departed Padang.

April 24–May 1. Made transit run south of Sumatra. Java and Bali, running magnetometer and echo sounder only. Stood standard shipboard watches and prepared gear for storage, off-loading in Honolulu, and shipment to San Diego from there. Also worked on refraction data from Leg 13. Took neuston tows on the 28th, 29th, and

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30th, (14-1, 14-2 and 14-3).

May 1–3. Started airgun operations at Lombok Strait. Took neuston tows 14-4 and 14-5 on May 1 and 2.

May 4. Slowed to 8 knots across the South Banda Basin to get better airgun records. Took neuston tow, 14-6.

May 5. Stopped for a piston and gravity core (49) in the South Banda Sea and later in the day took neuston tow 14-7, and tried a gravity core (50) in the Weber Deep. The core ran out of the core barrel as it was coming up.

May 6. Took neuston tow 14-8 and gravity core 51 in the Aru Basin.

May 6–10. Continued underway observations across the Aru Basin and Ceram Trough, taking neuston tows 14-9 and 14-10 on the 8th and 9th. All gear was brought in for a shallow-water run through Sagewin Strait. The airgun and magnetometer were launched again for a short run to Biak, West Irian.

May 10. Stopped at Biak and disembarked the Indonesian participants and then ran across the New Guinea Trench and Eauripik Rise.

May 11. Carried out a one-way refraction station on the south end of Eauripik Rise using drifting sonobuoys (14-1). Neuston tow 14-11 was taken just before the station, an XBT during the station, and a second neuston tow 14-12, following the station. Airgun operations were discontinued early on May 12.

May 12–17. Set off the small amount of explosives remaining on May 12 to dispose of them and continued on to Kwajalein, Marshall Islands, for a brief stop for refueling. Then went north to 10°50'N, 167°E for the start of the XBT survey.

May 18–26. Took XBTs once an hour along a line to 13°N, 179°E and then to 14°N, 165°E.

May 27. Turned to run to Honolulu, arriving at noon, 28 May.

INDOPAC LEG 15
CHIEF SCIENTIST: K. L. SMITH, JR.
Marine Biology Research Division
Scripps Institution of Oceanography
2–30 June (Honolulu-Honolulu, Hawaii) 1977

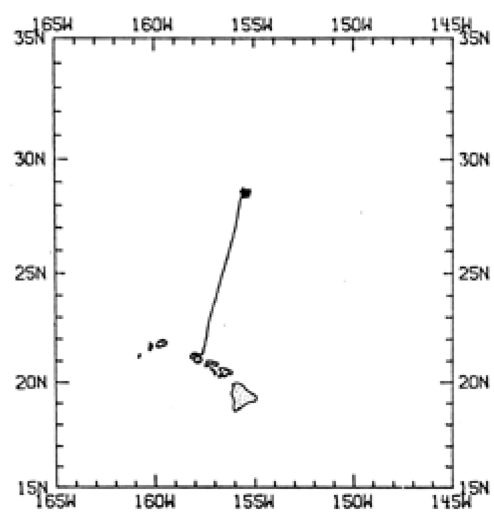

Fig. 7. Track chart of Leg 15.

Fig. 7. *Track chart of Leg 15.*

The principal purpose of this cruise was to examine the structural and functional ecology of an oligotrophic open ocean ecosystem in the central North Pacific. Our study area was primarily confined to a one degree square approximately 460 miles north northeast of Oahu, Hawaii. This area was chosen because of extensive biological, chemical, and geological sampling done previously in the same vicinity. The study area can be characterized as an oligotrophic central gyre area with a 5700 meter water column underlain by abyssal hills and red clay sediments.

Our cruise was highly successful with a total of 212 stations being completed in the study area. There were free-vehicle deployments including pressure-retaining amphipod traps, grab respirometers, midwater gill nets and baited amphipod traps. Wire operations included box coring, hydrocasts, water pumping stations, phytoplankton and zooplankton net tows and STD casts. A detailed bathymetric survey of the study area was also conducted.

One of the most significant accomplishments of the cruise was the recovery of live benthic amphipods from 5700 meters in pressure-retaining traps. These animals were then maintained alive on shipboard in a high pressure aquarium system for several days. This represents the first successful attempt to recover and maintain live deep-sea benthic animals in the laboratory.

Free-vehicle grab respirometers were deployed 4 times to measure the activity rates (respiration and nutrient regeneration) of the abyssal benthic community. Several malfunctions prevented collection of meaningful data but the feasibility of making such *in situ* measurements was assured.

Free-vehicle baited amphipod traps captured several thousand individuals of various species. Size of amphipods captured varied directly with the altitude of the traps off the bottom. Benthopelagic amphipods were caught as high as 50 meters off the bottom. Vagility of these amphipods was examined with a mark-recapture method using labeled bait. At least one amphipod with label in its gut was captured two days after and 4 to 8 miles from the bait.

The soft-bottom benthic community was sampled with a Spade corer and the resulting samples analyzed for macrofauna and microbiota density, ATP (microbiota biomass), and (^{14}C) carbon content. Sediment subsamples were also taken to determine the vertical distribution of transuranic radionuclides in the sediment.

Fig. 8. Concentrated survey area of Leg 15.

Fig. 8. *Concentrated survey area of Leg 15.*

An intensive water sampling program employing both water bottles and a pumping system, was conducted to determine the particulate and dissolved organic carbon-nitrogen in the water column. Results of this study will be used to generate a carbon and nitrogen budget for the entire water column including the air-sea and sediment-water interfaces.

Phytoplankton and zooplankton studies showed similar community structure to that found previously in this area. Chlorophyll and nutrient distributions were normal. Standard hydro and STD casts showed the presence of inversions which could be attributed to breaking internal waves.

Chronology

June 2–3. The R/V *Washington* departed Honolulu and steamed north-northeast toward the central North Pacific Gyre. Surface Niskin bottle casts were made routinely at 6 hour intervals during our transit for amino acid analysis. Meter net tows for zooplankton collections were made at noon and midnight each day.

June 4–27. We arrived on station (4 June) and the ship remained within a one degree square centered at 28°30'N, 155°30'W. A total of 212 stations were completed during this 23 day period. These stations included 38 free vehicle deployments with grab respirometers, pressure-retaining amphipod traps, midwater gill nets and baited amphipod traps. In addition, 16 box cores, 74 hydrocasts, 15 water pumping stations, 50 phytoplankton and zooplankton net tows and 19 STD casts were made. An intensive bathymetric survey of the station revealed abyssal hills with a maximum relief of 900 meters. From June 21 to 26 the *Washington* was under close surveillance by a Russian missile-tracking vessel.

June 28–30. The *Washington* departed the central North Pacific Gyre and steamed for Honolulu, arriving 0800 on June 30.

INDOPAC LEG 16
CHIEF SCIENTIST: MICHAEL M. MULLIN
Institute of Marine Resources
Scripps Institution of Oceanography
5 July (Honolulu, Hawaii) to
31 July (San Diego, California) 1977

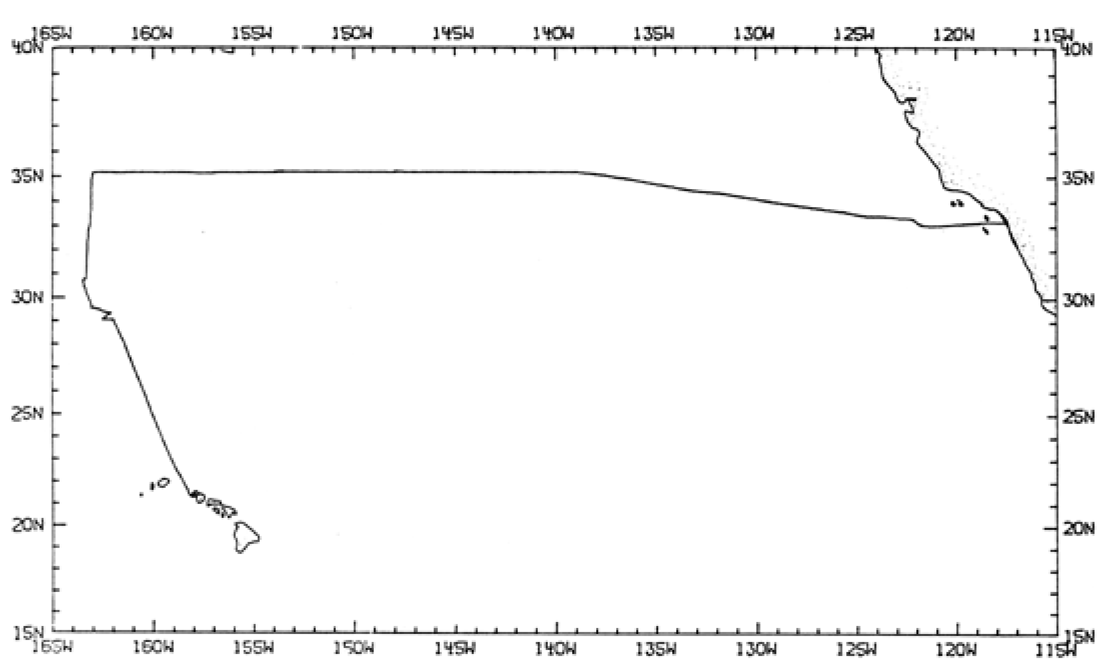

Fig. 9. Track chart of Leg 16.

Fig. 9. *Track chart of Leg 16.*

Four independent projects were carried out on this homeward leg of INDOPAC Expedition on R/V *Thomas Washington*.

An investigation of the horizontal distributions of near-surface plankton and the relation between these distributions and the physical properties of three pelagic environments was carried out by M. M. Mullin and colleagues. A towed pump-and-hose system was used for sampling phytoplankton (measured as chlorophyll in both continuous and discrete samples) and zooplankton (filtered for subsequent counting), and sensors measured continuously the temperature, pressure, incident illumination, and ship speed. Transects of about 10 hours' duration in the central gyre of the North Pacific, the open California Current, and the Southern California coastal zone were repeated day and night.

A hydrographic section along 35°10'N from 163°W to 139° was made using the STD, XBTs, and water bottles by G. Anderson, M. Tsuchiya and colleagues. This section filled in a portion of the U.S.-to-Japan section which was omitted during INDOPAC Leg 1. Temperature, salinity, oxygen, nutrient chemicals and (near the surface) chlorophyll were measured every degree of longitude. Stations made from surface to bottom alternated with stations confined to the upper 400 m.

Along the same transect, S. Kling took plankton samples with a fine-meshed, opening-closing trawl in order to study the vertical distribution of radiolarians, which are important sources of siliceous microfossils. A detailed vertical profile in the upper 1000 m was obtained.

M. Andreae studied the vertical and geographic distribution of dissolved arsenic and organometallic compounds near Oahu, the North Pacific Gyre, and in the California Current. Samples from the water column were taken by water bottles; an interstitial water sampler was used to obtain water from various depths in deep-sea sediment so that the possible role of the sediment as a source or sink for arsenic could be evaluated.

Underway measurements were made with echosounders and the towed magnetometer. The ship arrived in San Diego July 31, 1977.

Acknowledgements

Work carried out on INDOPAC legs 9 through 16 was supported by the following contracts and grants to the University of California:

Leg 9: Grant OCE 76-12017 from the National Science Foundation and funds from the Scripps Industrial Associates and the University of California.

Leg 10: Grant OCE 76-02036 from the National Science Foundation.

Leg 11: Contract N000-14-75-C-0152 from the Office of Naval Research.

Leg 12: Grant OCE 76-24101 from the National Science Foundation.

Leg 13: Grant OCE 76-24101 from the National Science Foundation.

Leg 14: Grants OCE 75-19387 and OCE 76-10177 from the National Science Foundation and contract N00014-75-C-0152 from the Office of Naval Research.

Leg 15: Grants OCE 76-10520 and OCE 76-12017 from the National Science Foundation and contracts EY-76-S-03-0034-247 and E(04-3)-34-PA236 from the Energy Research and Development Administration.

Leg 16: Grant OCE 76-23875 from the National Science Foundation and contract EY-76-C-03-0010 (PA20) from the Energy Research and Development Administration.

Other support for the programs of work was provided by the government of Indonesia (through the Institute of Geology and Mining, the Institute of Oceanography, the Geological Survey of Indonesia, and the Navy Hydro-Oceanographic Office), the government of Thailand, and the Myanma Oil Company of Burma. The CCOP (Committee for coordination of joint prospecting for mineral resources in Asian offshore areas) assisted in coordinating international aspects of the programs. We also wish to thank the many volunteer members of the scientific parties who gave their time to assist the programs of work.

INDOPAC EXPEDITION APPENDIX Statistics, Personnel and Sample Locations

STATISTICS

Distances, Km	Leg 9	Leg 10	Leg 11	Leg 12	Leg 13	Leg 14	Leg 15	Leg 16
Total Steaming	2633	9959	6097	4416	2018	13866	4292	6403
Bathymetry	2016	7738	5689	4355	1990	13541	1093	5884
Magnetics	200	5107	4392	3953	1038	13317	----	5309
Airgun Reflection	----	3538	4475	3897	1112	3058	----	----

An X following a station number indicates that no useful data was obtained.

For information on details of the data and samples listed on the following pages, and on availability of copies of data or sections of samples, contact S. M. Smith, Geological Data Center, Scripps Institution of Oceanography, La Jolla, California 92093 (Phone: 714-452-2752).

PERSONNEL

Leg 9		
Yayanos, Aristides	Chief Scientist	Scripps Institution of Oceanog.
Wilson, Robert	Resident Tech	Scripps Institution of Oceanog.
Bongard, Robert	Airgun Tech	Scripps Institution of Oceanog.
Crampton, Perry	Airgun Eng.	Scripps Institution of Oceanog.
Hubenka, Frank	Airgun Tech	Scripps Institution of Oceanog.
Abbott, Lynn	Computer Eng.	Scripps Institution of Oceanog.
Burkhalter, Arthur	Computer Tech	Scripps Institution of Oceanog.
Ferreira, Simon	Camera Tech	Scripps Institution of Oceanog.
Holmes, Gary	Volunteer	Scripps Institution of Oceanog.
Huckabay, William	Reflection Consultant	Self-employed
Ingram, Camilla	Biological Tech	Scripps Institution of Oceanog.
Mesce, Karen	Volunteer	Scripps Institution of Oceanog.
Minor, Brit	Biological Tech	Scripps Institution of Oceanog.
Robinson, Bruce	Biologist	Univ. of Calif., Santa Barbara
Von Boxtel, Ronald	Biological Tech	Scripps Institution of Oceanog.
Briggs, Bernice	Observer	Scripps Institution of Oceanog.

Leg 10		
Silver, Eli	Co-Chief Scientist	Univ. of Calif., Santa Cruz
Raitt, Russell	Co-Chief Scientist	Scripps Institution of Oceanog.
Wilson, Robert	Resident Tech	Scripps Institution of Oceanog.
Hubenka, Frank	Airgun Tech	Scripps Institution of Oceanog.
Burkhalter, Arthur	Computer Tech	Scripps Institution of Oceanog.
Holmes, Gary	Volunteer	Scripps Institution of Oceanog.
Kieckhefer, Robert	Student	Scripps Institution of Oceanog.
Manalu	Geologist	Indonesian Ministry of Mines

McCaffery, Robert	Student	Univ. of Calif., Santa Cruz
Mesce, Karen	Volunteer	Scripps Institution of Oceanog.
Nurwaji	Major	Indonesian Hydrooceanographic Office
O'Neill, Paul	Refraction Tech	Scripps Institution of Oceanog.
Smith, Sandra	Lecturer, Earth Sciences	The Open University, England
Sukamto, Rab	Geologist	Geological Survey of Indonesia
Wolfe, Margaret	Volunteer	Scripps Institution of Oceanog.

Leg 11		
Curray, Joseph	Co-Chief Scientist	Scripps Institution of Oceanog.
Moore, David	Co-Chief Scientist	Scripps Institution of Oceanog.
Wilson, Robert	Resident Tech	Scripps Institution of Oceanog.
Comer, Ronald	Resident Tech	Scripps Institution of Oceanog.
Abbott, Lynn	Computer Eng.	Scripps Institution of Oceanog.
Moore, Michael	Computer Tech	Scripps Institution of Oceanog.
Bongard, Robert	Airgun Tech	Scripps Institution of Oceanog.
Crampton, Perry	Airgun Eng.	Scripps Institution of Oceanog.
Hubenka, Frank	Airgun Tech	Scripps Institution of Oceanog.
Emmel, Frans	Geological Tech	Scripps Institution of Oceanog.
Holmes, Gary	Volunteer	Scripps Institution of Oceanog.
Huckabay, William	Reflection Consultant	Self-employed
Kieckhefer, Robert	Student	Scripps Institution of Oceanog.
Lawver, Lawrence	Post Doctoral Geophysicist	Scripps Institution of Oceanog.
Ramsey, Carrel	Student	Scripps Institution of Oceanog.
Chiramit Rasrikriengkrai	Sr. Geologist	Dept. Mineral Resources, Thailand
Suvit Sampattavanija	Sr. Geologist	Dept. Mineral Resources, Thailand
Aung Tin U	Chief Geophysicist	Myanma Oil Co., Burma

Leg 12		
Curray, Joseph	Co-Chief Scientist	Scripps Institution of Oceanog.
Karig, Daniel	Co-Chief Scientist	Cornell University
Comer, Ronald	Resident Tech	Scripps Institution of Oceanog.
Abbott, Lynn	Computer Eng.	Scripps Institution of Oceanog.
Moore, Michael	Computer Tech	Scripps Institution of Oceanog.

Crampton, Perry	Airgun Eng.	Scripps Institution of Oceanog.
Bongard, Robert	Airgun Tech	Scripps Institution of Oceanog.
Chao, Benjamin	Student	Scripps Institution of Oceanog.
Emmel, Frans	Geological Tech	Scripps Institution of Oceanog.
Holmes, Gary	Volunteer	Scripps Institution of Oceanog.
Huckabay, William	Reflection Consultant	Self-employed
Juliar	Geologist	Geological Survey of Indonesia
Kieckhefer, Robert	Student	Scripps Institution of Oceanog.
Lawver, Lawrence	Post Doctoral Geophysicist	Scripps Institution of Oceanog.
Moore, Gregory	Student	Cornell University
Ramsey, Carrel	Student	Scripps Institution of Oceanog.
Syaifuddin	Major	Indonesian Navy Hydrooceanographic Office
Sugiarta Wirasantosa	Geologist	Indonesian Institute of Geology and Mining

Leg 13		
R/V Thomas Washington		
Curray, Joseph	Co-Chief Scientist	Scripps Institution of Oceanog.
Shor, George	Co-Chief Scientist	Scripps Institution of Oceanog.
Comer, Ronald	Resident Tech	Scripps Institution of Oceanog.
Bongard, Robert	Airgun Tech	Scripps Institution of Oceanog.
O'Neill, Paul	Refraction Tech	Scripps Institution of Oceanog.
Moore, Michael	Computer Tech	Scripps Institution of Oceanog.
Chao, Benjamin	Student	Scripps Institution of Oceanog.
Hehuwat, Fred	Geologist, Director	Indonesian Institute of Geology and Mining
Holmes, Gary	Volunteer	Scripps Institution of Oceanog.
Lawver, Lawrence	Post Doctoral Geophysicist	Scripps Institution of Oceanog.
Ramsey, Carrel	Student	Scripps Institution of Oceanog.
Shor, Elizabeth	Volunteer	Scripps Institution of Oceanog.
Sudarmadji, Otto	Oceanographer	Indonesian Institute of Oceanog.
Syaifuddin	Major	Indonesian Navy Hydrooceanographic Office

Zoelf Zabier	Geologist	Geological Survey of Indonesia
K/M Samudera		
Emmel, Frans	Geological Tech	Scripps Institution of Oceanog.
Newhouse, Dale	Explosives Handler	Scripps Institution of Oceanog.
Kieckhefer, Robert	Student	Scripps Institution of Oceanog.
Sugiarta Wirasantosa	Geologist	Indonesian Institute of Geology and Mining
Abdul Gani Ilahude	Oceanographer	Indonesian Institute of Oceanog.

Leg 14		
Shor, George	Chief Scientist	Scripps Institution of Oceanog.
Comer, Ronald	Resident Tech	Scripps Institution of Oceanog.
Charters, James	Computer Tech	Scripps Institution of Oceanog.
Bongard, Robert	Airgun Tech	Scripps Institution of Oceanog.
Bambang, Dwiyanto	Geologist	Geological Survey of Indonesia
Chao, Benjamin	Student	Scripps Institution of Oceanog.
Holmes, Gary	Lab Helper	Scripps Institution of Oceanog.
Shor, Elizabeth	Volunteer	Scripps Institution of Oceanog.
Syaifuddin	Major	Indonesian Navy Hydrooceanographic Office

Leg 15		
Smith, Kenneth	Chief Scientist	Scripps Institution of Oceanog.
Wilson, Robert	Resident Tech	Scripps Institution of Oceanog.
Baldwin, Roberta	Lab Asst.	Scripps Institution of Oceanog.
Bennett, John	Student	Scripps Institution of Oceanog.
Burnett, Bryan	Benthic Ecology Tech	Scripps Institution of Oceanog.
Charters, James	Computer Tech	Scripps Institution of Oceanog.
Hayward, Thomas	Student	Scripps Institution of Oceanog.
Holmes, Gary	Volunteer	Scripps Institution of Oceanog.
Hoopes, Edward	Organic Chem. Tech	Scripps Institution of Oceanog.
Kaye, Ross	Electronics Tech	Scripps Institution of Oceanog.
Laver, Michael	Nutrient Chem. Tech	Scripps Institution of Oceanog.
Michaelsen, Julie	Student	Scripps Institution of Oceanog.
Minor, Brit	Biological Tech	Scripps Institution of Oceanog.

Olson, Robert	Student	Scripps Institution of Oceanog.
Venrick, Elizabeth	Biological Oceanographer	Scripps Institution of Oceanog.
Von Boxtel, Ronald	Biological Tech	Scripps Institution of Oceanog.
White, George	Electronic Tech	Scripps Institution of Oceanog.
Williams, Peter	Chemist	Scripps Institution of Oceanog.
Wilson, George	Benthic Ecology Tech	Scripps Institution of Oceanog.
Yayanos, Aristides	Physiologist	Scripps Institution of Oceanog.

Leg 16		
Mullin, Michael	Chief Scientist	Scripps Institution of Oceanog.
Coatsworth, James	Resident Tech	Scripps Institution of Oceanog.
Henry, Arthur	Computer Tech	Scripps Institution of Oceanog.
Anderson, George	Hydrographic & Chem. Tech	Scripps Institution of Oceanog.
Andreae, Meinrat	Student	Scripps Institution of Oceanog.
Barlow, Jay	Student	Scripps Institution of Oceanog.
Brooks, Elaine	Biological Tech	Scripps Institution of Oceanog.
Ferreira, Michael	Observer	US Merchant Marine Academy
Kaye, Ross	Electronics Tech	Scripps Institution of Oceanog.
Costello, James	Marine Tech	Scripps Institution of Oceanog.
Kling, Stanley	Micropaleontologist	Scripps Institution of Oceanog.
Landry, Michael	Biologist	Scripps Institution of Oceanog.
Mead, Richard	Marine Tech	Scripps Institution of Oceanog.
Richter, Kenneth	Student	Scripps Institution of Oceanog.
Snider, Leslie	Student	Scripps Institution of Oceanog.
Star, Jeffrey	Student	Scripps Institution of Oceanog.
Tsuchiya, Mizuki	Physical Oceanographer	Scripps Institution of Oceanog.
Vakassian, Leslie	Student	Scripps Institution of Oceanog.
Zakar, Karen	Biological Tech	Scripps Institution of Oceanog.

SAMPLE LOCATIONS		
No.	Latitude	Longitude
DREDGE HAULS		
		Starting Position
Leg 10		
11	02-48.7N	126-25.5E

12	02-27.8N	127-34.8E
13	01-09.2N	126-22.1E
14	00-44.1N	125-59.6E
15	00-04.7S	126-03.9E
16	00-13.2S	125-57.0E
Leg 11		
17	11-44.3N	94-26.0E

CORES		
Position	Position	Position
Leg 11		
G-38	11-07.9N	94-55.0E
Leg 12		
P-39	00-14.0N	97-20.4E
PG-39	00-14.0N	97-20.4E
P-40	00-15.1N	97-21.1E
PG-40	00-15.1N	97-21.1E
P-41	00-14.5N	97-21.7E
PG-41	00-14.5N	97-21.7E
P-42	00-08.2N	97-10.8E
PG-42	00-08.2N	97-10.8E
P-43	00-08.3N	97-10.7E
PG-43	00-08.3N	97-10.7E
P-44	00-07.9N	97-12.3E
PG-44	00-07.9N	97-12.3E
P-45	00-07.9N	97-17.6E
PG-45	00-07.9N	97-17.6E
P-46	00-08.5N	97-17.6E
PG-46	00-08.5N	97-17.6E
P-47	00-08.4N	97-17.0E
PG-47	00-08.4N	97-17.0E
Leg 13		
G-48	00-37.8N	96-58.3E
Leg 14		
P-49	05-49.9S	129-23.7E

G-49	05-49.9S	129-23.7E
G-50x	05-11.1S	130-57.6E
G-51	04-33.6S	133-17.9E

HEAT FLOW		
Leg 11		
1	11-08.5N	94-54.4E
2	11-00.5N	94-57.0E
Leg 12		
3	00-59.6N	96-01.6E
4	00-13.7S	97-00.6E
5	00-14.1N	97-18.9E
6	00-16.1N	97-18.2E
7	00-08.2N	97-14.1E
8	00-08.0N	97-14.9E
9	00-03.4N	97-16.4E
10	00-07.9S	97-01.5E
11	00-54.6N	96-36.1E
12	00-12.4N	96-44.3E
Leg 13		
13	00-03.6S	97-24.8E
14	00-37.7N	96-58.7E
15	01-16.7N	96-43.0E

MULTICHANNEL SEISMIC LINES		
Leg 11		
1	06-30.9N	98-04.4E
	11-06.3N	95-06.0E
2	14-24.6N	94-11.1E
	14-53.1N	95-40.6E
3	14-01.0N	95-14.2E
	08-01.6N	96-49.4E
Leg 12		
1	01-02.5N	96-07.2E
	01-04.6N	98-44.0E

SEISMIC REFRACTION AND WIDE ANGLE REFLECTION STATIONS					
No.	Recording System	Sound Source		Latitude	Longitude
Leg 10					
1	31 Jan 1977		Begin	01-25.3N	125-38.8E
	Shooting run		End	01-49.7N	125-51.1E
	Drifting Buoys	Explosives			
	A			01-23.7N	125-37.9E
	B			01-24.0N	125-38.1E
	C			01-24.8N	125-38.5E
	D			01-32.6N	125-42.5E
	E			01-36.4N	125-44.4E
	F			01-44.2N	125-48.4E
2	1 Feb 1977				
	Shooting run		Begin	02-39.5N	126-12.8E
			End	03-21.8N	126-28.6E
	Drifting Buoys	Explosives			
	A			02-38.3N	126-12.3E
	B			02-38.7N	126-12.5E
	C			02-53.4N	126-17.9E
	D			02-56.2N	126-19.0E
	E			03-00.0N	126-20.5E
	F			03-01.4N	126-21.0E
	G			03-13.0N	126-25.3E
3	1 Feb 1977				
	Shooting run		Begin	03-16.1N	127-17.4E
			End	02-34.8N	127-08.6E
	Drifting Buoys	Explosives			
	A			03-17.4N	127-18.1E
	B			03-17.0N	127-18.0E
	C			03-04.4N	127-15.2E
	D			03-00.6N	127-14.4E
	E			02-56.9N	127-13.7E

	F			02-49.2N	127-12.2E
4	2 Feb 1977				
	Shooting run		Begin	01-47.8N	126-50.2E
			End	01-15.4N	126-41.7E
			Begin	01-14.4N	126-42.6E
			End	01-45.4N	126-49.3E
	Moored Buoys	Explosives			
	A		In	01-49.1N	126-50.5E
			Out	01-51.1N	126-54.1E
	B		In	01-13.3N	126-42.2E
			Out	01-13.6N	126-42.6E
5	¾ Feb 1977				
	Shooting run		Begin	01-50.6N	126-19.5E
			c/cse	01-27.1N	126-14.6E
			End	01-46.3N	126-19.2E
	Moored Buoys	Explosives			
	A		In	01-53.0N	126-19.0E
			Out	01-52.0N	126-20.8E
	B		In	01-27.1N	126-14.1E
			Out	01-27.0N	126-14.2E
6	5 Feb 1977				
	Shooting runs		Begin	00-30.5N	126-38.9E
			End	00-59.8N	126-43.7E
			Begin	00-59.3N	126-43.0E
			End	00-35.5N	126-37.6E
	Moored Buoys	Explosives			
	A		In	00-32.2N	126-42.3E
			Out	00-30.6N	126-37.0E
	B		In	01-01.3N	126-43.9E
			Out	00-59.4N	126-43.7E
7	7 Feb 1977				
	Shooting runs		Begin	00-14.6S	125-35.8E
			End	00-10.4N	125-41.7E
			Begin	00-10.4N	125-14.6E
			End	00-12.9S	125-36.1E

	Moored Buoys	Explosives			
	A		In	00-15.7S	125-37.0E
			Out	00-17.4S	125-35.9E
	B		In	00-11.5N	125-41.8E
			Out	00-10.7N	125-39.3E
8	8 Feb 1977				
	Shooting runs		Begin	00-15.0S	126-09.4E
			End	00-23.8S	126-38.7E
			Begin	00-25.1S	126-41.4E
			End	00-16.4S	126-13.8E
	Moored Buoys	Explosives			
	A		In	00-13.4S	126-09.0E
			Out	00-14.7S	126-07.2E
	B		In	00-25.1S	126-42.5E
			Out	00-26.1S	126-42.1E
9	10 Feb 1977				
	Shooting run		Begin	00-05.7S	123-50.3E
			End	00-45.6S	123-45.3E
	Drifting Buoys	Explosives			
	A			00-04.4S	123-50.5E
	B			00-04.8S	123-50.4E
	C			00-05.2S	123-50.4E
	D			00-14.6S	123-49.3E
	E			00-20.4S	123-48.7E
	F			00-25.2S	123-48.2E
	G			00-31.8S	123-47.5E
10	11 Feb 1977				
	Shooting runs		Begin	00-52.9S	123-44.7E
			End	00-51.4S	124-08.9E
			Begin	00-52.1S	124-09.8E
			End	00-54.0S	123-49.7E
	Moored Buoys	Explosives			
	A		In	00-53.1S	123-42.9E
			Out	00-53.0S	123-43.6E
	B		In	00-51.3S	124-10.1E

			Out	00-52.2S	124-10.0E
11	12 Feb 1977				
	Shooting run		Begin	01-08.9S	122-49.6E
			End	01-27.2S	122-37.8E
	Drifting Buoys	Explosives			
	A			01-07.7S	122-50.2E
	B			01-08.0S	122-50.0E
	C			01-08.3S	122-49.9E
	D			01-11.7S	122-48.1E
	E			01-15.8S	122-46.0E
	F			01-18.4S	122-44.5E

Leg 11					
1	4 March 1977				
	Drifting Buoys	Airgun			
	A			08-03.9N	95-13.7E
	B			08-12.6N	95-10.2E
2	6 March 1977				
	Drifting Buoys	Airgun			
	A			10-27.5N	94-24.4E
	B			10-21.2N	94-40.6E
	C			10-20.4N	94-43.1E
3	6 March 1977				
	Drifting Buoy	Airgun			
	A			10-19.8N	95-26.8E
4	7 March 1977				
	Drifting Buoys	Airgun			
	A			11-12.6N	94-39.1E
	B			11-14.5N	94.37.0E
5	8 March 1977				
	Drifting Buoys	Airgun			
	A			13-43.4N	93-57.9E
	B			13-56.1N	93-56.4E
6	9 March 1977				

	Shooting run		Begin	15-26.6N	94-11.3E
			End	14-28.3N	93-53.7E
	Drifting Buoys	Airgun			
	B			14-45.4N	93-54.6E
	C			14-55.0N	93-58.2E
	Moored Buoys	Explosives			
	A		In	14-31.2N	93-49.7E
			Out	14-30.9N	93-48.9E
	G		In	15-27.6N	94-11.1E
			Out	15-26.8N	94-10.8E
	Drifting Buoys	Explosives			
	D			15-05.9N	94-01.7E
	E			15-07.4N	94-02.0E
	F			15-19.2N	94-04.6E
	Shore Station	Explosives		Ama Village, Burma	
7	10 March 1977				
	Drifting Buoys	Airgun			
	A			15-22.4N	94-22.3E
	B			15-19.1N	94-30.4E
8	10/11 March 1977		Begin	14-20.0N	94-17.8E
	Shooting run		End	15-09.2N	94-51.6E
	Moored Buoy	Airgun Explosives			
	A		In	15-10.1N	94-51.7E
			Out	15-10.1N	94-51.9E
	Drifting Buoy	Airgun			
	B			14-36.1N	94-28.1E
	Drifting Buoy	Airgun Explosives			
	C			14-25.5N	94-21.3E
	Moored Buoy	Explosives			
	D		In	14-14.2N	94-13.7E
			Out	14-15.7N	94-13.5E
	Drifting Buoys	Explosives			
	E			14-37.8N	94-28.5E
	F			14-51.7N	94-38.7E
	G			14-59.2N	94-44.4E

	Shore Station	Explosives		Ama Village, Burma	
9	13/14 March 1977		Begin	14-03.8N	95-17.3E
	Shooting run		End	14-53.4N	95-36.0E
	Moored Buoy	Airgun Explosives			
	A		In	14-55.2N	95-34.5E
			Out	14-56.0N	95-38.3E
	Drifting Buoy	Airgun			
	B			14-23.8N	95-25.9E
	Drifting Buoy	Airgun Explosives			
	C			14-13.5N	95-21.4E
	Moored Buoy	Explosives			
	D		In	14-03.4N	95-17.8E
			Out	14-03.5N	95-18.0E
	Drifting Buoys	Explosives			
	E			14-21.2N	95-23.8E
	F			14-29.1N	95-26.9E
	G			14-35.9N	95-29.4E
	H			14-43.4N	95-32.2E
	Shore Station	Explosives		Elephant Point, Burma	
10	10 March 1977				
	Drifting Buoy	Airgun			
	A			13-34.4N	95-09.9E
11	15 March 1977				
	Drifting Buoys	Airgun			
	A			12-38.8N	95-29.0E
	B			12-37.3N	95-30.6E
	C			12-35.8N	95-32.1E
	D			12-30.8N	95-37.6E
12	16 March 1977				
	Drifting Buoy	Airgun		11-44.7N	96-42.2E
13	16 March 1977				
	Drifting Buoys	Airgun			
	A			10-48.1N	95-19.0E
	B			10-41.7N	95-07.3E
	C			10-31.6N	94-50.1E

14	17 March 1977				
	Drifting Buoy	Airgun			
	A			10-20.7N	94-33.3E
15	19 March 1977				
	Drifting Buoys	Airgun			
	A			08-13.1N	95-18.9E
	B			08-12.7N	95-20.5E
16	19 March 1977				
	Drifting Buoys	Airgun			
	A			08-05.4N	95-58.6E
	B			08-05.5N	96-02.9E
17	20 March 1977				
	Shooting run		Begin	07-03.5N	96-38.8E
			End	08-04.7N	96-53.7E
	Moored Buoy	Airgun Explosives			
	A		In	08-03.3N	96-53.7E
			Out	08-04.8N	96-54.0E
	Drifting Buoys	Airgun Explosives			
	B			07-25.5N	96-46.7E
	C			07-14.0N	96-44.2E
	D			07-02.8N	96-38.7E
	E			07-02.8N	96-38.7E
	F			07-02.8N	96.38.7E
	G			07-28.8N	96-41.5E
	H			07-35.8N	96-42.2E
	I			07-45.1N	96-44.4E
	J			07-52.6N	96-47.9E

Leg 12					
1	25 March 1977				
	Drifting Buoy	Airgun			
	A			06-12.0N	96-22.2E
2	25 March 1977				
	Drifting Buoy	Airgun			
	A			05-58.4N	96-15.7E

3	27 March 1977				
	Drifting Buoy	Airgun			
	A			02-11.0N	94-29.2E
4	27 March 1977				
	Shooting run		Begin	01-00.9N	95-08.2E
			End	01-02.7N	95-36.7E
	Drifting Buoys	Explosives			
	A			01-00.0N	95-03.9E
	B			01-00.0N	95-03.9E
	C			01-00.0N	95-04.1E
	D			01-00.6N	95-04.0E
	E			01-01.4N	95-17.0E
	F			01-02.0N	95-26.6E
	G			01-02.0N	95-26.6E
5	30 March 1977				
	Drifting Buoys	Airgun			
	A			00-52.5N	98-25.9E
	B			01-00.1N	98-35.3E
6	31 March 1977				
	Drifting Buoy	Airgun			
	A			00-10.4S	97-03.3E
7	2 April 1977				
	Drifting Buoy	Airgun			
	A			00-14.8N	97-19.5E
8	2 April 1977				
	Drifting Buoys	Airgun			
	A			00-13.5N	97-11.0E
	B			00-07.2N	97-12.4E
9	6/7 April 1977				
	Shooting run		Begin	00-53.2N	96-36.8E
			End	00-05.9N	96-59.5E
	Moored Buoys	Explosives			
	A		In	00-06.5S	96-59.6E
			Out	00-07.0S	97-00.0E
	E		In	00-54.1N	96-36.2E

			Out	00-53.9N	96-36.3E
	Drifting Buoys	Explosives			
	B			00-00.0	96-57.2E
	C			00-30.6N	96-42.1E
	D			00-41.8N	96-40.2E
	F			00-32.4N	96-46.2E
	G			00-20.0N	96-51.8E
	H			00-11.8N	96-55.5E
10	8 April 1977				
	Drifting Buoy	Airgun			
	A			00-24.0N	97-20.1E
11	9 April 1977				
	Drifting Buoys	Airgun			
	A			00-46.3S	99-02.6E
	B			00-42.8S	99-09.3E
	C			00-38.1S	99-20.3E
12	9 April 1977				
	Drifting Buoys	Airgun			
	A			00-41.8S	99-42.8E
	B			00-48.4S	99-48.5E

Leg 13					
1	12 April 1977				
	Drifting Buoys	Airgun			
	A			00-54.6S	99-26.3E
	B			00-50.8S	99-17.2E
2	13/14 April 1977				
	Towed	Explosives	Begin	00-11.0N	97-17.2E
	array		End	00-33.4N	97-03.1E
3	15 April 1977				
	Towed	Explosives	Begin	00-24.1N	97-13.5E
	array		End	00-04.6S	97-26.0E
4	16 April 1977				
	Streamed	Explosives	Begin	00-17.5S	98-16.6E
	hydrophones		End	00-18.3S	98-18.8E

5	17 April 1977				
	Towed	Explosives	Begin	00-10.5S	98-08.6E
	array		End	00-33.4N	97-38.8E
6	18 April 1977				
	Streamed	Explosives	Begin	00-39.3N	97-13.5E
	hydrophones		End	00-37.4N	97-17.5E
7	18/19 April 1977				
	Towed	Explosives	Begin	00-41.9N	97-14.8E
	array		End	01-24.2N	96-48.3E
8	20 April 1977				
	Towed	Explosives	Begin	02-03.0N	97-41.6E
	array		End	01-10.5N	98-04.6E
9 In	20/21 April 1977				
	Streamed	Explosives	Begin	01-10.4N	98-04.3E
	hydrophones		End	01-07.6N	98-02.2E
9 Out	21 April 1977				
	Streamed	Explosives	Begin	01-07.5N	98-02.1E
	hydrophones		End	01-07.1N	98-02.3E
10	22 April 1977				
	Streamed	Explosives	Begin	01-12.4N	98-37.1E
	hydrophones		End	01-11.2N	98-37.6E
11	22 April 1977				
	Towed	Explosives	Begin	01-11.1N	98-38.3E
	array		End	00-38.5N	98-50.2E
12	23 April 1977				
	Drifting	Airgun			
	Buoy				
	A			01-14.0S	99-21.3E
13	23 April 1977				
	Drifting	Airgun			
	Buoys				
	A			01-15.9S	99-38.7E
	B			01-07.3S	99-53.4E
	C			01-04.2S	99-58.9E

Leg 14					
1	11 May 1977				
	Shooting run		Begin	00-52.1N	142-11.2E
			End	00-58.0N	142-31.2E
	Drifting Buoys	Explosives			
	A			00-51.7N	142-10.5E
	B			00-51.8N	142-10.7E
	C			00-51.9N	142-11.0E
	D			00-52.0N	142-11.2E

SALINITY, TEMPERATURE, DEPTH			
No.	Depth, meters	Position Latitude	Position Longitude
Leg 15			
1	300	28-32.4N	155-31.2W
2	300	28-32.6N	155-31.2W
3	1000	28-33.3N	155-31.4W
4	1000	28-33.2N	155-31.2W
5	1000	28-38.7N	155-31.6W
6	1000	28-38.5N	155-31.5W
7	1000	28-36.5N	155-18.4W
12	1000	28-36.6N	155-18.1W
13	1000	28-36.6N	155-17.9W
14	1308	28-39.1N	155-10.5W
15	1308	28-39.3N	155-10.1W
16	1010	28-21.6N	155-27.5W
17	1010	28-21.5N	155-27.4W
18	1015	28-44.0N	155-33.2W
19	1015	28-44.0N	155-33.3W
20	375	28-44.1N	155-33.3W
21	375	28-44.1N	155-33.3W
22	1016	28-30.4N	155-31.1W
23	1016	28-30.4N	155-30.5W
24	1012	28-32.1N	155-18.2W
25	1010	28-32.0N	155-18.1W

26	1018	28-37.1N	155-27.3W
27	1010	28-37.1N	155-27.2W
28	1028	28-31.0N	155-30.8W
29	1028	28-31.2N	155-30.8W
30	1022	28-37.3N	155-28.7W
31	1022	28-37.3N	155-28.7W
32	1010	28-34.4N	155-25.2W
33	1010	28-34.5N	155-25.3W
34	1015	28-41.2N	155-20.6W
77	2878	28-33.7N	155-31.9W
Leg 16			
5	5692	35-09.3N	162-01.2W
7	1185	35-09.0N	162-00.2W
13	1181	35-10.8N	158-59.6W
14	6050	35-09.1N	157-59.9W
16	1185	35-07.6N	158-00.3W
17	1188	35-10.4N	157-02.3W
20	1185	35-09.5N	156-02.5W
23	1195	35-10.8N	154-59.6W
25	5685	35-09.9N	153-57.7W
27	1188	35-10.4N	153-57.8W
28	1188	35-10.1N	153-00.7W
29	5752	35-10.1N	151-57.0W
32	1188	35-10.3N	151-59.4W
33	1188	35-10.1N	150-59.0W
34	5753	35-10.4N	149-59.5W
36	1184	35-10.7N	150-00.0W
37	1184	35-09.9N	148-59.1W
38	5675	35-10.4N	147-58.4W
40	1173	35-10.8N	147-56.8W
41	1188	35-09.8N	147-00.3W
42	5372	35-10.5N	145-59.1W
44	1184	35-11.0N	145-59.7W
45	1188	35-09.6N	144-59.5W
46	5070	35-10.4N	143-59.9W

48	1188	35-10.4N	144-00.1W
49	1195	35-10.4N	143-00.2W
50	5300	35-09.3N	142-00.3W
52	990	35-09.1N	141-59.9W
53	1188	35-09.9N	141-00.0W
54	5500	35-10.7N	139-57.9W
56	986	35-11.2N	139-58.7W
58	1199	35-09.4N	139-00.9W

HYDROGRAPHIC CASTS		
Leg 15		
	21-28.5N	157-33.3W
	22-35.4N	157-19.2W
	23-37.2N	157-00.4W
	24-40.0N	156-41.3W
	25-25.7N	156-25.7W
	25-25.6N	156-25.8W
	26-15.1N	156-10.1W
	27-03.0N	155-54.8W
	27-56.0N	155-43.9W
	28-33.3N	155-31.4W
	28-33.5N	155-31.1W
	28-33.7N	155-31.6W
	28-34.3N	155-31.9W
	28-35.8N	155-31.3W
	28-38.1N	155-31.8W
	28-38.4N	155-31.4W
	28-38.3N	155-31.7W
	28-29.9N	155-30.5W
	28-31.2N	155-30.6W
	28-35.9N	155-26.4W
	28-37.0N	155-26.3W
	28-35.6N	155-28.4W
	28-38.2N	155-26.6W

	28-45.9N	155-31.1W
	28-24.0N	155-27.5W
	28-35.0N	155-24.8W
	28-36.2N	155-21.2W
	28-24.4N	155-23.9W
	28-22.9N	155-25.3W
	28-36.7N	155-18.3W
	28-21.6N	155-27.7W
	28-21.4N	155-27.0W
	28-33.3N	155-33.6W
	28-42.1N	155-32.1W
	28-43.9N	155-33.2W
	28-44.3N	155-33.3W
	28-31.9N	155-28.1W
	28-30.8N	155-23.8W
	28-30.2N	155-17.3W
	28-31.9N	155-18.1W
	28-32.4N	155-17.7W
	28-33.1N	155-35.2W
	28-36.5N	155-29.9W
	28-34.7N	155-13.8W
	28-34.3N	155-12.7W
	28-35.0N	155-12.5W
	28-38.0N	155-41.3W
	28-35.9N	155-20.3W
	28-38.7N	155-20.8W
	28-36.7N	155-30.9W
	28-30.9N	155-34.2W
	28-33.6N	155-31.1W
	28-32.4N	155-24.4W
	28-32.9N	155-27.1W
	28-34.3N	155-25.2W
	28-35.7N	155-27.2W
	28-39.7N	155-26.4W
	28-38.0N	155-27.1W

	28-40.4N	155-20.7W
	28-41.2N	155-20.5W
	28-41.2N	155-20.6W
	28-41.2N	155-20.6W
	28-41.1N	155-21.5W
	28-41.0N	155-21.6W
	28-41.6N	155-22.3W
	28-41.9N	155-22.5W
	28-26.6N	155-25.1W
Leg 16		
	21-35.9N	158-21.4W
	30-46.2N	163-30.3W
	30-48.0N	163-22.1W
	35-11.2N	162-59.4W
	35-09.3N	162-01.2W
	35-09.0N	162-00.2W
	35-10.8N	159-59.2W
	35-09.3N	159-58.7W
	35-10.8N	158-59.6W
	35-09.1N	157-59.9W
	35-07.6N	158-00.3W
	35-10.4N	157-02.3W
	35-09.9N	156-02.4W
	35-09.5N	156-02.5W
	35-10.8N	154-59.6W
	35-09.9N	153-57.7W
	35-10.4N	153-57.8W
	35-10.1N	153-00.7W
	35-10.1N	151-57.0W
	35-10.3N	151-59.4W
	35-10.1N	150-59.0W
	35-10.4N	149-59.5W
	35-10.7N	150-00.0W
	35-09.9N	148-59.1W
	35-10.4N	147-58.4W

	35-10.8N	147-56.8W
	35-09.8N	147-00.3W
	35-10.5N	145-59.1W
	35-11.0N	145-59.7W
	35-09.6N	144-59.5W
	35-10.4N	143-59.9W
	35-10.4N	144-00.1W
	35-10.4N	143-00.2W
	35-09.3N	142-00.3W
	35-09.1N	141-59.9W
	35-09.9N	141-00.0W
	35-10.7N	139-57.9W
	35-11.2N	139-58.7W
	35-09.4N	139-00.9W
	33-20.7N	124-16.5W
	33-20.7N	124-15.9W
	33-14.7N	122-08.1W
	33-09.0N	117-26.4W

MIDWATER TRAWLS			
Leg 9			
1	B	11-19.0N	142-05.2E
	E	11-19.5N	141-37.1E
2	B	11-20.1N	141-53.3E
	E	11-26.7N	142-05.4E
3	X	11-22.3N	141-36.1E

NET TRAWLS			
Leg 9			
1	B	11-19.4N	141-53.4E
	E	11-19.5N	141-48.2E
2	B	11-19.9N	141-48.6E
	E	11-26.4N	142-03.9E
3	X	11-22.8N	142-19.3E

NEUSTON TOWS		
Leg 10		
10-1	01-02.3N	126-23.2E
10-2	00-31.8N	126-42.6E
10-3	00-11.8S	126-06.2E
10-4	00-52.0S	124-10.3E
Leg 11		
11-1	11-08.9N	94-54.0E
11-2	15-26.8N	94-10.9E
11-3	14-53.8N	95-39.5E
11-4	08-02.2N	96-52.3E
Leg 12		
12-1	01-01.4N	96-04.6E
12-2	01-01.3N	98-48.3E
Leg 13		
13-1	01-00.2S	100-22.2E
13-2	00-03.2S	97-24.9E
13-3	00-17.3S	98-16.4E
13-4	00-11.7S	98-10.1E
13-5	00-37.4N	97-17.7E
Leg 14		
14-1	04-56.5S	102-41.0E
14-2	07-28.2S	106-22.2E
14-3	08-20.6S	110-50.2E
14-4	08-52.8S	115-34.3E
14-5	07-49.6S	118-59.9E
14-6	06-27.2S	127-39.4E
14-7	05-11.1S	130-58.5E
14-8	04-32.6S	133-22.0E
14-9	01-59.9S	131-00.5E
14-10	00-41.2S	134-11.4E
14-11	00-49.7N	142-05.7E
14-12	00-59.6N	142-34.1E

OPEN NET TOWS		
Leg 15		
	25-15.3N	156-29.2W
	25-15.7N	156-29.3W
	25-25.4N	156-26.7W
	26-50.5N	155-58.2W
	28-33.8N	155-31.8W
	28-36.0N	155-31.3W
	28-36.5N	155-31.5W
	28-36.9N	155-31.6W
	28-33.7N	155-31.7W
	28-38.2N	155-31.8W
	28-45.7N	155-32.8W
	28-45.8N	155-32.1W
	28-45.8N	155-31.0W
	28-45.7N	155-30.8W
	28-45.6N	155-30.7W
	28-45.3N	155-30.6W
	28-45.0N	155-30.3W
	28-44.8N	155-30.0W
	28-35.1N	155-24.4W
	28-35.4N	155-23.6W
	28-35.6N	155-22.8W
	28-36.6N	155-18.1W
	28-39.3N	155-10.1W
	28-39.3N	155-10.1W
	28-39.3N	155-10.2W
	28-39.2N	155-10.3W
	28-20.6N	155-28.2W
	28-21.1N	155-27.9W
	28-21.5N	155-27.2W
	28-42.1N	155-32.1W
	28-42.6N	155-32.4W
	28-42.8N	155-32.7W
	28-30.3N	155-17.4W

	28-30.8N	155-17.7W
	28-31.3N	155-17.9W
	28-42.8N	155-12.9W
	28-43.1N	155-12.9W
	28-43.4N	155-12.9W
	28-43.7N	155-12.9W
	28-33.4N	155-15.8W
	28-33.5N	155-15.2W
	28-33.7N	155-14.5W
	28-36.8N	155-30.8W
	28-36.9N	155-30.4W
	28-37.0N	155-29.8W
	28-33.2N	155-27.2W
	28-33.5N	155-26.7W
	28-33.8N	155-26.1W
Leg 16		
	29-04.7N	162-01.7W
	30-45.2N	163-30.6W
	33-20.9N	124-16.4W

CLOSING NET TOWS		
Leg 16		
	35-11.7N	153-56.4W
	35-11.8N	153-55.2W
	35-12.2N	153-54.0W
	35-12.5N	153-52.5W
	35-12.2N	153-49.9W
	35-12.2N	153-42.9W
	35-11.4N	147-52.2W
	35-10.4N	147-58.2W
	35-10.9N	147-57.9W
	35-12.6N	147-57.6W
	35-11.9N	147-48.9W
	35-11.1N	147-51.8W
	35-11.0N	147-51.8W

	35-10.4N	147-55.1W
	35-10.2N	147-56.1W
	35-10.1N	147-56.7W
	35-10.4N	147-44.0W
	35-10.5N	147-35.2W

MIDWATER NET TOWS			
Leg 15			
1	B	28-35.2N	155-27.4W
	E	28-35.2N	155-28.2W
2	B	28-29.3N	155-31.0W
	E	28-28.9N	155-30.8W
3	B	28-23.9N	155-27.7W
	E	28-24.0N	155-27.8W
4	B	28-24.7N	155-27.2W
	E	28-25.2N	155-27.2W
5	B	28-29.7N	155-32.9W
	E	28-29.8N	155-31.8W
6	X	28-34.6N	155-21.2W
7	B	28-31.3N	155-12.9W
	E	28-33.7N	155-10.3W
8	B	28-40.0N	155-20.8W
	E	28-40.3N	155-20.6W

CAMERA DROPS			
Leg 9			
	B	11-19.7N	142-09.3E
	E	11-19.8N	142-09.2E
	B	11-21.3N	142-13.8E
	E	11-20.6N	142-04.7E
	X	11-20.1N	142-25.2E

TRAP DROPS			
Leg 9			
1	B	11-18.7N	142-09.9E

	E	11-17.7N	142-10.0E
2	B	11-18.2N	141-55.8E
	E	11-18.4N	141-55.3E
3	X	11-18.5N	141-55.2E
4	B	11-18.6N	141-56.5E
	E	11-19.3N	141-52.9E
5	B	11-19.9N	142-14.8E
	E	11-19.4N	142-16.2E
6	B	11-19.5N	141-52.6E
	E	11-22.4N	141-35.7E
7	B	11-22.3N	141-35.9E
	E	11-21.7N	142-09.5E
8	B	11-20.7N	142-12.5E
	E	11-20.3N	142-11.5E
9	B	11-20.7N	142-12.2E
	E	11-21.0N	142-11.2E
10	B	11-31.1N	141-00.5E
	E	11-37.0N	140-35.1E
11	B	11-21.7N	142-09.5E
	E	11-21.0N	142-08.6E
Leg 15			
1	B	28-33.3N	155-31.0W
	E	28-33.1N	155-31.9W
2	B	28-32.8N	155-31.8W
	E	28-33.6N	155-31.1W
3	B	28-38.3N	155-26.4W
	E	28-38.0N	155-24.3W
4	B	28-34.2N	155-29.3W
	E	28-39.9N	155-32.5W
5	B	28-40.1N	155-29.6W
	E	28-45.6N	155-32.9W
6	B	28-37.9N	155-24.6W
	E	28-37.0N	155-26.2W
7	B	28-23.4N	155-25.4W
	E	28-22.9N	155-25.5W

8	B	28-28.7N	155-26.8W
	E	28-28.9N	155-25.1W
9	B	28-33.5N	155-27.9W
	E	28-32.4N	155-28.1W
10	B	28-19.1N	155-30.6W
	E	28-19.8N	155-28.7W
11	B	28-42.0N	155-32.1W
	E	28-31.1N	155-12.9W
12	B	28-33.4N	155-34.8W
	E	28-33.1N	155-35.2W
13	B	28-31.2N	155-12.9W
	E	28-32.4N	155-19.4W
14	B	28-36.8N	155-30.6W
	E	28-31.2N	155-31.6W
15	B	28-37.5N	155-28.8W
	E	28-38.1N	155-28.8W
16	B	28-38.0N	155-41.3W
	E	28-38.0N	155-41.7W
17	B	28-35.7N	155-20.5W
	E	28-36.0N	155-20.5W
18	B	28-37.7N	155-27.4W
	E	28-37.9N	155-27.2W

BIOLOGICAL BOX CORES		
Leg 15		
	28-31.6N	155-31.5W
	28-31.4N	155-30.7W
	28-34.3N	155-30.2W
	28-30.6N	155-29.8W
	28-34.2N	155-26.7W
	28-37.7N	155-16.5W
	28-37.9N	155-11.5W
	28-20.1N	155-29.2W
	28-30.1N	155-31.7W
	28-30.7N	155-17.7W

	28-35.8N	155-30.3W
	28-36.5N	155-27.3W
	28-41.8N	155-12.9W
	28-30.8N	155-32.4W

YINCH PUMP STATIONS		
Leg 15		
B	28-33.0N	155-31.2W
E	28-33.2N	155-31.2W
B	28-40.5N	155-29.8W
E	28-42.0N	155-30.6W
B	28-29.3N	155-31.0W
E	28-29.9N	155-30.5W
B	28-39.3N	155-10.3W
E	28-39.5N	155-10.7W
B	28-35.0N	155-35.6W
E	28-35.2N	155-36.0W
B	28-37.7N	155-26.8W
E	28-37.7N	155-27.0W
B	28-32.6N	155-24.9W
E	28-32.8N	155-26.1W
B	28-34.9N	155-26.1W
E	28-35.4N	155-26.2W
B	28-30.3N	155-30.4W
E	28-31.1N	155-29.9W
B	28-34.0N	155-30.7W
E	28-35.3N	155-30.4W

PLANKTON PUMP STATIONS		
Leg 16		
B	29-04.7N	162-02.0W
E	29-03.8N	162-31.8W
B	29-04.5N	162-31.9W
E	29-20.5N	162-07.9W

B	29-21.4N	162-06.0W
E	29-25.9N	162-33.8W
B	29-27.2N	162-35.4W
E	29-34.4N	163-04.9W
B	33-13.6N	122-06.3W
E	33-02.7N	121-47.8W
B	33-00.9N	121-41.7W
E	32-58.3N	121-15.2W
B	32-58.6N	121-09.6W
E	33-01.0N	120-47.2W
B	33-07.9N	117-25.6W
E	33-00.1N	117-21.4W
B	33-00.4N	117-21.0W
E	32-37.5N	117-20.5W
B	32-35.1N	117-20.5W
E	32-47.8N	117-23.4W

GRAB RESPIROMETER		
Leg 15		
B	28-30.2N	155-30.5W
E	28-30.5N	155-30.4W
B	28-32.1N	155-28.2W
E	28-32.7N	155-28.8W
B	28-31.5N	155-15.9W
E	28-32.9N	155-14.8W
X	28-32.4N	155-31.3W

SECCHI DISK		
Leg 15		
	28-24.0N	155-27.5W
	28-30.8N	155-23.7W
	28-38.5N	155-20.7W
	28-35.5N	155-27.2W
	28-41.1N	155-21.5W

SET LINE		
Leg 15		
	28-36.7N	155-20.9W
	28-37.8N	155-16.5W
	28-44.2N	155-33.7W
	28-40.4N	155-36.5W
	28-32.8N	155-17.4W
	28-33.6N	155-09.7W
	28-35.9N	155-16.5W
	28-39.2N	155-13.5W
	28-37.5N	155-26.5W
	28-37.6N	155-26.6W