Report of a Meeting on OCEANOGRAPHY OF THE NORTH PACIFIC

Honolulu, February 13-17, 1956

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Representatives of the agencies which carried out the cooperative oceanographic survey of the North Pacific known as NORPAC met in Honolulu, T. H., from February 13 to 17, 1956, to consider the results of that survey and to plan further cooperative oceanographic work in the Pacific.

Attendance:

Japan

Dr. Kanji Suda, Japanese Hydrographic Office, Tokyo
Dr. Koji Hidaka, Geophysical Institute, Tokyo University
Dr. Shigeru Motoda, Institute of Fisheries, University of Hokkaido
Dr. Yoshitada Takenouti, Hakodate Marine Observatory
Dr. Michitaka Uda, Tokyo University of Fisheries
Dr. Kozo Yoshida, Geophysical Institute, Tokyo University
Dr. S. Yamaguchi, Faculty of Fisheries, University of Hokkaido

Canada

Dr. A. W. H. Needler, Fisheries Research Board, Nanaimo, B. C.
Dr. John P. Tully, Pacific Oceanographic Group, Nanaimo, B. C.
Mr. A. J. Dodimead, Pacific Oceanographic Group, Nanaimo, B. C.

New Caledonia

Mr. H. Rotschi, French Institute of Oceania, Noumea

United States

Mr. Thomas S. Austin, U. S. Fish and Wildlife Service, Pacific Oceanic Fishery Investigations, Honolulu
Mr. Edward Brinton, Scripps Institution of Oceanography, La Jolla
Mr. Townsend Cromwell, Inter-American Tropical Tuna Commission, La Jolla
Dr. Richard H. Fleming, University of Washington, Seattle
Mr. R. J. Harris, U. S. Air Force Weather Service, Tokyo
Mr. Milton C. James, Pacific Marine Fisheries Commission, Portland, Oregon
Mr. John A. Knauss, Scripps Institution of Oceanography, La Jolla
Mr. John C. Marr, U. S. Fish and Wildlife Service, South Pacific Fishery Investigations, La Jolla
Mr. James W. McGary, U. S. Fish and Wildlife Service, Pacific Oceanic Fishery Investigations, Honolulu
Mr. Garth I. Murphy, U. S. Fish and Wildlife Service, Pacific Oceanic Fishery Investigations, Honolulu
Mr. Boyd E. Olson, U. S. N. Hydrographic Office, Washington, D. C.
Mr. Joseph L. Reid, Jr., Scripps Institution of Oceanography, La Jolla
Dr. Roger Revelle, Scripps Institution of Oceanography, La Jolla

Cdr. L. S. Robinson, U. S. N. Hydrographic Office, Washington, D. C.
Mr. O. E. Sette, Ocean Research, U. S. Fish and Wildlife Service, Stanford, California
Dr. Albert L. Tester, U. S. Fish and Wildlife Service, Pacific Oceanic Fishery Investigations, Honolulu
Mr. Richard Vetter, Office of Naval Research, Washington, D. C.
Dr. Warren S. Wooster, Scripps Institution of Oceanography, La Jolla

Mr. O. E. Sette was chairman of the meeting and Mr. Joseph L. Reid, Jr., secretary.

NORPAC:

In July, August and September, 1955, agencies of Japan, United States and Canada cooperated in a synoptic survey of the Pacific Ocean north of 20°N Latitude which was the greatest project of its kind ever undertaken. Twenty vessels occupied about one thousand oceanographic stations according to an agreed plan. Not only were the sea operations carried out successfully but records of all the data, with preliminary processing completed, were exchanged by all the agencies at this meeting in February, 1956--less than five months after the field work was over. The agencies, the vessels and the approximate areas covered by each are shown in Appendix I. The magnitude of the project and the spirit in which it was carried out, demonstrate on a larger scale than ever before what can be achieved by international cooperation in oceanographic research.

The project was originally proposed in informal discussions between research agencies interested in the oceanography of the Pacific. It called for a considerable departure on the part of the Japanese agencies from their ordinary, scheduled operations. That it was possible in the short time available to alter and replan these operations was due to the assistance and cooperation of Dr. Suda. Its purpose was to obtain oceanographic data simultaneously over the whole northern part of that ocean, thus giving a more complete picture of the properties and dynamics of the water masses than was available from the piecemeal investigations of the past. The importance of the project to the many fields of applied oceanography helped to enlist the necessary support to carry it out.

The Conference marked the completion of the first phase of the NORPAC project --the collection and preliminary processing of the data. In addition to the exchange of data records representatives of each agency presented the results of such further analysis as had been possible in the short time available. The conclusions reached were necessarily of a preliminary nature but when combined already demonstrate the effectiveness of the project and the great value of the picture which is emerging. The characteristics of the water masses and water movements in particular areas can now be delineated. The discussions emphasized, however, the need for information on the whole oceanic system if any of the parts are to be fully understood. The experience and the information obtained through NORPAC make it possible to plan more effectively for further work in neighboring regions and in parts of the NORPAC area itself.

The Conference noted the many ways in which the results of the NORPAC surveys assist in discovering and understanding the distribution and movements of commercially valuable fishes and marine mammals. In the north, for example, conditions were revealed which influence salmon distributions. Farther south lie other important populations of fish in the high seas, some of which support highly developed industries such as the Japanese and American albacore fisheries, the Japanese and Hawaiian skipjack fisheries, and the intensive fisheries for herring-like species on both sides of the North Pacific. In addition, many areas not now fished support what appear to be dense stocks of valuable fishes. NORPAC is an important forward step in the development of new fisheries and the extension of old.

The Conference considered the problem of bringing about further analysis of the NORPAC data and of making the NORPAC results available for us by oceanographers and others. A number of lines of further analysis were discussed which will be undertaken by various individuals and agencies.

The Conference agreed to propose the publication of a narrative account of the NORPAC operations, of the data records in as complete a form as possible and of an atlas in which a quasi-synoptic picture would be presented in about one hundred and ten charts. The purpose of the publication is to make the data and the results of preliminary analysis fully available to all those who may subject them to further analyses or apply them as they are. It is proposed that publication be sought as a special number of "Oceanic Observations of the Pacific" through cooperation between the Universities of California and Tokyo, the printing to be carried out by the Japanese Hydrographic Office. Drs. Suda, Revelle, and Needler undertook to explore ways and means of financing the publication. The details of the proposed publication and of the responsibilities for preparing various sections are outlined in Appendix II. Publication is proposed by March 1, 1957.

The Conference recommends that future scientific reports and publications based on NORPAC data be distributed to all of the participating agencies.

Relationship of Oceanography to Salmon Distribution

The results of surveys related to the NORPAC project in the northernmost part of the Pacific have already delineated, in a preliminary way, superficial water masses of relatively low salinity which seem to be associated with the distribution of salmon. These surveys have thus contributed to the oceanographic background for the study of salmon distribution which is an important part of the research program of the International North Pacific Fisheries Commission. It is also indicated that variations in these water masses can be studied profitably in order to throw light on changes in salmon distribution. On this basis it was concluded that further oceanographic observations in this area would be valuable whether obtained in special oceanographic surveys or in conjunction with sea operations for other purposes.

EASTROPIC

The EASTROPIC expedition of September-December 1955 was a "multiple-ship" survey to make a detailed study of the current system in a portion of the eastern tropical Pacific. Emphasis was placed on the relationship of productivity to physical and chemical factors and on the use of a variety of direct and indirect means of studying currents. The cooperating agencies were the Scripps Institution of Oceanography, the

Inter-American Tropical Tuna Commission, the Pacific Oceanic Fishery Investigations, Consejo de Investigaciones Hidrobiológicos, Peru, and the Department of Fish and Game, State of California. Five vessels were used.

The EASTROPIC expedition covered an area previously studied by cooperative expeditions in 1952. It was planned to a large degree to attack specific problems raised by the earlier work. These were concerned with the dynamics of the currents and their influence on the distribution of tunas. The Conference noted the important progress made by this expedition in developing new lines of attack on the problems of oceanic circulation.

A committee of the Conference considered plans for analyzing the results. Its report is appended (Appendix III).

EQUAPAC

The EQUAPAC project is proposed as a cooperative ocean-wide survey of the equatorial zonal circulation of the Pacific in the summer of 1956. Five Japanese, one French and two United States agencies are expected to use a total of ten vessels in this operation. The proposal was initiated in informal discussions in 1955 and accepted at this Conference. A committee of the Conference, representative of the agencies concerned, undertook the planning of the project. Some details of plans remain to be finalized. The committee's report appears in Appendix IV.

The Conference endorsed the proposed cooperation between Japanese and Australian oceanographers during EQUAPAC as suggested at the meeting of the UNESCO Interim Advisory Committee on Marine Science by the Australian member, Dr. Rochford. It is hoped that Australian oceanographers may be able to participate in the work on the Japanese vessels in Australian waters.

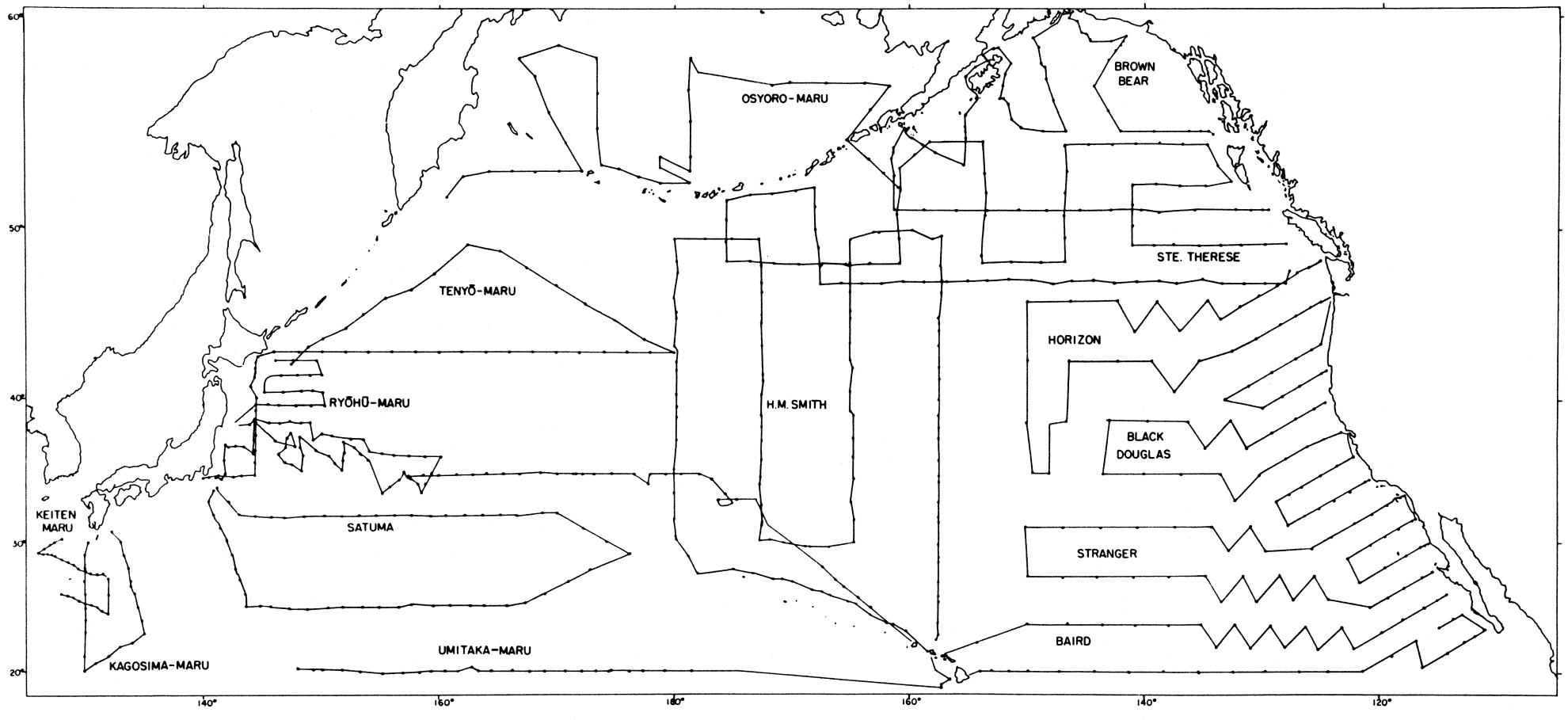
IGY Plans

Because many interested agencies were represented at the Conference, a working group discussed plans for the oceanographic program of the International Geophysical Year, July 1, 1957 to December 31, 1958. They plan to meet again in March, 1957, in Kyoto, Japan.

The broad outlines of the oceanographic program have been established by the Comité Spécial de l'Année Géophysique Internationale and amplified by national committees, but for the effective conduct of the program there are many details that must be discussed by the participating agencies.

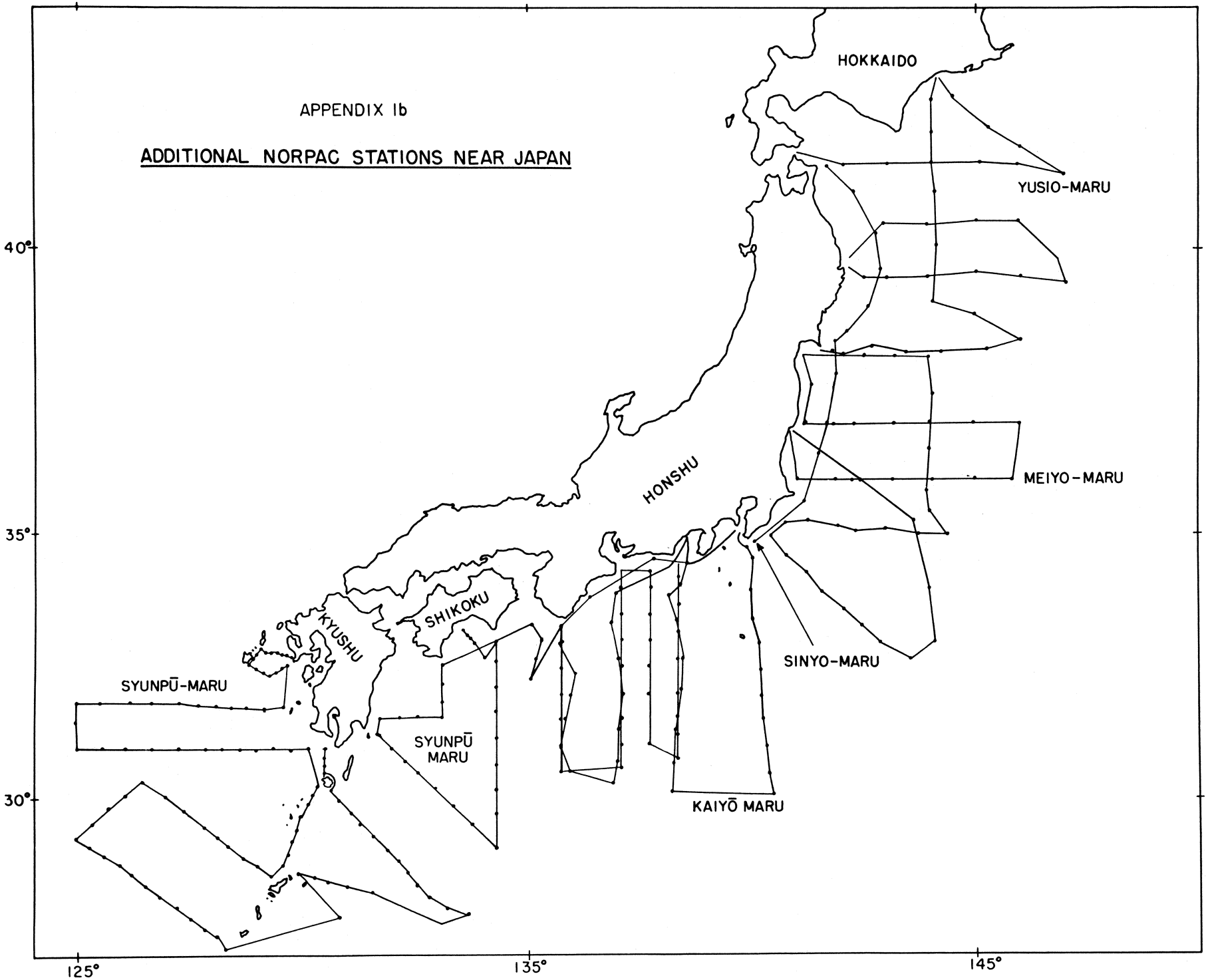
The topics discussed are described in detail in the minutes of the IGY working group (Appendix V).

It was recognized by the Conference that the practical experience and scientific results of NORPAC and EASTROPIC are of great importance to the effective conduct of oceanographic operations of IGY. It was strongly recommended that the NORPAC data and atlas be published by March 1957 and that the results of EASTROPIC and of the contemplated EQUAPAC (1956) and International North Pacific Fisheries Commission operations be made available to the other participating agencies at as early a date as possible by the exchange of informal reports.



NORPAC STATIONS OCCUPIED IN JULY – SEPTEMBER 1955 (not including some stations near Japan and excluding exploratory fishing cruises)

APPENDIX Ia


APPENDIX Ib
ADDITIONAL NORPAC STATIONS NEAR JAPAN
HOKKAIDO
YUSIO-MARU
MEIYO-MARU
HONSHU
SHIKOKU
KYUSHU
SINYO-MARU
SYUNPŪ-MARU
SYUNPŪ MARU
KAIYŌ MARU
40°
35°
30°
125°
135°
145°

The excellent results from NORPAC demonstrate the value of standard methods of observation, analysis and reporting of observations. The Conference recognized the importance of this and urged that all possible efforts be made to achieve high and uniform standards of accuracy among all oceanographic agencies. This can best be accomplished by the temporary exchange of the scientists directly concerned with the operation and with the development of new equipment.

The value of informal discussions by representatives of participating agencies was apparent to all. It is therefore recommended that similar meetings be held prior to the start of the International Geophysical Year.

The vessel operations planned for IGY and the establishment of observing stations in remote locations for the sea-level program offer exceptional opportunities for collateral programs. All agencies were unanimous in their intent to encourage the full exploitation of these opportunities for comprehensive scientific investigations. Financial support for such investigations will have to come from sources other than those appropriated for the IGY.

Proposed Standard Method of Zooplankton Collection

A committee of the Conference developed proposals, described in Appendix VI, for standard methods and equipment for collection and quantitative treatment of zooplankton. It is not suggested that these standard methods replace those now in use, which are designed to meet the needs of particular investigations. They are proposed rather as a means of obtaining comparative results by using them in oceanographic surveys in addition to methods used for special purposes.

The Conference recommends that further serious efforts be made to develop satisfactory standard methods of collecting and analyzing zooplankton.

Future cooperation in Oceanographic Research

The Conference expressed the hope and faith that the NORPAC project would encourage other cooperative researches in the field of oceanography. It stressed the value of the free and thorough discussion of plans and the early exchange of data and analyses which contributed so greatly to the inspiring success of NORPAC.

Acknowledgments

The Conference expressed its great appreciation of the excellent hospitality and facilities afforded by Pacific Oceanic Fishery Investigations and the University of Hawaii.

It also expressed its gratitude to the Office of Naval Research and the National Academy of Sciences for invaluable assistance in travel arrangements for the Conference.

Joseph L. Reid, Jr.
Secretary

APPENDIX II

Report of the committees on the preparation and publication of the NORPAC data report and Atlas.

Committee on Ways and Means	-	Dr. Suda and Dr. Revelle
Committee on Physical and Chemical Data	-	Chairman, Dr. Fleming
Committee on Biological Data	-	Chairman, Mr. Brinton

The data collected by the NORPAC expeditions will be published as a special number of the Oceanic Observations of the Pacific, called

DATA AND CHARTS OF THE
NORPAC EXPEDITIONS
IN THE SUMMER OF 1955

Prepared by the
NORPAC COMMITTEE, consisting of one representative from

Japanese Hydrographic Office (J.H.O.)
Central Meteorological Observatory
Tokyo Fisheries University
Tokai Regional Fisheries Research Laboratory
Hokkaido University
Kagoshima University
Hakodate Marine Observatory
Pacific Oceanographic Group (POG)
University of Washington (U. of W.)
Scripps Institution of Oceanography, University of California (SIO)
South Pacific Fisheries Investigations, U. S. Fish and Wildlife Service (SPFI)
Pacific Oceanic Fishery Investigations, U. S. Fish and Wildlife Service (POFI)

Chairman - O. E. Sette
Secretary - J. L. Reid, Jr.

If possible it will be published by the University of California Press and the University of Tokyo Press with editorial boards from both universities, and probably printed by the Japanese Hydrographic Office. Typing of tables and final drafting will be done by the Japanese Hydrographic Office. The tabulated data will be furnished to the J.H.O. in the proper format by each agency. This format will be selected and described by Joseph L. Reid and Warren S. Wooster.

There will be one volume of tabulated data, containing a foreword by Dr. K. Suda, and an introduction, narrative and description of methods by J. L. Reid, and one volume of charts.

In order not to delay other volumes of OOP it is hoped that the costs can be shared by the University of California, University of Washington, the Pacific Oceanographic Group, Japanese agencies, and perhaps others. The method of paying is as yet unsettled, but may be by purchase of copies of the Atlas. The cost will be estimated and reported by Dr. Suda. The number of copies to be printed and the dis-

tribution list are yet to be decided and will be determined by the needs of the different agencies. Distribution will be made through the J.H.O. to the Japanese and through SIO to its normal world-wide distribution list (except the Japanese) and by other agencies as desired.

The data report will contain oceanographic and biological observations made by the participating vessels, and a bibliography of other publications from NORPAC.

With respect to the biological data, records should include:

Zooplankton A complete description of the gear, methods of operation and laboratory methods (especially what items discarded. Tables should show both net weights and displacement volumes where possible. Other detail (lists of other types of collections, remarks on predominance of groups, etc.) to be included at option of agency.

Phytoplankton Tables of quantitative data to be included in data record when available.

The Atlas will consist of the following charts:

Horizontal

Distributions of T, S, O_2, PO_4, σ_T on the levels of 10, 50, 100, 200, 400, 600, 1000 meters.

Three additional mean monthly surface temperature charts from merchant vessel observations in July, August and September.

Monthly averages of pressure, air temperature, and wind in July, August and September.

A station map and a grid.

The dynamic height anomaly

$^{0}/_{1000}$ db, $^{200}/_{1000}$ db, and $^{400}/_{1000}$ db

Zooplankton A chart to show displacement per volume of water filtered ($cm^3/1000m^3$). Data are or can be made reasonably comparable in three groups. Collections by SIO and POFI were made with 0-140 M. oblique tows with 100 cm. nets with .65 mm. mesh openings (30xxx grit gauze). Japanese collections were made with 0-150 M. vertical hauls with 45 cm. nets with .33 mm. mesh openings (#54 grit gauze). University of Washington used oblique tows of Clarke-Bumpus samplers mainly 0-200 M, with mesh opening of .24 mm. POG vertical tows 0-100 M. and 100-200 M were made with 25 cm. nets and .31 mm. mesh openings but overlap sufficiently with University of Washington for development of approximate conversion factors. It is proposed that the SIO, POFI, Japanese and U. of W.—POG data be plotted using different lines to show contours and not necessarily making corresponding contours meet. The methods of collection should be explained in the legend.

Birds One chart (to be prepared by Mr. King) showing distribution of birds recorded, without attempting to show species separately.

Mammals One chart (to be prepared by Mr. King, Mr. Gilmore or Mr. Pike) to show distribution of sea mammals sighted.

Fish Dr. Needler to discuss with Drs. Walford and Fujinaga the inclusion of three charts showing catches by high-seas commercial fishing and by exploratory fishing in months of July, August and September. If the appropriate agencies of the three countries will provide this material for the Atlas arrangements would be made for presending it in three charts (which can be prepared by the Fisheries Research Board of Canada if desirable).

Fish larvae Dr. Motoda offered to prepare material on fish larvae collected in a standard method (by 10-minute surface tows with 130 cm. stramin net) by the various Japanese agencies. No attempt would be made to show species separately.

Vertical Profiles

Ten sections were selected for drawing vertical profiles. Roughly they are along

20° North latitude
30-32° North latitude
42-46° North latitude
55° North latitude
157° West longitude
180° longitude
150° East longitude
140° West longitude
Along the Kuroshio current
Along the California current

Profiles will be drawn of the upper 1200 meters of T, S, O_2, PO_4. The thermosteric anomaly (δ_T) will be shown on the O_2 and PO_4 profiles. In addition, the temperature will be shown on an expanded scale in the upper 200 meters, based on both bathythermograph and station observations.

The horizontal distributions will be presented on a Lambert Equal-Area Azimuthal projection showing approximately 20° to 60° north. The base map, station pattern, and grid will be prepared by SIO and distributed to the other agencies. Publication will be on a page approximately 18"x22", and two or more charts will be printed on each page. The base map prepared for drafting will be about 33"x12"

The T, S, O_2, PO_4 vertical profiles will be printed with scales of approximately 100 meters depth to one centimeter on the page and 200 kilometers to one centimeter. The separate 0 to 200 meter temperature profiles will have 200 meters to 10 centimeters.

SIO will prepare and distribute forms for the vertical profiles, probably enlarged for working sheets.

Preparation of the Charts

Charts and vertical profiles will be prepared as follows:

Temperature	Tokyo Fisheries U. and Tokyo U.	M. Uda and K. Yoshida
T (0/200)	SIO	M. Robinson
Salinity	J.H.O. and Tokyo U.	K. Suda and K. Hidaka
Oxygen	POG	~~J. Tully~~ A. Dodimead
Phosphate	U. of W.	~~R. Fleming~~ F. Favorite
δ_T	SIO	J. Reid Jr.
ΔD	POFI	J. McGary
Surface currents and surface temperature from merchant vessels	U.S. Hydrographic Office Japan Meteorological Agency	B. Olson
Weather data--pressure air temperature wind	~~C.M.O.~~ and U.S. Hydrographic Office	Y. Takenouti and B. Olson
~~Bathythermograph data from weather ships~~	~~Agency maintaining vessel~~	
Base map, station pattern, grid and profile forms	SIO	J. Reid Jr.
Plankton volumes	SPFI (FWS)	E. Ahlstrom
~~Birds~~	~~POFI~~	~~J. King~~
Mammals	SPFI (FWS)	R. Gilmore
~~Fish~~	~~Fisheries Research Board of Canada~~	A. Needler (as a member of INPFC Committee will undertake to explore the possibilities of preparing such charts).
Larvae	Tokai Regional F.R.L. and Hokkaido U.	T. Nakai and S. Motoda

The persons listed are responsible for preparing the final charts. The agencies expressed a desire to prepare the T, S, O_2, PO_4, δ_T and ΔD charts from their own areas and submit them to the person coordinating to assist him in his work.

Time of Publication

In order to meet a publication date of 1 March 1957 the preparation will be done in the following periods:

SIO furnishes profile paper and charts	-	not later than 31 March 1956
Preliminary charts to coordinators	-	do. 30 June 1956
Charts and tabulated data to J.H.O.		do. 15 Sept. 1956
Proofreading		do. 15 Dec. 1956
Publication		do. 1 March 1957

APPENDIX III

Report of the Committee on EASTROPIC

During the period from September to December 1955, five research vessels studied the physical, chemical and biological oceanography of the eastern tropical Pacific on EASTROPIC EXPEDITION.

Personnel of the Scripps Institution of Oceanography and the Inter-American Tropical Tuna Commission aboard the Scripps' vessels BAIRD and HORIZON operated southward from San Diego as far as northern Peru and from the Central American coast westward to the longitude of California. On these vessels were emphasized special studies of currents and productivity (1) in the Equatorial Countercurrent and (2) at its northern boundary, (3) in the Equatorial Undercurrent, and (4) along the northern boundary of the Peru Current between Ecuador and the Galapagos Islands. A general survey including 190 stations (T, S, O_2 and PO_4) was accomplished while running between these areas of special interest. The Peruvian vessel BONDY occupied Nansen bottle stations and made numerous bathythermograph (BT) casts along the north boundary of the Peru current, and then worked southward along the Peruvian coast.

The SCOFIELD, of the Department of Fish and Game, State of California, conducted longline fishing in the four special areas mentioned above.

The HUGH M. SMITH, of the Pacific Oceanic Fishery Investigations, obtained information on east-west gradients in temperature, salinity, phosphate, zooplankton and forage fish abundance along the northern boundary of the Countercurrent and along the Equator between 110°W and 156°W. The basic rate of productivity was determined at the surface and at 20 meters depth at 76 stations using the C14 technique; plant pigments were measured at 44 stations. Closing-net zooplankton hauls totalled 130, open-net zooplankton hauls 129, pelagic trawl hauls 54. A survey of tuna bait fish was conducted in the Marquesas Islands.

Each agency plans to process its own data. There will then be an exchange of these data so that they can be used freely in any analyses. Workers using the data will be in contact with each other to avoid duplication of effort.

APPENDIX IV

Report of the Committee on EQUAPAC

Purpose Ocean-wide survey of equatorial, zonal circulation as a basis for IGY planning.

Participants

1. Japanese
   a. Tokyo University of Fisheries vessel - UMITAKA MARU
   b. Kagoshima University - KAGOSHIMA MARU
   c. Shimonoseki Fisheries Institute - SYUNKOTU MARU
   d. Japanese Hydrographic Office - SATUMA
   e. Fisheries Agency - new vessel as yet unnamed.

2. French
   a. French Institute of Oceania - ORSOM III

3. United States
   a. Scripps Institution of Oceanography - R/V HORIZON
      - R/V STRANGER
   b. Pacific Oceanic Fishery Investigations - HUGH M. SMITH
      - C. H. GILBERT

At the present stage of planning, it is envisioned that the equatorial circulation will be surveyed in a quasi-synoptic style (10 vessels) between 135°W and 125°E longitude (east coast of the Philippines and New Guinea) and between 15°N and 15°S latitude. In general terms, moving east to west, POFI will operate in the area between 135°W and 160°W; the Scripps Institution of Oceanography and the French between 160°W and 160°E; with the Japanese vessels surveying the region west of 160°E.

Several questions are still to be answered. First is the time schedule, requiring consideration of ship availability and of the typhoon season. Next is the type and frequency of observations, and then the final integration of the efforts of the various activities in order that the most comprehensive coverage and detailed information may result.

An important aspect of EQUAPAC will be the measurement of the distribution of radioactivity in the waters and in organisms. It can be expected that Japanese ships and ships of the SIO will be principally concerned. It is recommended that methods used in measuring the radioactivity be carefully coordinated and that, if possible, there be an exchange of personnel between the Japanese and American ships.

An attempt should be made to arrange for logistic support of the Japanese and French vessels participating in the operation at American ports in the western Pacific. A request for such support will be made through the Office of Naval Research.

In view of the above problems, the committee recommends that Dr. Suda of the Japanese Hydrographic Office and Mr. Austin of POFI act as coordinators of the project, with assistance on logistics and standardization of radioactivity methods by Dr. Wooster of SIO. Further, that a composite track chart, with all available pro-

posed vessel tracks, be prepared and forwarded to participating agencies. Each agency will criticize and alter as necessary and, as soon as practicable, forward the suggestions and a firm schedule to Dr. Suda and Mr. Austin for preparation of the final plans.

APPENDIX V

Report of the Committee for IGY

The working committee for the oceanographic program for the International Geophysical Year held meetings on 16, 17, 18 February 1956. The following delegates to the NORPAC conference attended one or more sessions:

Japan

Dr. Koji Hidaka, Geophysical Institute, Tokyo University, Tokyo
Dr. Kanji Suda, Japanese Hydrographic Office, Tokyo
Dr. Yoshitada Takenouti, Hakodate Marine Observatory, Hakodate, Hokkaido
Dr. Michitake Uda, Tokyo University of Fisheries, Tokyo
Dr. Kozo Yoshida, Geophysical Institute, Tokyo University, Tokyo
Dr. S. Yamaguchi, Faculty of Fisheries, University of Hokkaido

Canada

Dr. John P. Tully, Pacific Oceanographic Group, Nanaimo, B. C. (POG)
Dr. A. J. Dodimead, Pacific Oceanographic Group, Nanaimo, B. C.

France

Mr. J. Rotschi, French Institute of Oceania, Noumea

United States

Dr. Roger Revelle, Scripps Institution of Oceanography (SIO)
Mr. John A. Knauss, Scripps Institution of Oceanography
Mr. Townsend Cromwell, Inter-American Tropical Tuna Commission
Mr. Richard Vetter, Office of Naval Research, Washington, D. C.
Mr. O. E. Sette, Ocean Research, FWS
Mr. Boyd E. Olson, USN Hydrographic Office, Washington, D. C.
Dr. Richard H. Fleming, University of Washington
Dr. Albert L. Tester, Pacific Oceanic Fishery Investigations (POFI)
Mr. Garth I. Murphy, Pacific Oceanic Fishery Investigations
Mr. Thomas S. Austin, Pacific Oceanic Fishery Investigations
Mr. James W. McGary, Pacific Oceanic Fishery Investigations

The purpose of the meetings was to exchange information on progress the different organizations were making in their plans for the IGY and to clarify the ideas and concepts behind the proposed projects. (The report that follows was prepared by the acting secretary of the committee, J. A. Knauss, after the meetings. There was no opportunity for the report to be read by the delegation prior to publication.)

IGY Program in Oceanography

The program is divided into two general parts, the Island Observatory program and the Ship Operations program. The Island Observatory program consists of tidal observations, steric sea level observations and long period wave recording. The Ship Operations program consists of studies of the deep currents, multiple ship operations, polar front surveys, carbon dioxide measurements.

Island Observatory Program

I. Tidal Observation

The state of our knowledge on the seasonal variation in mean sea level has been recently reviewed, Pattullo et al (1955), Lisitzen (1955). There is an increase in the height of mean sea level during the summer and fall months in both northern and southern hemispheres. Three explanations have been offered.

1. This variation is due to mass transport across the equator.

2. Since nearly all of the observations are along the outer periphery of the oceans, it could be explained by a slowing down of the circulation in summer with the consequent decrease in slope of the water surface.

3. The change in height may be partly or entirely explained, not by a change in the mass distribution, but by a volume change in the water column due to the heating and expanding of the water during the summer months. This latter explanation is called the "steric change in sea level."

Although a large part of the observed seasonal variation can be explained by steric changes, it is not evident as yet whether all of the change can be so explained. The hope of the tidal observations program is to:

1. Maintain all existing tide stations.

2. Increase the tidal station coverage. In particular, better coverage is needed in the southern hemisphere and in the central ocean areas. It is urged that where new tide stations are established for this program they be free from local effects such as tidal races. It has further been suggested that where new tide gauges are installed they be tied into existing bench marks, so that if they are discontinued after the IGY they can be relocated for future programs.

II. Steric Sea Level

At as many tide stations as is possible it is hoped to make temperature and salinity measurements at monthly or shorter intervals (preferably two-week intervals). These should be in deep water and within 100 miles of the tide station. The question of minimum depths of observations was discussed and it was agreed that SIO would advise participants on this matter.

III. Long Period Wave Recording

This is defined as waves which are less than tidal period, but are long compared to the regular gravity waves. Tsunami waves are in this category. The propagation characteristics of these waves are not clearly understood, Press and Ewing (1955). Also little is known about their energy spectrum. It is thought that such things as the width and character of the continental shelf are important factors in determining the type of waves that arrive at any given location. Van Dorn of SIO has detailed plans and drawings of the long period wave recorder used by SIO, Van Dorn (1956). These plans are available to anyone who wishes to build his own recorder. A local company has undertaken to build this recorder, so that it can be bought by any of the

participants who prefer not to build their own. Information with respect to the plans or to the purchase of a ready-built instrument can be had by writing J. D. Frautschy, at the Scripps Institution.

Ship Operations

I. Deep Currents

The circulation in the deep water is believed to be slow, but there is no general agreement as to how slow. Various bits of evidence to date (Kulp's and Ewing's C^{14} data, oxygen measurements by Worthington, of the Woods Hole Oceanographic Institution, Maxwell and Revelle's heat flow measurements, Worthington (1954), Revelle and Maxwell (1956)) lead to estimates of the age of deep water that vary between 100 - 10,000 years. Four methods of measuring the deep circulation were discussed.

1. Samples for Carbon - 14 Analysis Carbon-14 analysis requires about 30 liters of water per analysis. W. G. Van Dorn of SIO has developed a 50-liter sampler that was used successfully on EASTROPIC. SIO will send plans for the sampler to anyone who is interested. It was agreed that all sampling should be done in the same water mass, for example, Antarctic Bottom Water. SIO will analyze the existing hydrographic data which will be used as the basis for deciding the sampling depth to be used in various parts of the Pacific. The final decision as to sampling depth must be based on the capabilities of the various ships participating in this part of the program.

2. Temperature, Salinity, and Oxygen Measurements If the Woods Hole interpretation of oxygen data is correct (i.e., deep water is formed periodically during years of very cold winters, the present deep water in the Atlantic having been formed in 1812), then the C^{14} method will not be very useful. Deep hydrographic stations (deeper than 3500 meters and preferably to the bottom) should be made as near as possible to locations of previous deep stations where good temperature, salinity and oxygen data are available. In areas where no deep hydrographic stations are available observations should be made, anyway, so they can be used as a basis for comparison 25-50 years hence. Because of the inherent error in salinity measurements, it was suggested that, if possible, bottles be spaced as close as 100-200 meters apart in deep water so that an adequate statistical analysis of salinity and sigma-t gradients could be made.

3. Tritium Measurements Tritium is hydrogen-3. It is formed in the upper atmosphere by cosmic rays and has a half life of 12 years. About 30 liters of water is needed for a single analysis. Just as it is hoped that carbon-14 can be used to measure the age of very deep water, assuming it is older than several hundred years; so it is believed that tritium can be used to measure the age of the intermediate water and to give some estimate of the amount of mixing through the main thermocline. It is suggested that samples be taken at the surface, in the main thermocline, and at 1000 meters.

4. Direct Current Measurements Several possibilities of direct current measurements were discussed such as the neutrally buoyant float of Swallow at NIO, Swallow (1955), the use of very large drogues with small surface floats, and the use of a slightly buoyant drogue anchored to the bottom or to a highly buoyant underwater float anchored to the bottom. It was suggested that all participants consider various

possible techniques for direct current measurements and exchange ideas on success with developing techniques. Measurements must be made at one place for a long enough period of time to get meaningful measurements (probably at least two days).

II. Multiple Ship Operation

There was an extensive discussion between participants on the nature and philosophy of a multiple ship operation. The prime example of such an expedition was the CaBOT survey of the Gulf Stream in 1949 in which the U. S. Hydrographic Office, Woods Hole, and Canadian ships participated, Fuglister and Worthington (1951). It was generally agreed that a multiple ship expedition could be described by the following characteristics:

1. The ships work as a team under a leader or master ship.
2. The team studies a problem not an area.
3. Operations and plans can be changed from day to day by the master ship.

For this type of expedition to be successful it was agreed that the following prerequisites be met:

1. There must be good communication between ships.
2. The observations made should be of the type that are quickly interpretable, such as GEK, BT, and drogue measurements so that operations can be changed on the basis of syhoptic observations.

III. Polar Front Survey

It was generally agreed that by a polar front survey was meant an operation similar to NORPAC but if necessary on a reduced scale.

IV. Carbon Dioxide Analysis

Measurements indicate that the amount of CO_2 in the atmosphere has increased markedly in the last 50 years as the result of the burning of a large amount of fossil fuels (coal, petroleum and natural gas), Callander (1940). It has further been suggested that an increase in CO_2 content in the atmosphere might result in an increase in the infra-red absorption and could account for the observed warming of the atmosphere over the part half century.

It appears that most of the early CO_2 determinations are open to question and that the world-wide carbon dioxide measuring program for the IGY will serve as an initial series of measurements to be compared with another set to be measured in another 25-50 years.

It is suggested that the CO_2 content of near-surface water be measured, perhaps by determining pH, alkalinity, and temperature, and that air samples be measured for CO_2 content by infra-red spectroscopy. The latter can be done to an accuracy of one percent with equipment rugged enough to be used on shipboard. The International Working Group on Oceanography will be asked to promulgate standardized techniques.

Miscellaneous

It was generally agreed by all participants that as many additional or collateral observations be undertaken as is possible on all parts of the Ship Operations program. Two were particularly stressed.

1. Good echo soundings are important to fill out our knowledge of the geomorphology of the ocean floor. They are particularly important with respect to the Deep Current program.

2. It was urged that as many different chemical analyses as possible be made on the deep hydrographic stations in the Deep Current program. The analysis of PO_4 was particularly stressed.

Plans for the IGY Program in Oceanography

Not all of the IGY Program in oceanography for the Pacific was discussed at these meetings because of both limited time and limited representation. What follows is a regrouping by areas and subject matter of the discussions that did take place between the representatives present.

Island Observatory

Japan: Dr. Hidaka, who is Secretary for Oceanography, National Committee for IGY Science Council of Japan, presented the tentative plans of the Japanese for the IGY. All regular tide stations will operate during the IGY. Steric sea level observations will be made at four stations within 100 miles of the station. (Note: the locations of the four stations were not given at the meetings, but from previous correspondence it is believed they are Ayukawa, Aburatsubo, Hososhima, and Naze. JAK). Long period wave recorders are to be established at two locations, Ayukawa and Oshima. It was urged that an additional long period wave recorder be established at Misaki in order to record propagation from Oshima to the mainland. Dr. Revelle indicated that Van Dorn of SIO would visit Japan sometime this year to discuss the long period wave program.

Pacific Oceanic Fishery Investigations, Hawaii: The U. S. Coast and Geodetic Survey maintains the tide stations in the Hawaiian Islands. It was felt that POFI was perhaps better equipped with ships and personnel to make steric observations than the University of Hawaii. It was suggested by Revelle that the National Science Foundation withhold any transfer of funds for this program until it could be ascertained whether or not POFI could undertake it. Murphy thought they could tell better in another 5-6 months. There was no discussion about long period wave recording at Hawaii.

Pacific Oceanographic Group, Canada: Tully of POG discussed the establishment of a new tide station for the IGY. A west coast of Queen Charlotte Island site is too expensive to maintain. There is some question as to the validity of measurements made at most of the possible east coast sites. This problem was left open. POG will make steric sea level observations near the tide gauge operated by the Canadian Hydrographic Service on the north end of Vancouver Island. Tully pointed out that the weather station "Papa" in the Gulf of Alaska will begin regular hydrographic observations sometime this summer.

University of Washington: Fleming will be responsible for steric sea level observations in Alaska and the Aleutians. He will try to get the use of Navy tugs to make steric observations with respect to one or more of the tide gauges operated in the Aleutians.

French: Rotschi reported two tide gauges in operation at New Caledonia. He will attempt to make monthly steric observations and to look into the possibility of installing another gauge in the New Hebrides. He thought it possible that he could install a gauge at either Port Vila or Wallis Island and that he could incorporate steric observations with his regular program. He reported that the French Hydrographic Office will install and operate a gauge at Tahiti.

Line Islands--Scripps Institution of Oceanography: Revelle reported that funds will be available for installations and maintenance of magnetic and/or sea level recorders on Jarvis, Palmyra, and Christmas Island. There is a question of how to maintain these installations once established. The use of Gilbert and Ellice Island personnel was considered. POFI has had experience in using native help on island installations and Murphy of POFI volunteered to help SIO look into the various possibilities. In general the SIO program is to fill in areas in the Pacific where observations are needed. Not all of the SIO operated sites have yet been chosen. In conclusion Revelle reported that funds, as long as they last, are available for the purchase of equipment, for the payment of personnel, and for the operation of boats.

Ship Operations

Western Pacific

The ship operations program in the Western Pacific, so far as is known now, will be carried out by the Japanese and the Russians.

Japan: Dr. Hidaka produced a chart showing the Japanese plans for the IGY. It includes the following program. It has not yet been decided which agencies will operate which ships.

A. Multiple Ship Current Measurements
   1. 35-45°N, Japanese Islands to 150°E - two ships for 40 days in July 1957
   2. 0-10°N, 140°-155°E - two ships for 45 days in August 1958.
   3. 0-10°N, 140°-155°E - two ships for 45 days in March 1958.

B. Deep Current Program
   1. From the Japanese Islands to the Equator and return along the following approximate meridians 128°, 135°, 145° and 155°E - two ships 50 days each, beginning August 1958.

C. Polar Front Survey
   1. From the Japanese Islands to as far as 180° in the northern section, from 15°-45°N - 8 ships between 30-50 days in October 1957.
   2. From the Japanese Islands to 180°, from 30°-50°N - six ships between 30-50 days in August 1958. In addition there will be another ship, if possible, in the Bering Sea for about 55 days.

The Japanese were not aware of the carbon dioxide measuring program, which has not been previously outlined in detail, but expressed an interest in it.

After considerable discussion on the nature of a multiple ship expedition, the Japanese indicated that they would probably change their plans somewhat to include more ships in operations of this type.

Russian: There were no Russian representatives at the meetings. It was the opinion of Revelle and Hidaka, who have discussed IGY plans with Russian representatives, that their plans call for a polar front survey during the summer of 1957 and the late winter of 1958. The extent and number of ships is not definitely known.

Eastern Pacific

Multiple Ship Expeditions

There will be two expeditions in the equatorial regions: one in March and the other in August 1958. One will study the transient nature of the countercurrent; the other the equatorial undercurrent. There will be two or more SIO ships. It was thought that plans for these multiple ship expeditions as well as other parts of the IGY program might be fitted into the long term research program of POFI, on a cooperative basis with SIO. The possibility of a Peruvian ship participating in these expeditions was discussed.

There are at present tentative plans for a multiple ship expedition in the Northeastern Pacific during the summer of 1957. The nature of this program is not decided, but the possibility of measuring the circulation below the thermocline was discussed. SIO, U. of Washington, POG and, possibly, POFI will cooperate in this operation.

Deep Currents

SIO will send two ships on two approximate north-south lines into the South Pacific. The exact course has not been decided, but it is expected that the ships will travel to 40° South. This cruise will take place in the winter of 1957. The University of Washington and POG will run the line up into the North Pacific from about 35°N. This will probably be done in the summer of 1958.

Polar Front Surveys

Plans for a polar front survey in the North Eastern Pacific are still in the discussion stage. It was pointed out that a large program under the auspices of the International North Pacific Fisheries Commission would probably be underway at this time.

Carbon Dioxide Observations

SIO will make CO_2 measurements on their Deep Current Expedition. The possibility of further measurements by the U. of Washington and POG was discussed.

Coordination of IGY

SIO has set up an operating committee composed of the following people: Jeffery D. Frautschy (Chairman), Elizabeth Strong (Secretary), June Pattullo (tide gauges and steric sea level), William G. Van Dorn (long period waves), H. W. Menard (deep currents), John A. Knauss (multi-ship expeditions).

It was agreed that this group would serve as a clearing house for information and plans for the IGY oceanographic program in the Pacific. Prof. Hidaka is at present serving as coordinator of Japanese activities.

It was agreed that another meeting of those concerned with the IGY program for oceanography in the Pacific should be held in a year, (approximately March 1958). The meeting was tentatively decided for Kyoto, Japan.

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APPENDIX VI

Proposal for a standard zooplankton net and procedure to be used on EQUAPAC and other cooperative oceanographic surveys in tne North Pacific.

I. Cooperation in further analysis of plankton collections.

It was agreed to ask Mr. King to undertake to explore with other plankton specialists the production of more detailed ocean-wide accounts of plankton distribution (especially the distribution of individual species).

II. There was some discussion of standardization of methods of collection of zooplankton. It was agreed that it would be desirable to have a standard method used, to some extent at least, in future operations but that this should not discourage the use also of a variety of methods suited to particular needs.

The need for research to improve knowledge of flows through nets (under various conditions) and of means of metering these flows reliably was stressed.

The collection and reporting of phytoplankton and plant pigment data was considered but no standardized procedure could be considered at this meeting.

III. Proposed specifications for a standard zooplankton net and procedure.

Diameter: 45 cm. at mouth
Shape: Conical
Length: 180 cm.
Material: .33 mm. aperture width, grit gauze, bolting silk, or nylon (if available).
Meter: A simple, inexpensive meter of the Tsurumi type shall be mounted in the center of the mouth of the net. The meter shall be accurately calibrated.

Description of Hauling procedure: The hauls shall be either vertical or oblique, from an estimated depth of 150 meters to the surface. If desired, the standard net may be used on the wire in conjunction with other types of nets or samplers attached below it. A maximum hauling speed (actual speed of the net in the water) shall be 2 meters per second. It is hoped that the hauling speed of oblique tows can be kept down, in order to more closely approximate the speed of 1 meter per second which is commonly used for vertical tows.

It is suggested that a preferred time for sampling with the standard net be between 2 hours after sunset and 2 hours before sunrise. If sampling with the standard net is more or less incidental to the zooplankton collecting program of an agency, the sampling should be nightly, between suggested hours. If the standard net is to be used by an agency as the main type of zooplankton collector at all hydrographic stations, there will be undoubtedly enough night time samples taken.

Laboratory procedure: Organisms of greater length than 2 cm. (except euphausiids and chaetognaths) shall be removed. It is suggested that the wet weight determination be made after removing water from the organisms by rolling the organisms repeatedly on the blotting paper, or by any other convenient way.

Reporting of data: Data on zooplankton concentrations collected with the standard net shall be reported as mg. wet weight per 1,000 cubic meters of water filtered. This does not preclude the reporting of displacement volumes, as well.