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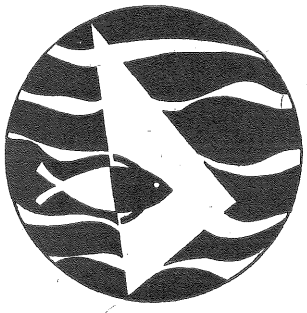

Report of the Second Session

FAO EXPERT PANEL FOR THE FACILITATION OF TUNA RESEARCH

Tokyo, 15 - 21 August 1966

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME, 1966

FAO FISHERIES REPORTS

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FIt/R19	**(Es)**	**Informe de la reunión de la FAO sobre la importancia de la investigación teórica en el aprovechamiento del pescado, Husum, República federal de Alemania, 26-30 mayo 1964**	**1965**
FIb/R20	**(En)**	**Report of the second session of the advisory committee on marine resources research, Rome, 6-12 February 1964**	**1965**
FIb/R20	**(Fr)**	**Rapport de la deuxième session du comité consultatif de la recherche sur les ressources de la mer. Rome, 6-12 février 1964**	**1965**
FIb/R20	**(Es)**	**Informe de la segunda reunión del comité asesor sobre investigaciones de los recursos marinos. Roma, 6-12 febrero 1964**	**1965**
FIe/R21	**(En)**	**Report of the fourth session of the continuing working party on fishery statistics in the north Atlantic area, Rome, 9-12 March 1965**	**1965**
FIe/R22.1	**(En)**	**Report of the meeting on business decisions in fishery industries, Rome, 21-25 September 1964. Vol. 1 — report**	**1965**
FIe/R22.1	**(Fr)**	**Rapport de la réunion sur la prise des décisions dans l'industrie des pêches. Vol. 1 - rapport. Rome, 21-25 septembre 1964**	**1965**
FIe/R22.1	**(Es)**	**Informe de la reunión sobre iniciativas de índole comercial de la industria pesquera. Vol. 1 — informe. Roma, 21-25 septiembre 1964**	**1965**
FIe/R22.2		**Report of the meeting on business decisions in fishery industries, Rome, 21-25 September 1964. Vol. 2 — working papers**	**1965**
FIe/R22.3		**Report of the meeting on business decisions in fishery industries, Rome, 21-25 September, 1964. Vol. 3 — working papers**	**1965**
FIb/R23	**(En)**	**Report of the third session of the advisory commitee on marine resources research, Rome, 1-8 March 1965**	**1965**
FIb/R23	**(Fr)**	**Rapport de la troisième session du comité consultatif de recherche sur les ressources de la mer. Rome, 1-8 mars 1965**	**1965**
FIb/R23	**(Es)**	**Informe de la tercera reunión del comité asesor sobre investigaciones de los recursos marinos. Roma, 1-8 marzo 1965**	**1965**
FIe/R24	**(En)**	**Mechanization of small fishing craft under revolving fund arrangements in developing countries**	**1965**

FAO, Rapports sur les pêches, FRm/R37(Fr)

E R R A T A

Location	Pour	Lire
Page 4, Ecologie du thon, 3ème ligne en italiques	... fixes	... fixes porteuses d'instruments;
Page 6, Perfectionnement, ler paragraphe, voir (a)	... de 2 à 4 semaines);	... de sang (de 2 à 4 semaines);
Page 8, ligne 2	... en vue de la publication.	... en vue de sa publication.
Page 23, Dimensions de maille, ligne 2	... les oeufs et larves de poissons et crustacés.	... les oeufs et larves de poissons et les crustacés.
Page 32, deuxième paragraphe, ligne dernière	... le coucher du soleil.	... le coucher du soleil; si l'on en effectue deux, 3 et 7 heures après le coucher du soleil.

MR/63122

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, December 1966

PREPARATION OF THIS REPORT

This is an edited and approved version of EPFTR:2/WP/18 as amended at the closing session of the Panel and which incorporates the Panel's Working Party Report on Methods of Collecting Larvae, as well as documentation prepared for the Second Session by some members of the Panel.

Distribution

FAO Fisheries Division
FAO Regional Fisheries Officers
Members of the Expert Panel for the Facilitation of Tuna Research
Members of ACMRR
FAO Member and Associate Member Nations
Selector 5

"Current Bibliography" entry

FAO Expert Panel for the Facilitation of Tuna Research, Tokyo, 15-21 August 1966 (1966) 12-1M010
FAO Fish.Rep., (37):64 p.
Report of the second session of the .....
Procedural matters; Conclusions and Recommendations; Appendixes concerning research on Thunnidae.
Do9-139me.

C O N T E N T S

1. PROCEDURAL MATTERS

Election of officers

The FAO Expert Panel for the Facilitation of Tuna Research convened at the Fisheries Agency, Ministry of Agriculture and Forestry, Tokyo, from 15 to 21 August 1966. Dr. M. B. Schaefer (U.S.A.) was re-elected Chairman, and Dr. H. Nakamura (Japan) as Vice-Chairman. Mr. J. Hamre (Norway), Dr. E. Postel (France) and Dr. A. Suda (Japan) were elected Rapporteurs. Mr. J. Joseph, Principal Scientist, Mr. M. P. Miyake, Associate Scientist of the Inter-American Tropical Tuna Commission and Dr. I. Yamanaka[1/], Chief Oceanographer of the Nankai Regional Fisheries Research Laboratory, were invited to attend as observers. A list of officers and participants is given in Appendix 8.

Adoption of the agenda

AGENDA

1. Opening of the session
2. Election of officers (p.19: IV-3)[2/]
3. Reports of Working Groups
   a. Tuna taxonomy (p.4: III-1,2)
   b. Methods of collecting larvae (p.7-8: III-6)
   c. Tuna length measurements and tabulation (p.12: III-8)
   d. Research on North Pacific Albacore and Bluefin Tuna (p.15: III-11)
   e. Tuna ecology (p.15: III-12)
4. Subpopulation identification by genetic techniques (p.5-6: III-4) (p.9: III-7)
   a. Standardization of collecting methods
   b. Arrangements for comprehensive application of the techniques
   c. Training Center on subpopulation identification employing genetic techniques
5. Identification of larvae and juveniles (p.4-5: III-2)
6. Illustrated Review of Tuna Tags (p.7 III-5)
7. Annual inventory of tuna tagging programs (p.7 III-5)
8. Tuna Tagging Working Group (not yet formed) (p.6: III-5)
9. Total catch reports, catch and effort data (pp.9-10-11: III-8)
10. Data processing (p.13 III-8)
    a. Utilization of electronic data processing (EDP) equipment for the rapid compilation and dissemination of data respecting catch and effort
    b. Utilization of high-speed digital computer and analogue computers in tuna research
11. Economic effects of tuna regulations (p.13: III-10)
12. Training, education and exchange (p.8-9: III-7)
13. Other subjects
    a. On the Report of the First Session
    b. New - Underwater sound for tuna research
       - Tuna research review
       - Exchange of publications and information

1/ Now: Chief, Marine Environment Section, Marine Biology and Environment Branch, Fishery Resources and Exploitation Division, FAO Department of Fisheries.

2/ All references made refer to the Report of the First Session of the Panel, EPFTR/1/WP/3.

14. Future operation of the Panel
15. Approval of Report of the Panel
16. Date and place of Third Session
17. Election of officers for the period between the Second and Third Sessions
18. Adjournment

The work of the Panel

During plenary sessions, the recommendations contained in the report of the First Session and the reports of the working parties were reviewed as well as documentation prepared for the second session by some members of the Panel and by the staff of the Department of Fisheries of the Food and Agriculture Organization of the United Nations (FAO). A list of this documentation is given in Appendix 9. Papers considered by the Panel and not published elsewhere are reproduced in Appendices 2, 3, 4 and 5.

2. CONCLUSIONS AND RECOMMENDATIONS OF THE PANEL

Reports of working groups

Tuna Taxonomy

The Panel noted the report of the Working Party on Tuna Taxonomy (EPFTR:2/WP/13). It confirmed the decision taken during its first session concerning the establishment of three centers for the taxonomic study of tuna specimens collected on a worldwide basis. Being, however, aware of the problems involved with the upkeep of three collections and communications among the scientists studying them, it was decided to set up, for the time being, one main center at the U.S. National Museum, Washington, D.C., where a complete collection will be maintained. Other regional centers should also be kept open and collaborate with the main center.

In this connection, the convenor of the Working Party on Tuna Taxonomy was requested:

to take immediate action in preparing a list of required specimens and distribute it to all laboratories and museums of interest with the help of the Food and Agriculture Organization of the United Nations (FAO) and members of the Panel

to prepare a report on the scope and contents of the illustrated monograph on the scombroids and submit it to FAO who, it was suggested, should explore ways and means of publishing the monograph.

The Panel reconsidered the question of the multidisciplinary attack on taxonomic problems of tuna and requested the convenor of the Working Party:

to identify an appropriate problem with a view to making a report to the Chairman of the Panel and the subsequent formation of a sub-group in consultation with the Chairman to study the problem.

Methods of Collecting Larvae

The Panel noted the report of the Working Party on Methods of Collecting Larvae (EPFTR:2/WP/9 and 2/WP/10). The recommendations were discussed and it was agreed that:

double oblique towing for larvae sampling should be made to a standard depth of 75 meters.

the Working Party be requested to provide the Panel with further information on equipment required for double oblique towing and to establish an ancillary standard surface tow for vessels not equipped for that type of towing.

Tuna Length Measurements and Tabulation

The Panel noted with satisfaction the action taken by FAO to establish a Working Party on Tuna Length Measurement and Tabulation. It reviewed the draft interim report of the Working Party (EPFTR:2/WP/7) on the standardization of tuna standard length measurements and standard grouping. The members of the Panel were then requested:

to comment on the proposals of the draft report and inform the convenor of the Working Party accordingly not later than 1 November 1966.

The members of the Working Party were asked:

to continue their work and report to the Chairman of the Panel upon completion.

Research on North Pacific Albacore and Bluefin Tuna

The Panel considered the progress made on the research on North Pacific Albacore and Bluefin Tuna (EPFTR:2/WP/12 and 2/WP/14) and commended the agencies and individuals concerned.

Tuna Ecology

The Panel commended the report of the Working Party on Tuna Ecology (EPFTR:2/WP/6). It was recommended that:

the observations listed be carried out as far as possible and as required by oceanographic expeditions and moored instrumental oceanographic stations;

tows from depths of 75 meters would be sufficient for collection of tuna larvae (EPFTR:2/WP/6, p 4, C2 - iii; p 5 - B4 and 2/WP/9, p 17 - 4a), and

such tows be taken when possible in addition to the 300 meter hauls for biomass of zooplankton recommended by the Working Party.

The Panel thanked the Working Party for its excellent work and discharged it for the time being.

Subpopulation identification by genetic techniques

The Panel confirmed the action of the first session, especially with respect to the

(a) importance of subpopulation identification;
(b) need for additional workers in this field, and
(c) need for the comprehensive application of these techniques.

Location of laboratories

There was need for increased support of laboratories already engaged in studies of subpopulation identification and for the support of other laboratories to undertake such studies. For example, in addition to the work in progress at the U.S. Bureau of Commercial Fisheries Honolulu laboratory, and the Inter-American Tropical Tuna Commission's laboratory in California, it was hoped that additional studies would be possible in Japan, and perhaps in Australia, for the Pacific and Indian Oceans. While initial studies of Atlantic tunas would probably need to be carried out by Pacific laboratories, the desirability of the eventual addition of this capability to Atlantic laboratories was noted. It was pointed out that laboratories engaged in these studies should be located near major air terminals, as, for example, Miami, in order to facilitate the shipment of blood samples. The Panel requested FAO:

to enquire of laboratories in Europe now engaged in serological studies as to the possibility of their undertaking tuna studies, emphasizing the fact that laboratories making provision for such studies should ensure that they are carried out under the direction of individuals competent in the field of immuno-genetics.

Development of techniques

The Panel suggested that all laboratories engaged in these studies should devote substantial effort to the development of techniques. Those in use at present were of two kinds:

(a) the study of blood group systems (based on the antigen-antibody reaction), and
(b) the study of certain serum proteins, for example, transferins and phosphatases.

Subpopulation identification should not necessarily be restricted to these techniques and the scientists concerned should be alert for the possible application of new techniques. It was recommended that:

all laboratories should pursue work to discover blood group systems and to develop reagents for the classification of individuals within the system.

However, once blood group systems were discovered and reagents developed, a mechanism was necessary to provide for "intercalibration" of reagents and for the production of "standard reagents" for widespread application wherever possible. It was suggested that:

the Tuna Blood Group Center in Honolulu should be the appropriate mechanism (see below).

Application of techniques

It was expected that individual laboratories would actively apply the proposed techniques in the study of tuna subpopulations. Even so, there would undoubtedly be areas which should be sampled and from which, for one reason or another, it would not be possible for these laboratories to obtain samples directly. Two solutions were possible. At the present stage of the development and application of these techniques, for the immediate future the Panel recommended that:

technicians be trained from those out of the way areas in the collection and preservation of samples which can then be shipped immediately to the nearest appropriate laboratory.

Coordination

The Panel requested the Tuna Blood Group Center in Honolulu:

to continue to function as in the past with respect to providing facilities for the "intercalibration" and exchange of reagents, coordination of problems of terminology, provision of collecting instructions and materials, etc.;

to investigate the feasibility and cost of the provision of "standard reagents" by commercial laboratories and other possible means of resolving the problem of providing them for wide application.

Training

The Panel noted that the Honolulu laboratory was, with prior arrangement, disposed to receive individuals for training as, undoubtedly, would other laboratories with interests in blood group studies. Such training, which would be useful in the immediate future, would include:

(a) collection and preservation of blood samples, which would require 2 to 4 weeks, and
(b) application of the techniques to fish, especially tuna, for those experienced in immuno-genetics, which would require 6 to 12 months.

A shortage of individuals qualified generally in immuno-genetics was recognized, and the Panel requested that:

universities, active in this field, be made aware of this shortage, and graduate students there be encouraged to enter this field.

Genetic research

The Panel recognized the need for further research on the genetics of fish blood group systems, particularly with respect to similarities and/or differences between fishes and higher vertebrates, and encouraged work along these lines. While it may be expected that such studies will most likely be undertaken in university laboratories, advantage should be taken of special facilities or opportunities which may exist or arise in fishery laboratories.

Identification of eggs, larvae and juveniles

The Panel reviewed the identification of larvae and juveniles (EPFTR: 2/WP/10 and 2/WP/12). It agreed that:

a further examination of the value of red pigmentation for specific identification of certain tuna be made;

the development of keys for the identification of larvae through cooperation of research workers in the field as suggested in EPFTR:2/WP/10 was important, and

a working party be convened by Mr. W.M. Matsumoto[1] to study further the development of such keys with a view to producing well-illustrated material on identification keys, and to investigate the identification of tuna eggs.

The value of studying pigmentation on live larvae for purposes of identification was noted and FAO was requested:

to distribute to the members of the Panel information on a larvae net at present being manufactured in Japan, to develop better apparatus suitable for various requirements.

Mr. J. C. Marr agreed to provide some information about a color preservative used in the preservation of tuna larvae in order to prevent fading of pigment spots. This information is given in Appendix 6.

Tagging

The Panel confirmed the recommendation made at its first session that priority should be given to conducting international tagging experiments on yellowfin tuna, skipjack, bluefin and albacore. It stressed the importance of an organized information system on tuna-tagging programs conducted at various laboratories.

The Panel also reconsidered its previous suggestion to form a working group to exchange propositions on the above experiments. It was recommended that:

two regional working groups: one for the Atlantic and adjacent seas, and one for the Pacific and Indian Oceans, be formed. Dr. E. Postel[2] was appointed convenor of the former group, and Mr. J. Joseph[3], of the latter;

the two convenors were requested to form their groups and report to the Chairman of the Panel in due course. The terms of reference of the two groups are given in Appendix 1.

The Panel also reaffirmed the recommendation made at the first session concerning research to determine the efficiency of the present different tuna tagging systems. It recommended that:

1/ Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii
2/ Réseau océanographie - pêches maritimes, Office de la recherche scientifique et technique outre-mer (ORSTOM), 24 rue Bayard, Paris 8e
3/ Inter-American Tropical Tuna Commission, c/o Scripps Institution of Oceanography, La Jolla, California, U.S.A.

a standard tag be selected with which to compare other tuna tags, and the plastic dart tag of IATTC[1]/ was proposed.

Review of tuna tags

The Panel examined thoroughly an illustrated guide of various tuna marks now in use and an inventory of tuna marking projects (EPFTR:2/WP/5), which had been prepared by FAO. It was agreed that the paper contained valuable background material for further work on a guide to tuna marks and marking projects. It requested that:

Mr. F. J. Mather III, of the Woods Hole Oceanographic Institution, assist FAO in revising the paper for publication.

The members of the Panel were requested:

to re-examine the issued draft thoroughly and submit it to Mr. Mather for comment at their earliest convenience or not later than 1 October 1966. To the final revision of the guide a biannual tabular summary of tag releases and recoveries be added in loose leaf form.

Total catch reports, catch and effort data - Data processing

The Panel noted the activities of FAO Fishery Statistics and Economic Data Branch in worldwide tuna statistics (EPFTR:2/WP/8). It reaffirmed the recommendations made during its first session, requesting FAO to compile and publish, on an annual basis, summarized data on total catches and catch and effort statistics.

The Panel hoped that, in view of the recent expansion of the activities of the Department of Fisheries of FAO in fishery statistics, and due to the unique international character of tuna resources, special attention would be given by FAO to the compilation and publication of catch and effort statistics of tuna. The Annual Report of Effort and Catch Statistics by Area on Japanese Tuna Long-line Fishery, 1963, issued in 1966, and prepared according to the recommendation of the first session was referred to the attention of FAO. A volume containing statistics for 1964 is now in preparation.

The need for FAO to employ modern methods such as electronic-data processing equipment for the compilation and dissemination of the data in question was again emphasized by the Panel.

The possibility of instituting a world standard logbook, designed by the Panel as proposed in EPFTR:2/WP/8, was considered. The Panel supported in principle the idea of using logbooks. It was, however, found impracticable to design and use one standard logbook in all parts of the world, in view of the marked differences existing in the various tuna fisheries.

Size composition

The conclusion reached during the first session of the Panel that it

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1/ Inter-American Tropical Tuna Commission, c/o Scripps Institution of Oceanography, La Jolla, California, U.S.A.

would be premature to attempt to establish any centralized data exchange system for size frequency information was reaffirmed. However, FAO's plans to establish a fisheries data center were noted, and the Panel recommended that:

the Working Party on Tuna Length Measurements and Tabulation communicate with FAO on the development of this center.

Economics of tuna fisheries

The Panel identified institutions conducting economic studies on tuna fisheries, such as Nagoya University and the Tuna Fishermen's Association of Japan. It recommended that:

FAO follow up economic studies of tuna fisheries and consider the possibilities of supporting, by grant and contract, similar studies in other tuna fishing countries with a view to compiling and analyzing economic data important for evaluating the economics of world tuna fisheries.

On initiating those studies, FAO try to secure the services of economists interested, or already working on, the subject.

Such a study could well form a model for similar work on other fisheries. It was also desired that the economics of both commercial and recreational tuna fisheries should be considered in selected areas where both activities occur.

Training, education and exchange

The Panel confirmed its request to FAO to identify the opportunities for exchange training as well as those for "at sea" training aboard research vessels. It requested that:

FAO prepare and publish a list of all existing national and international agencies, including private foundations supporting training and research, together with a list of laboratories and universities accepting trainees for the various aspects of tuna fishery biology, and

FAO together with UNESCO, identify in International Marine Science cruises open to scientists from various countries concerned with tuna investigations.

The Panel confirmed its opinion that once a trainee completes his training, all possible assistance, including adequate salary, should be given to him to apply his knowledge in his working environment.

Underwater sound for tuna research

A report on an echo-survey of tuna fishing grounds by a Japanese scientist was reviewed. The various problems involved in the application of this technique were discussed, particularly with regard to target identification and estimation of target strength as to number of individuals and schools. In this connection, attention was drawn to the report of the Advisory Committee on Marine Resources Research (ACMRR) Working Party on the Direct and Speedier Estimation of Fish Abundance which is concerned with analogous problems on a broader technical approach. It was felt that the application of the present technique should be further investigated and work on this field encouraged by institutions and organizations interested in tuna research.

The Panel recommended that:

FAO establish a working party, the convenor to be selected by the Chairman of the Panel in consultation with FAO, to keep in contact with those research bodies engaged in research on underwater sound in relation to biota of the sea and report to the Chairman of the Panel on the progress made between sessions.

Review of tuna research

The publication of a periodical, critical review of scientific literature on tuna was deemed essential. Such a periodical should be issued every three years and should cover literature published during that period. It should contain a bibliography of all papers published during that time and any information on tuna fisheries pertinent to biological research, such as world tuna catches.

The Panel requested that:

Dr. E. Postel, in consultation with the Chairman of the Panel, form a working party to produce a Review of tuna research. Through correspondence, a list of subjects relevant to tuna research to be covered in the review be developed, and a decision taken on the size of the publication. The working party should select the contributors and an editor;

when decisions had been taken on the subject coverage, size and date of the publication, the assistance of FAO be sought when seeking a suitable publisher.

It was pointed out that the bibliographic services provided by the Biological Data Section of the Fishery Resources and Exploitation Division of the FAO Department of Fisheries were available.

Exchange of publications

To maintain information on research on tuna and pertinent subjects, the Panel recommended that:

a regular exchange of publications be made to all members of the Panel, including its Secretary, and to the Biological Data Section of the FAO Department of Fisheries.

3 OTHER BUSINESS

Date and place of the third session

The Panel noted with interest the invitation made by Mr. J. C. Marr to hold the third session in the Biological Laboratory of the U.S. Bureau of Commercial Fisheries, Honolulu, Hawaii. It also considered the advantages of meeting in the area of the Atlantic Ocean when the International Commission for the Conservation of Atlantic Tunas will be in operation. The Panel agreed that the third session should take place within the next two or three years.

Interim officers

The Panel unanimously elected Dr. E. Postel as Chairman and Dr. A.

Suda as Vice-Chairman for the interim period until the third session, and for the third session.

Relations with ACMRR

The Panel requested that:

FAO continue to inform ACMRR on its activities;

a representative of the Panel be a member of ACMRR or, alternatively, attend its meetings as observer.

At the closing of the session a recommendation was passed by the Panel expressing its appreciation of the very generous hospitality extended to its members by the Fisheries Agency of Japan.

APPENDIX 1

TERMS OF REFERENCE OF THE WORKING PARTIES ON TUNA TAGGING

1. To record and follow up any tagging program being carried out or planned, and inform the Secretary of the Panel, who will give the information wide distribution.

2. To obtain the collaboration of those concerned with the tuna industry (private companies, fishermen, boat owners, fishmongers, canners, etc.) to secure the maximum returns of released tuna tags with adequate recapture data.

3. To encourage actively and develop tagging programs, and particularly to assist with arrangements for international collaboration in their execution.

APPENDIX 2

CATCH AND EFFORT STATISTICS IN EAST ASIAN COUNTRIES

by

Akira Suda

Japanese longline fishery

The data collecting and processing system was improved recently by cooperation between the Federation of Tuna Fishermen's Co-operative Associations, the Major Office of Fisheries Agency of Japan, and the Nankai Regional Fisheries Research Laboratories (NRFRL).

System of collecting data

All vessel owners are obliged by law to present fishing records in an approved form by a certain date.

Processing of data

The electronic data processing system is employed. It is so organized that work is completed within one year after the termination of the fishing season. Data processed in recent years, in units of days, are about 200,000 fishing days. The process is as follows:

1. Number of catch and effort in the records presented (raw data) are summarized by 5° square, month, kind of bait, type of operation and size of boat.

2. Above-mentioned numbers are re-summarized by 3 months (secondary aggregate of number sampled).

3. Number of catches and effort in the secondary aggregate of batch of numbers are enlarged by using specific raising factors by type of operation and size of boat to get the estimated total catch and effort by species, by three-month period, 5° square, type of operation, size of vessel and kind of bait (primary aggregate of enlarged number).

4. Primary aggregate of enlarged number is reprocessed to derive:

   (a) estimate of yearly and quarterly total in major fishing grounds, type of operation, kind of bait and size of vessels;

   (b) estimate of yearly total by 5° square, type of operation, kind of bait and size of vessels.

5. Hooking rate by species, by 5° square, three-month period, and kind of bait is derived from the secondary aggregate of the number sampled.

Publication of the data

The Annual Report of Effort and Catch Statistics by Area on Japanese Tuna Longline Fishery is to be published annually by the Research Division, Fisheries Agency of Japan. Each table and figure in the report covers the following items:

Table 1. Number of hooks and catch by species, month, 5° square, type of operation, size of vessel and kind of bait. The number of efforts is outlined as:

(a) number of sets of longlines, and
(b) number of hooks used.

Catch is shown as the number of fish caught: bluefin, southern bluefin, albacore, bigeye, yellowfin, skipjack, broadbill swordfish, striped marlin, blue marlin, black marlin and sailfish.

Table 2. Estimates of total number of hooks and catch by species shown by type of operation, kind of bait, size of vessel, three-month period and 5° square.

Table 3. Estimates of yearly and quarterly total numbers of hooks and catches by species shown by major fishing grounds, types of operation, kinds of bait and size of vessels.

Table 4. Estimates of yearly and quarterly numbers of hooks and catches by species, shown by type of operation, kinds of bait and size of vessels.

Figure 1. Chart of major fishing grounds.

Figure 2. Distribution of estimated total fishing effort with hooks.

Figure 3. Distribution of estimated total fishing effort in number of Japan-based boats using hooks by size of vessel.

Figure 4. Distribution of estimated total fishing effort with hooks by type of operation.

Figure 5. Distribution of catch in number by species.

Figure 6. Distribution of hooking rate by species and by three-month period.

In the above-mentioned report, the estimated weight of catch by species and by major fishing grounds is given. Under present conditions, however, it is difficult to compile promptly catch statistics in terms of weight by 5° square by three-month periods or even one month. Size frequency data have to be processed beforehand to obtain the average weight of catch by small area (if possible, 5° square) and this is time consuming.

Japanese pole and line fishery

This system is now being developed by Tchoku-RFRL, the Federation of Tuna Fishermen's Co-operative Associations and the Major Office of the Fisheries Agency. As in the case of longline fisheries statistics, vessel owners have been obliged by law to present their fishing records on specified forms since the beginning of 1966.

Formosan longline fishery

The system of catch and effort statistics for Formosan longline fishery is well developed and the monthly Research Report on Tuna Fisheries and its Resources in Kaohsiung is published by Kaohsiung Branch of Taiwan Fisheries Research Institute.

Data in the above-mentioned report are presented as follows:

1. By 5° square/month, and by major fishing ground/month.
2. Number of fishing efforts in terms of
   (a) number of fishing cruise investigated, and
   (b) hooks.
3. Catch data by species, given in number of fish caught and hooking-rate, but not by weight.

The figures in the statistics almost coincide with the total number because almost all catches are unloaded on Kaohsiung where the Branch is situated.

APPENDIX 3

RECENT ACTIONS ON THE RESEARCH OF NORTH PACIFIC ALBACORE AND BLUEFIN TUNA IN JAPAN

by

Akira Suda

1. Data exchange between the Bureau of Commercial Fisheries (BCF), Honolulu and Nankai Regional Fisheries Research Laboratory (NRFRL)

Mr. Otsu, from the Bureau of Commercial Fisheries (BCF), Honolulu, visited the NRFRL for six months. He was provided with all historical effort and catch data on the North and South Pacific albacore. However, analysis on a cooperative basis was left for the future.

2. Tagging experiments

Albacore

Discussions on cooperative tuna tagging have been held between BCF, Honolulu and NRFRL. It was decided to leave further discussion until 1967, or thereafter.

Bluefin

Kochi prefectural fisheries experimental station, with the cooperation of NRFRL, released 600 young bluefin tuna (25-33 cm in fork-length) off the south and east coasts of Japan from 1963 through 1965. Twenty-one were recaptured in the adjacent waters of Japan within the fishing season they were released, and one was recaptured this year (1 year after release) off California (information by Mr. Clemens, California Fish and Game).

3. Exchange of scales for age determination

When Suda was in California in 1964, Mr. Clemens pointed out the effectiveness of exchanging scales sampled in different areas and time between scientists concerned. He suggested it would facilitate the comparison of scale reading techniques and, moreover, would help the understanding of the nature of ring formation. In Japan, no scientist is working on this item now.

4. Recent studies on this subject in Japan

Asano, M., 1964 — Young albacore taken from the northeastern sea area of Japan in August and September 1963

Inoue, M., 1963 — Studies on movement of albacore fishing grounds in the north-western Pacific Ocean-V. Migrations of deep swimming albacore community in wintertime and good or poor fishing conditions of summer albacore in the southwestern waters off Cape Nojima. Rep.Fish.Res.Lab., Tokai Univ., 1(1)

Koto, T. and K. Hiseda, 1966 Studies on the albacore XII, length frequency distribution of albacore caught by Japanese longline and pole and line fisheries in the western North Pacific in 1960-1964 season. Rep.Nankai Reg.Fish.Res.Lab., (24)

Suda, A., 1966 Catch variations in the North Pacific on the catch and abundance of albacore in the northwest Pacific by use of some simplified mathematical model (contd). Rep.Nankai Reg.Fish.Res.Lab., (24)

_____, 1966 Catch variations in the North Pacific albacore VII. Considerations on the sustainable yield. Rep.Nankai Reg.Fish.Res. Lab., (24)

APPENDIX 4

TUNA TAGGING EXPERIMENTS IN RECENT YEARS IN JAPAN

by

Akira Suda

Skipjack

Tohoku RFRL has a project to tag skipjack in the adjacent seas of Japan and the necessary budget is being negotiated now. Discussions will be held on this project at the special meeting proposed by IATTC which is expected to take place on 25 August 1966.

Yellowfin

Nankai RFRL is planning yellowfin marking in the Western Tropical Pacific. Cooperation is expected from organizations in other countries as well as support from FAO. Project consists of two parts.

Preliminary project:

1. Preparatory research on the possibility of pole and line fishing as a means of catching tuna to be tagged in tropical waters (Nankai staff thinks long-line is not a suitable means for catching tuna to be tagged)

2. Collection of morphometric data and serological samples as a control of tagging experiments

Major project:

It is aimed to tag yellowfin, but other tuna species caught incidentally will also be tagged.

NRFRL intends to start the preliminary project as soon as possible after it has resolved the following problems:

1. How to ensure the live bait supply; how to transport temperate bait species to tropical waters after long navigation. The best way is to get live bait supply at the place of tagging.

2. How to obtain special permission to collect bait fish in the territorial waters of foreign countries. An understanding of organizations and countries concerned with this problem is needed.

Albacore

The proposal on the cooperative tagging experiment was made by BCF Honolulu to Nankai RFRL and discussions took place on several occasions between them. They will be continued in 1967, or thereafter. NRFRL has taken a major interest recently in the tagging of tropical tuna. This tagging of albacore in the North Pacific has been left in abeyance until time and funds are available.

The following are some results:

TABLE 1. RESULTS OF SPECIAL TUNA TAGGING CRUISES

Year	Month	Organization	Station released	Number released
1957	May-June	NRFRL*	32-36N, 142-151E	378 AL
1958	"	" *	32-34N, 143-145E	565 AL (10)
				163 BE (16)
1959	Feb-Mar.	" **	21-22N, 143-144E	195 YF (25)
1959	Apr-June	" *	31-35N, 139-143E	2 YF
				133 SJ
1959	Nov-Dec.	" **	7- 9N, 145-150E	173 YF
				1 SJ
1960	Feb-Mar.	" **	15-21N, 143-146E	1 BE
				210 YF (8)
1960	Dec.	" **	20-21N, 142-143E	55 YF (7)
1963	Aug-Sep.	Kochi Pref.FES***	Off Suzaki	141 BF
1963	Sept.	" " " ***	34-36N, 139-141E	30 BF (1)
1964	July-Nov.	" " " ***	Off Suzaki	43 BF
1964	Aug.	" " " ***	38-39N, 141-142E	387 BF (20)
1965	Aug.	" " " ***	35N 141E	35 BF (1)

Total number released and recaptured:

AL: 943 (10) BE: 164 (16) YF: 635 (40) BF: 636 (22) SJ: 144

NOTE: AL - Albacore BE - Bigeye YF - Yellowfin
BF - Bluefin SJ - Skipjack
Figures in () represent number of recaptured fish
* Pole and line ** Hand line *** Trolling

TABLE 2. NUMBER OF FISH RELEASED BY PREFECTURAL, EXPERIMENTAL AND TRAINING BOATS BY YEAR DURING THEIR LONGLINE OPERATIONS

Year	Yellowfin	Bigeye	Albacore
1957	79	126	3
1958	160	146	9
1959	196	232	2
1960	243	302	13
1961	136	352	14
1962	322	380	0
1963	314	432	61
1964	46	111	10
Total	1,496	2,081	112

APPENDIX 5

WORKING PARTY REPORT ON METHODS OF COLLECTING LARVAE

I. THE WORKING PARTY

The Working Party on Methods of Collecting Tuna Larvae was organized in June 1965. The Working Party was composed of Walter M. Matsumoto, Bureau of Commercial Fisheries Biological Laboratory (BCF), Honolulu, Chairman; Witold L. Klawe, Inter-American Tropical Tuna Commission; William J. Richards, BCF, Tropical Atlantic Biological Laboratory; and Shoji Ueyanagi, Nankai Regional Fisheries Research Laboratory. Because all deliberations were to be conducted through correspondence, the size of the Working Party was kept to a minimum. Information on the status of similar studies by other working groups or parties for ICES, SCOR and NASCO was obtained through correspondence.

II. OBJECTIVE

From the outset, it was apparent that the diversity of interests that scientists have in zooplankton and their resultant differing demands in sampling gear, methods, and sample size precluded the selection of a "standardized" method to suit all needs. For example, the ICES-SCOR-UNESCO Working Party 2, which is concerned with standardizing gear and methods of sampling planktonic organisms in the size range 0.2-10 mm, has selected a conical 57 mm diameter net (mesh aperture 0.200 mm) to be towed obliquely to 200 m; and Working Party 3, which is concerned with larger plankton, often sampled by stramin or other coarse meshed nets, has recommended an encased sampler and net with mesh aperture of 1 mm, to be designed shortly, and an interim unencased net of monofilament nylon with 1 m^2 mouth area and mesh aperture of 1 mm. The NASCO Zooplankton Working Group has yet to decide on its choice.

In view of extremely poor past results in capturing tuna larvae in tows designed to assess zooplankton abundance - usually oblique tows to 200 m the Working Party has decided to follow strictly the terms of reference set forth in Resolution 6 of the Report of the First Session of the Expert Panel. These called for the selection of standard gear and a standard method of sampling specifically designed to collect tuna larvae.

III. SELECTION OF APPROPRIATE STANDARD NET FOR TUNA LARVAE

1. General requirements

So that it may be useful on as wide a variety of vessels as will be likely to participate in future international oceanographic expeditions, the net selected must be small enough for easy handling and still large enough to assure capture of larval tuna. Furthermore, the standard net should be similar to nets presently being used successfully for collecting tuna larvae, so that past collections made with these nets may be utilized to their fullest potential, though this requirement need not be followed too rigidly if a better net design can be agreed upon. Except in a few known localities, tuna larvae are taken in very small numbers, generally between 1 and 10 per 1,000 m of water filtered. It is therefore important that the net be able to filter large amounts of water (at least 1,500 m^3 per tow) at a high level of filtration efficiency.

2. Specific requirements

Type of net

Two principal types of nets are presently used to sample plankton: the encased nets, such as the Gulf III sampler, the Clarke jet net, the Bary sampler, to name a few, which are designed primarily for high speed sampling; and the unencased plankton nets of various shapes and sizes, which are designed for towing at speeds of 1 to 3 knots.

The encased, high-speed nets have the advantage of being able to catch more of the larger and more agile organisms than the low-speed nets, but certain disadvantages make them unfit for our purpose. Generally, these small nets strain insufficient amounts of water. This would be a problem if large amounts of material were required or if rare organisms including larval tuna, were sought (Barnes and Tranter, 1965). These nets also have problems in water acceptance at high speeds. Moreover, because the nets are towed at high speeds, the larval fish (this may not apply to juvenile fish) can be damaged badly enough to make identification difficult, if not impossible.

The unencased, open nets, although towed at lower speeds, filter considerably larger volumes of water and are capable of catching large quantities of fish larvae. These nets have been the mainstay of most sampling programs. The problems associated with them, such as maintaining high filtration efficiency, obstruction of bridles ahead of the mouth, etc., are minor and can be remedied by proper design. Consequently, the unencased net appears better suited than the encased for sampling tuna larvae.

Net size

Large nets are more efficient than small for taking the more agile organisms (Fleminger and Clutter, 1965; Barkley, 1964). Very large nets, for example those whose mouth areas are greater than 2 m^2, are difficult to handle, however, and require stronger towing cable; therefore their use may not be feasible on some of the smaller vessels. Smaller nets, such as the 45 cm net often used in the past in the central Pacific and the 50 cm Be net used in the Indian Ocean Program, inadequately sampled larval tunas.

The choice of net size, therefore, is narrowed to a 1 m diameter net (0.786 m^2 mouth area) or a net of 1 m^2 mouth area. Although there is a difference in the mouth area of about 25 percent between the two nets, it is not so great as to make one preferable to the other. If we compare the nets on the basis of 1,500 m^3 of water filtered, the 1 m diameter net towed at 2 knots would require only 6-1/2 minutes more of towing time to filter as much water as the 1 m^2 net (mouth area) for surface tows, and about 4 minutes more for oblique tows to 100 m (wire angle of 60°). Perhaps of greater importance, the 1 m diameter net has been used more extensively for larval tuna than the 1 m^2 mouth net and therefore is responsible for a greater backlog of as yet unsorted plankton samples.

Net material

Saville (1957) has shown that bolting silk shrinks upon use and the degree of shrinkage varies between dry and wet mesh and between new and used netting. A new silk net with mesh aperture of 0.312 mm will shrink to 0.261 mm (16.3 percent) when wet; a used net will shrink from 0.236 to 0.221 mm (6.4 percent) when wet. The total shrinkage between new dry silk and used wet silk, from 0.312 to 0.221 mm, is 29.1 percent. Nylon nets, on the other hand, stretch during use, but nylon monofilament net is less

susceptible to distortion than nylon multifilament or silk gauze, the linear distortion being "less than 4 percent at normal maximum mesh velocities" (paper presented at the ICES-SCOR-UNESCO Working Party Meeting at Cronulla). Although tests on net material are not yet complete, the NASCO Zooplankton Working Group has found that silk nets appear to resist clogging more than nylon nets.

The nylon net has a decided advantage in economy over the silk. The latter must be hung to dry in the shade to prevent deterioration; often this cannot be done at sea. Nylon nets, however, do not require such care and usually outlast the silk. All things considered, nylon appears superior to silk.

Mesh size

Saville (1957) also determined the size of silk mesh necessary for the retention of fish eggs, fish larvae and crustaceans. For an organism to be fully retained by a mesh, its maximum cross-sectional diameter must be greater than the diagonal of the mesh. A similar relationship was found for nylon mesh by the NASCO Zooplankton Working Group in its studies of net clogging.

A group of the smallest tuna larvae preserved in formalin were measured at the Biological Laboratory, Honolulu. This group consisted of 20 larvae (the most we could find in the short time available) 2.3-2.9 mm long, whose average cross-sectional diameter (the greatest body depth) was 0.683 mm. The next larger group of 23 larvae were 3.0-3.5 mm long and had an average cross-sectional diameter of 0.981 mm. A nylon mesh whose diagonal dimension is equal to or less than 0.683 mm would be 0.483 mm; the nearest to this mesh size available commercially, however, is 0.471 mm (Nitex 471), or 0.505 mm (Nitex 505).

On the basis of these measurements and the fact that nylon nets tend to stretch slightly under strain, the 0.471 mm mesh would seem appropriate. In view of the susceptibility of nylon to clogging - a characteristic that could reduce the effective mesh size considerably more than stretching could increase it - and the impracticality of scrubbing the net after each use, since merely hosing the net cannot clean it adequately, the 0.505 mm mesh may be more appropriate.

Mesh amount

The amount of mesh area relative to mouth area (MA:M) markedly affects the filtering capacity of the net. The test results of the NASCO Working Group show that the volume of water filtered by a net increased exponentially relative to increase in the ratio MA:M. Although the Group did not test nylon nets having mesh sizes of 0.471 and 0.505 mm, test results of silk nets having mesh apertures of 0.450 mm and 0.550 mm provide sufficient information to estimate an adequate MA:M ratio for our nets. The two silk nets had a MA:M ratio of 4.8:1, and both nets filtered over 3,000 m^3 of neritic water at greater than 85 percent efficiency for more than 60 minutes.

Hence it seems that either the 0.471 mm or the 0.505 mm nylon nets with MA:M ratio of 4.8:1 or greater would be adequate for our purpose. A choice between the two nets, if any need be made, would favour the 0.505 mm net.

Net shape

Unencased plankton nets have a number of shapes, but basically there are the following three kinds:

i) Cone, tapering evenly from a wide mouth to a narrow cod end.

ii) Cylinder-cone, having a cylindrical anterior section preceding a conical section.

iii) Cylinder, having an opaque cone at the end for easy removal of the catch.

Clogging tests made by the NASCO Working Group have shown that cylindrical nets clogged less rapidly than cylindrical-conical nets, and the latter clogged less rapidly than conical nets. Although the cylindrical net clogged the least, it had a greater drag and was more difficult to launch and recover. The Group therefore concluded that the combination cylinder-cone design was the best.

With the required MA:M ratio (4.8:1 or better) and the type of net (cylinder-cone combination) known, the dimensions of the cylindrical and conical sections must be determined. Recent tests of plankton nets conducted at the David Taylor Model Basin by various parties indicated that the factor that determined filtration efficiency was the MA:M ratio, regardless of mesh size. The minimum ratio for filtering clean water was found to be 3:1.

Hence we believe the conical section should have a MA:M ratio of 3:1 and the cylindrical section a ratio of at least 1.8:1. For nets with overall ratios greater than 4.8:1, the excess filtering section should be placed in the cylindrical section. The linear dimensions[1/] of such a net would then be as follows:

For a net made of nylon with 0.471 mm mesh aperture:

i) The filtering conical section should be a truncated cone, tapering from a radius of 50 cm to a radius of 5 cm, with a height of 278cm.

ii) The filtering cylindrical section should be 92 cm long.

For a net made of nylon with 0.505 mm mesh aperture (Fig. 1):

i) The filtering conical section should be 267 cm.

ii) The filtering cylindrical section should be 88 cm.

Relocation of bridle

Recent tests of a 1 m diameter net and a square 1.7 m net (mouth area 2.89 m^2) at Hawaii have shown that the larger net was more successful in taking skipjack larvae 4-6 mm long than the 1 m net, but the catch of larvae 7 mm or larger was almost nil for both (Fig. 2). Since all the tows were made at night, the difference in catch between the two nets and the sharp drop in larvae over 7 mm for both nets most likely were due to the larger larvae dodging the net. If this is true, then it is logical to suspect that the bridle, located directly in front of the net, must have played an impor-

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1/ Computations in Appendix.

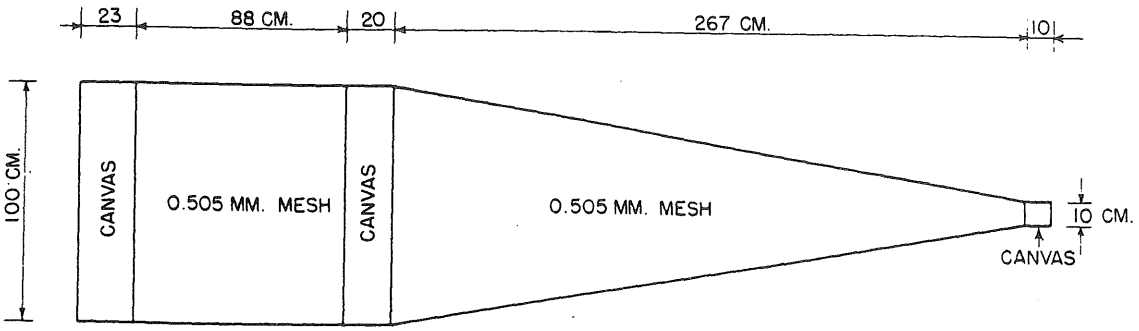

Fig. 1. Dimensions of 1-m net with MA:M ratio of 4.8:1.

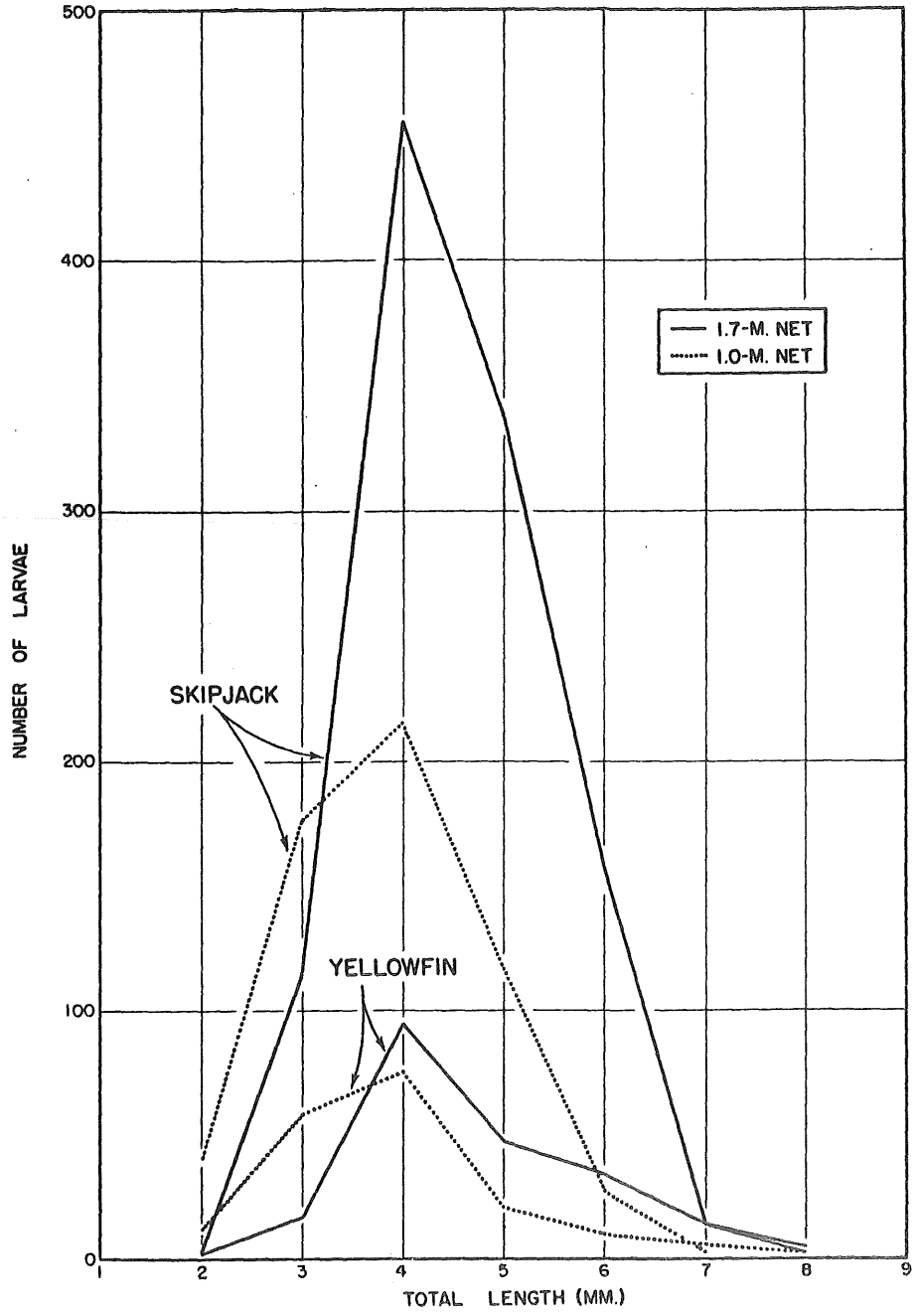

Fig. 2. Length frequency distribution of tuna larvae taken in a 1-m net and a 1.7-m net off Oahu, Hawaii, June 1965.

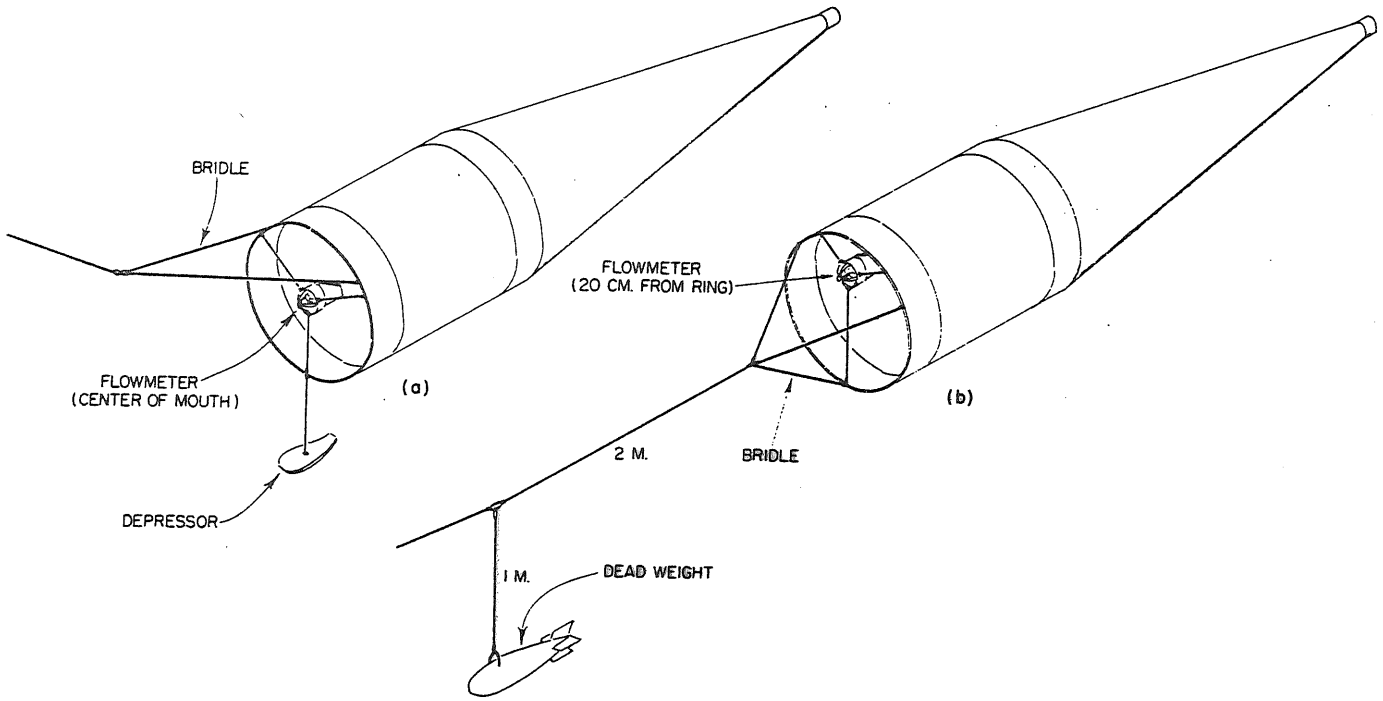

Fig. 3. Bridle and depressor or dead weight arrangement for 1-m plankton net.

tant role in warning or frightening away the larvae. Obviously, if we wish to reduce the effect of dodging, we must relocate the bridle or devise some other method of towing the net.

Hydrodynamically, the placement of the bridle in the center of the mouth ahead of the net was shown to have a marked effect on the uniformity of the flow of water across the mouth. Recent hydrodynamic tests of 1 m nets in the David Taylor Model Basin showed that with the bridle attached, there was a noticeable decrease in water velocity near the center of the mouth (Mahnken and Jossi, in press). With the bridle removed, however, the flow across the mouth was nearly uniform.

One method of reducing the effects of dodging and the distortion of flow across the mouth would be to shorten the bridles. At present the bridle on most 1 m nets is 1 m long, and the tow point is located approximately 87 cm ahead of the center of the mouth. This distance could be reduced by more than 40 percent, so that the tow point would be only 50 cm ahead of the net mouth.

A 1 m net with bridle length of 71 cm was tested at sea by the Biological Laboratory, Honolulu in May 1966. The net was towed for 40 minutes at a towing speed of 2 to 2.5 knots and again for 30 minutes at a towing speed of 3.5 to 4.5 knots. After each tow the net ring was examined for any sign of distortion, but none was visible. Even with the shortened bridles, the ring, made of 3/4 inch galvanized pipe, was strong enough to sustain the additional tension.

A second method would be to eliminate all obstructions, including the dead weight, ahead of the net mouth. This may be done by attaching the bridle at two points in the upper section of the net ring and by suspending a depressor from the lowest point of the ring (Fig. 3a). Such a net has been used before, but the details of the placement of the bridle and the optimum size of the depressor are not known. We have no definite knowledge whether such a depressor will function efficiently at a ship's speed of 2 knots and be able to keep the towing warp angle reasonably low. Such tests have not been attempted by the Working Party.

Flowmeter

A flowmeter is required for all nets if we wish to compare the catches from different localities on an equivalent basis. The flowmeter should be well constructed and should have stops to prevent reversing and turning in air.

Since the bridle located in front of the net distorts the flow of water across the mouth, the flowmeter must be mounted away from the center (Mahnken and Jossi, in press). In the hydrodynamic test mentioned above, the mean flow of water through the mouth at filtering velocities up to 4 knots was found at a point 20 cm from the net rim (Fig. 3b). Consequently a flowmeter placed in this position would give a better measure of water filtered than one placed at the center of the mouth.

If the bridle is modified according to the second method described above, there will be no problem of distorted water flow across the mouth, and the flowmeter can be placed in the center of the net opening.

Flowmeters should be accurately calibrated at least at the beginning and end of each cruise. Care should be taken to see that the revolving spindle sits firmly on the bearings and turns easily without excessive play.

IV. SAMPLING FOR TUNA LARVAE

Great though the concern be about the selection of a "recommended" net, there is greater concern for the proper method of sampling. Differences in the latter can affect catches much more extensively than small differences in the net itself. The method of sampling must therefore be standardized to a type of tow that will permit quantitative estimates of abundance in areas with differing oceanographic conditions.

In order to do this properly, considerable knowledge about the occurrence and distribution of tuna larvae in time and space is needed. Sampling for tuna larvae by a number of research groups has provided some information along this line, but the picture is far from being complete. Critical studies have yet to be made in many localities.

We already know that (1) tuna larvae are found from late spring to early autumn in subtropical waters and throughout the year in tropical waters, (2) the best catches are made near the surface, (3) there is a significant drop in catches at the surface during daylight and during periods of bright moonlight, and (4) except in a few known areas (e.g., eastern Pacific, Marquesas Islands, Hawaiian Islands), tuna larvae are not caught in very large numbers. Exact information is still incomplete regarding the depth distribution of these larvae.

1. Type of tow

In comparison with the numbers of other planktonic organisms, particularly those of invertebrates captured in a tow, those of tuna larvae are quite small. Generally, tows made at night near the surface provide the most larvae. However, surface tows also provide the greatest variation in catches between day and night. Much of this variation is the result of net dodging and vertical migration by the larvae. The effects of dodging and vertical migration are so prevalent at the surface that they can be noticed between tows made in complete darkness and in bright moonlight.

To minimize or eliminate variations in the catch due to net dodging and vertical migration, we must rely on oblique tows made only at night.

2. Determination of best sampling depth

Recent sampling with an enlarged Clarke-Bumpus net in the eastern Pacific (Klawe, 1963) and eastern Atlantic (Gulf of Guinea - unpublished data, Tropical Atlantic Biological Laboratory) indicates that tuna larvae may be restricted to depths of less than 40 m, much shallower than previously suspected. In both areas the surface mixed layer is relatively shallow, averaging 20-40 m from the surface. No tuna larvae were taken in depths greater than 40 m.

In the Hawaiian Islands area (lat. 15°-25° N, long. 150°-170° W), the average depth of the mixed layer is about 50 m in summer (May through August). The distribution of larvae, therefore, does not differ too greatly from that in the areas mentioned above. This can be seen from the catch figures for the 1 m diameter net (Table I).

Table I

Tuna larvae taken in Hawaiian waters, 1949-64

Depth of tow (m)	Number of tows	Number of larvae	Larvae per 30-minute tow [1/]	Percent of surface catch
0-2 horizontal (night only)	262	4,276	16.3	-
0-60 oblique (night only)	197	2,266	11.5	70.5
0-200 oblique	170	621	3.6	22.1

1/ Catch per 30-minute tow is used instead of catch per unit volume of water filtered because the latter calculations had not been completed at the time this report was being prepared.

The average catch for the 0- to 60- m night oblique tows of 11.5 is 70.5 percent of the night surface catch. If we assume that the bulk of the larvae were concentrated near the surface at a depth of less than 60 m and that larval density, for practical purposes, was relatively uniform throughout this zone of concentration, the ratio of the average catch of the 0- to 60 m oblique tows to the average surface catch would represent the proportion of time the net spent in the zone of high density of larvae.

Furthermore, since the net was lowered and raised at a uniform speed as much as possible, the proportion of time it spent in the zone of high larval density would also represent the proportion of depth in which the larvae were caught. On the basis of these assumptions, the depth of larval density in the Hawaiian Islands area calculated from the average catch of the 0- to 60 m oblique tows is 42.3 m (70.5 x 60) and the depth of larval density calculated from the average catch of the 0- to 200 m oblique tows is 40 m (22.1 x 200); both estimates approach those obtained with the Clarke-Bumpus net in the eastern Pacific and Atlantic Oceans.

Applying this procedure to larval catches made in the equatorial central Pacific (lat. 5° N.-15° S, long. 130°-145° W), where the average depth of the mixed surface layer is about 130 m, the estimated depth of uniform larval density is found to be between 38 and 57 m (Table II). Because of non-uniform monthly sampling in this area for each type of tow, only catches from two cruises on which multiple net tows were made are summarized. These cruises were made in March 1956 and February-March 1957.

This discussion is not intended to show that tuna larvae are completely absent in depths greater than 60 m; instead the discussion and the table below (Table III), which shows the catch of larvae in opening and closing net tows, are intended only to provide a basis to determine, temporarily at least, the most appropriate depth to which the net should be towed for maximum results.

Table II

Tuna larvae taken in equatorial central Pacific
(lat. 5° N-15° S, long. 130°-145° W)

Depth of tow (m)	Number of tows	Number of larvae	Larvae per 30-minute tow[1/]	Percent of surface catch	Depth of uniform density (m)
0-2 horizontal (night only)	21	229	10.9	-	-
0-60 oblique (night only)	20	139	6.9	63.3	38
0-200 oblique	8	25	3.1	28.4	57

1/ Catch per 30-minute tow is used instead of catch per unit volume of water filtered because the latter calculations had not been completed at the time this report was being prepared.

Table III

Tuna larvae taken in opening and closing net tows in equatorial waters
(lat. 5° N-5° S, long. 140° W)

Depth of tow (m)	Number of tows	Number of larvae	Larvae per 30-minute tow[1/]	Percent of surface catch
0-2 horizontal (night only)	5	49	9.8	-
70-130 oblique	19	11	0.58	5.9
140-200 oblique	19	1	0.05	0.5

1/ Catch per 30-minute tow is used instead of catch per unit volume of water filtered because the latter calculations had not been completed at the time this report was being prepared.

It is obvious from the opening and closing net data (Table III) that nearly all of the tuna larvae captured had come from the upper 70 m of water. The few that were taken at 70-130 m and 140-200 m amount to only 5.9 and 0.5 percent, respectively, of the larvae taken at the surface.

Consequently, taking into account the rather restricted vertical range of tuna larvae, the ability of the larvae near the surface to dodge the net in daylight or in moonlight, and the very small catches to date

in deep tows, the most suitable tow for sampling tuna larvae seems to be an oblique tow to 60 or 70 m. Perhaps the depth of tow could be increased to 80 or 90 m, but tows deeper than this could result in considerable time and effort being wasted in filtering unproductive waters.

3. Duration of tow

The NASCO Working Group has shown that a 1 m net having mesh aperture size of 0.471 mm and a MA:M ratio of 4.8:1 is capable of filtering neritic water at greater than 85 percent efficiency for over 60 minutes. The tows were presumably made during daylight, as evidenced by Secchi disc readings, and all tows were made at a depth of 5 m.

Zooplankton migrate upward at night and tows made near the surface at night usually result in greater catches (up to 4 times more) than tows made during daylight. The increase in catch at night may be large enough to reduce appreciably the length of tow at the desired maximum filtration efficiency. To allow for large increases in catch at night, since most, if not all, of the sampling for tuna larvae will be done at night, the duration of the standard tow should be approximately 32 minutes or within 30 and 35 minutes.

4. Method of tow

There are two ways in which a 30 to 35 minute oblique tow can be made: (a) by lowering the net to the desired depth in 2 or 3 minutes and retrieving it slowly to the surface in 29 or 30 minutes - the single oblique tow; or (b) by lowering and retrieving the net at a constant winch speed for 15 to 16 minutes each way - the double oblique tow. Either method is acceptable, but the double oblique tow is preferable because it permits greater control over the net's attaining the proper depth.

It is desirable that all tows be made as uniformly as possible, and that the volume of water filtered be as near the 1,500 m^3 requirement selected for the proposed net design. In order to achieve this volume of filtration, a standard 32 minute double oblique tow to a depth of 70 m would require a towing warp angle of 60° at a ship speed of 2 knots. Such a tow will allow the net to filter 1,509 m^3 of water at a sustained filtration efficiency of 85 percent. The angle of stray of the towing warp should not be less than 55° nor more than 65°. A sinker of suitable weight, between 40 and 50 kg, should be suspended 1 m from the towing warp and 2 m ahead of the bridle (Fig. 3b).

In making the tow, the observer should have a table that shows, for each degree of wire angle between 45° and 75°, the amount of wire required for the net to reach the desired vertical depth. The amount of wire required is the quotient of the depth and cosine of the angle of stray of the towing wire from the vertical (length of wire = depth/cosine θ). During the tow the wire angle should be measured at least every two minutes and the rate of lowering should be adjusted so that the net will reach the desired depth in about 16 minutes. The same procedure should be followed while the net is being retrieved. Direction of tow should be as near to a straight line as possible. Towing in a circular path reduces the desired net speed at depth and usually results in low filtration and catch.

5. Time of tow

As previously mentioned, tows made near the surface (between 0 and 60 m) at night catch more plankton, as well as larval tuna, than tows made

during daylight. Generally, the catch of larval tunas increases after sunset and reaches a peak between 3 and 7 hours later (Strasburg, 1960; Klawe, 1963; unpublished data for 1965, BCF, Honolulu). Therefore, if only one tow is required each day, the ideal sampling time would be at three hours after sunset; if two are required, at 3 and 7 hours after sunset.

V. PRESERVATION OF SAMPLES

Fish larvae kept in preservation undergo varying amounts of shrinkage, depending upon the length of time they have been preserved, the frequency of changes of the preservatives by addition or replacement with newer solution, and the changing from one preservative to another.

Two preservatives, 70 percent ethyl alcohol and 10 percent formalin, have been used most commonly. Because specimens preserved in alcohol shrink more than those preserved in formalin, the latter is preferred as the preserving agent.

The saturated aqueous solution known as "concentrated formalin" contains 38 to 40 percent formaldehyde. One part of concentrated formalin should be added to nine parts of sea water (including the plankton sample) to obtain a 10 percent solution.

As a precaution against dissolution of calcareous parts of the plankton, it is essential that the formalin be buffered; either hexamine or borax (sodium tetraborate) may be used as a buffer. Hexamine is probably better, but "apart from being expensive, it has the disadvantage of easily crystallizing around organisms when the sample is subject to even a slight amount of evaporation, e.g., while being examined under the microscope in an open dish" (Interim Report on Standardization of Plankton Methods, Working Party Two, ICES-SCOR-UNESCO). Borax tends to lose its effectiveness with time, but the addition of about 5 g to a liter of 10 percent formalin should provide not only sufficient immediate buffering action, but enough reserve to extend its effective period to 4 or 5 years.

Plankton samples in storage should be checked periodically with litmus paper and more borax should be added as needed, since the samples will turn acidic in time.

Once the samples have been preserved, formalin should not be changed unless the sample shows signs of deterioration. Frequent changes of the preservative could affect the rate and amount of shrinkage. This precaution should be followed even after the tuna larvae have been sorted from the plankton sample.

Each sample jar should not be more than half-filled with planktonic organisms; formalin should be added to the top. Certain organisms such as leptocephalii secrete large amounts of mucous-like substance which hinders proper preservation of the plankton. Such organisms should be preserved in separate jars.

VI RECOMMENDATIONS

In accordance with the terms of reference set forth in Resolution 6, the Working Party makes the following recommendations:

1. That the net recommended should serve as an interim sampler until a better bridle arrangement has been developed and tested.

2. That the net be small enough for use on all sizes of research craft, yet sufficiently large for adequate catches of tuna larvae.

3. That the net be a simple unencased net with the following specifications:

   a. Size of net to be 1 m in diameter at the mouth.

   b. Net material to be monofilament nylon.

   c. Mesh aperture to be either 0.505 mm (first choice) or 0.471 mm (second choice).

   d. Shape of net to be a combination of a cylindrical forward section and a truncated conical after section tapering from a radius of 50 cm to a radius of 5 cm (Fig. 1).

   e. Overall ratio of mesh aperture area to mouth area (MA:M) to be at least 4.8:1 and the ratio of the conical section be not less than 3:1.

   f. Minimum length of filtering cylindrical and conical sections to be as follows:

      1) For nets with mesh aperture of 0.505 mm

         a) Cylindrical section of 88 cm

         b) Conical section of 267 cm

      2) For nets with mesh aperture of 0.471 mm

         a) Cylindrical section 92 cm

         b) Conical section 278 cm

   g. Bridle lines to be 71 cm so that tow point will be 50 cm ahead of net.

   h. Flowmeter of good quality to be placed 20 cm from net rim.

   i. Sinker to be a dead weight suspended 1 m from towing cable and 2 m ahead of bridle (Fig. 3b), and heavy enough (40 to 50 kg) to keep angle of towing warp between 55° and 65°.

4. That the sampling method be as follows:

   a. Double oblique tow to a depth of 70 m.

   b. Duration of tow to be 32 minutes.

   c. Towing speed of vessel to be 2 knots.

   d. Towing warp angle to be not less than 55° nor greater than 65°, preferably 60°.

e. Speed of lowering and retrieving the net be adjusted so that the desired maximum depth will be reached in 16 minutes.

f. Towing direction to be as close to a straight line as possible.

g. Towing time to be at 3 hours after sunset if only one tow is required, or at 3 and 7 hours after sunset if two tows are required per day.

5. That samples collected be preserved and handled as follows:

a. Preservative to be 10 percent solution of formalin buffered with 5 g of borax (sodium tetraborate) per liter of preservative, including the plankton sample.

b. Strained plankton volume to be no more than half the capacity of the sample jar; buffered formalin to be filled to the top.

c. Gelatinous and mucous-secreting organisms be preserved in separate jars.

d. Preservative not to be changed except when the samples show signs of deterioration.

e. Plankton samples not to be washed in water prior to removal of tuna larvae.

6. That interested parties take steps to develop a net with the bridle removed from directly in front of the mouth or to test the method suggested in the report.

7. That the existence of a standardized gear will not hinder the development of new gear or new methods suitable for collecting larval tuna.

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APPENDIX

COMPUTATIONS OF STANDARD NET DIMENSIONS FOR NYLON MESH 0.50 MM

Mesh aperture area to mouth area ratios required:

Total net	4.8:1
Truncated conical section	3:1
Cylindrical section	1.8:1

Conical section:

Mouth area	7,857 cm^2
Truncated conical filtering area	7,857 cm^2 x 3 = 23,571 cm^2
Total conical area	23,571 cm^2 + 238.1 cm^2 = 23,809.1 cm^2 where, 238.1 cm^2 is area of cone tip excluded from filtering section.
Height of total conical section	23,809.1 cm^2/3.1416 x 50 cm = 151.5 cm
Open area of 0.505 mm nylon mesh	51 percent
Height of total mesh area	151.5 cm/0.51 = 297.1 cm
Height of filtering mesh area	297.1 cm - 29.7 cm = 267.4 cm where, 29.7 cm is height of cone tip excluded from filtering section.

Cylindrical section:

Total filtering area	7,857 cm^2 x 1.8 = 14,142.6 cm^2
Height of filtering area	14,142.6 cm^2/2 x 3.1416 x 50 = 45.0 cm
Open area of 0.505 mm nylon mesh	51 percent
Height of filtering mesh area	45.0 cm/0.51 = 88.2 cm

APPENDIX 6

INFORMATION ABOUT A COLOR PRESERVATIVE USED IN THE PRESERVATION OF TUNA LARVAE IN ORDER TO PREVENT FADING OF PIGMENT SPOTS

1. The information of color preservative first obtained from Dr. William Richards concerned the solution under the trade name of IONOL CP-40. The solution is sold by Shell Chemical Co., P.O. Box 751, Martinez, California, and retails for about $10 per one-half gallon.

2. IONOL CP-40 is the trade name for BHT (3,5-di-tert-butyl-4-hydroxytoluene).

3. Dr. Toyama reportedly uses 0.1 percent concentration of BHT and considers this adequate. Mr. Matsumoto uses a concentration of 0.5 to 1.0 percent (2 to 4 ml per 16-ounce jar of plankton in 10 percent formalin, equivalent to 400 ml).

4. Excessive amounts of BHT (1 percent or over) turn the formalin milky white and makes plankton sorting difficult.

APPENDIX 7

REPORT OF THE U.S. BUREAU OF COMMERCIAL FISHERIES BIOLOGICAL LABORATORY, HONOLULU, TO SECOND SESSION OF THE FAO EXPERT PANEL FOR THE FACILITATION OF TUNA RESEARCH

This report describes actions taken by the U.S. Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii, in response to recommendations made by the FAO Expert Panel for the Facilitation of Tuna Research (EPFTR), First Session, held in Rome, Italy, 8-12 June 1964. Each section is preceded by the heading of the particular recommendation as given in the Report of the First Session, FAO Fisheries Reports, No. 18.

Identification of Larvae and Juveniles (III-(2))

Identification of Tuna Larvae

Identification of tuna larvae thus far has been based on patterns of black pigment in preserved specimens. Variations in pigmentation have sometimes caused taxonomists to disagree on identification. Recent studies by scientists of the Nankai Regional Fisheries Research Laboratory have led them to believe that the specific identity of certain tuna could be clarified by examination of the pattern of red pigmentation. The red pigment ordinarily disappears about a week after preservation and most observations must be made at sea. The Bureau of Commercial Fisheries Biological Laboratory, Honolulu, has begun to examine this pigmentation by using a color preservative in the plankton samples.[1/] Preliminary results from 75 thunnid and 133 skipjack tuna larvae show that this pigmentation varies considerably between individuals of the same species and on either side of the body. The results are not conclusive, however, and further studies are contemplated.

Subpopulation Identification by Genetic Techniques (III-(4))

Collecting Instructions

In response to the recommendation of the EPFTR, a standardized set of collecting instructions for blood and serum specimens was prepared by the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, and published by FAO.[2/] This circular is available upon request either to FAO or the Burea of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii.

Cooperation with Japanese Research Agencies

An agreement was reached among scientists of the Nankai Regional Fisheries Research Laboratory, the Tokai Regional Fisheries Research Laboratory, and the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, to implement the recommendation of the EPFTR (III-(4), paragraph 7) that Japanese research vessels collect blood samples in their Atlantic tuna investigations and make such collections available to the Tuna Blood Group Center in Honolulu. This agreement has been amplified to include the Pacific and Indian Oceans as well. Under the agreement, the Japanese have sent to the Tuna Blood Group Center blood samples from 20 yellowfin and 1 bigeye from the Pacific; 32 yellowfin and 7 bigeye from the Indian; and 17 yellowfin and 88 albacore from the Atlantic Ocean. Blood group testing showed the Atlantic albacore samples to differ significantly from Pacific

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1/ See Appendix 6.

2/ Fujino, Kazuo. 1966. Instructions for collecting blood and serum samples from tuna fishes. FAO Fisheries Circular No. 26, 5 p.

albacore. This result supports earlier findings by Suzuki (1962).[1/]

The Tuna Blood Group Center will continue analyses of blood specimens of various species of tunas as they are obtained from the Japanese research vessels and will exchange reagents with other laboratories conducting similar research.

The Japanese Fishery Agency has also been asked to make arrangements to collect blood samples of Atlantic tuna from the Japanese commercial longline boats.

Cooperation with Tropical Atlantic Biological Laboratory, Miami

Arrangements for the collection of blood specimens of Atlantic tuna by the Bureau of Commercial Fisheries Tropical Atlantic Biological Laboratory, Miami, are now in progress. A first shipment of blood samples collected from the Atlantic has been received at the Tuna Blood Group Center, Honolulu. The results show that the method of handling is technically feasible.

Other Cooperative Arrangements

In addition to the samples received from the Japanese and from the Tropical Atlantic Biological Laboratory, tuna bloods have also been received from Australia through the cooperation of the CSIRO, New Caledonia and Tahiti through the Institut Français d'Océanie, eastern Pacific through the Inter-American Tropical Tuna Commission, South Africa through the South African Museum, and Norway through the Fiskeridirektoratets Havforsknings Institut. Reagents for standardization purposes have been exchanged with the Japanese Fishery Agency and the Inter-American Tropical Tuna Commission. Samples from Palau were taken by Laboratory personnel through arrangement with the Office of the High Commissioner, Trust Territory of the Pacific Islands.

Review Paper on Subpopulation Identification

Although genetic techniques have been applied to fishery problems for more than a decade, many fishery scientists lack the specialized training required to understand fully the implications of the results obtained. Lucian M. Sprague of the Laboratory in Honolulu has agreed to provide FAO with a review paper in which he will (1) examine the utility of genetic techniques in subpopulation identification, (2) describe the applications that have been made and the results obtained, and (3) list the pertinent literature. One of his principal objects will be to fit the marine studies into the mainstream of genetic research.

Tagging (III-(5))

South Pacific Albacore

Albacore tagging in waters of Valparaiso, Chile, was one of the objectives of Anton Bruun Cruise 14, one of a series of cruises in the southeastern Pacific Ocean by the research vessel of the U.S. National

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1/ Suzuki, Akimi. 1962. Serological studies of the races of tuna. VI. Bigeye antigen occurred in the albacore. Report of Nankai Regional Fisheries Research Laboratory 16: 67-70

Science Foundation. Since the albacore season in Chile usually falls in January and February, and the start of Anton Bruun Cruise 14 from Valparaiso was scheduled for February 14, 1966, the experiment was conducted during the three-week period preceding the cruise.

Through the cooperation of the University of Chile and the Catholic University of Valparaiso, who made their research vessels available, waters extending as far as 200 miles west of Valparaiso were intensively trolled. No albacore were caught.

The occurrence of albacore in Chilean waters is apparently erratic. No albacore were landed in 1960 and 1961. The landings were as little as 0.5 ton in 1965 and as much as 60.7 tons in 1963. Data for earlier years, 1940-52, show more consistent, though small, landings ranging to 496 tons in 1952.

Although our attempt to tag albacore in Chile was unsuccessful, owing to the unavailability of albacore in this particular year, it is hoped that there will be other opportunities for albacore tagging in the South Pacific Ocean.

Tuna Tagging in Australia

In line with the Expert Panel's recommendation that tuna tagging be carried out on an international basis and in all major fisheries, the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, recently cooperated with Frank H. Talbot, Director of the Australian Museum in Sydney, to conduct yellowfin tuna tagging. Dr. Talbot requested us to provide suitable tags for yellowfin tuna tagging by members of the Sydney Game Fishing Club and we did so.

Though the effort was minimal, it is hoped that this experience will have formed the basis for additional tagging experiments in Australian waters.

Collection of Larvae and Juveniles (III-(6))

Collection of Tuna Larvae

A Working Group on Methods of Collecting Larvae was organized under the chairmanship of Walter M. Matsumoto of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu. This group has evaluated techniques of collecting larval tunas. Its findings and recommendations are presented as a separate report. 1/

Collection of Tuna Juveniles

Despite our relative success at catching larval tuna up to about 12 mm long with plankton nets, we have rarely captured juveniles with this gear. Moreover, not a single juvenile has been caught in 93 hauls of the neuston net. We have achieved some success with other collecting methods, however, and during the period 1951-60, 68 juveniles were caught by dipnetting at night-light stations, 27 were removed from the stomachs of pelagic fishes, and 1 was taken with a tuna bait seine. Dipnetting and stomach sampling continue to provide us with juveniles from various parts of the Pacific. But sampling is often limited to insular areas, and juveniles from stomach contents are frequently in poor condition.

Midwater trawls seem to offer the most promise for the future. The Laboratory has made two cruises in the past 2 years to collect juvenile

1/ See Appendix 5

tuna. On the first cruise, August 1964, the British Columbia Mark IV mid-water trawl (mouth opening approximately 25 square feet), developed by the Fisheries Research Board of Canada, Biological Station, Nanaimo, B.C., and modified at the Laboratory in Honolulu by the addition of a 1/4-inch mesh cod end liner, and the Cobb pelagic trawl (mouth diameter approximately 60 feet) modified by a 1/2-inch cod end liner, were tested off Hawaii. The Mark IV trawl caught two juvenile tunas in 12 tows and the Cobb pelagic trawl caught one juvenile in 16 tows. On the second cruise, January-February 1966, the Mark IV net was used in the equatorial central Pacific. It caught 13 juvenile tuna in 32 tows.

Although the trawls used on the above cruises were probably large enough to minimize or eliminate net dodging, they had a common defect; the mesh sizes in the body of each net were too large (1-1/2 to 6 inches). As far as juvenile tuna are concerned, the effective straining area was probably restricted to the 1/4-inch cod end liner.

A large, small-mesh trawl was recently (December 1965) designed by gear specialists at the Bureau of Commercial Fisheries, Seattle. This net is about 170 feet long, has a mouth diameter of about 40 feet, and is constructed entirely of 3/4-inch mesh netting. Experimental fishing with this net in Puget Sound has resulted in catches of a variety of small fishes, including anchovy. The addition of a 1/4-inch mesh netting at the cod end should make this net ideal for capturing the elusive juvenile tuna. The Laboratory in Honolulu has contracted for the construction of two such nets. They should be ready for use on our next trawl cruise, which is scheduled for January and February, 1967.

Because the usual collecting gear has been relatively unsuccessful in capturing juvenile tunas, beginning in the middle of 1962, the Albacore Ecology Program started to sample stomachs of predators of juvenile tuna, primarily billfishes, at the Honolulu auction markets. The billfishes appeared to be relatively good "collectors" of juvenile tuna. In January 1964, therefore, sampling was expanded to include the longline fishery based at American Samoa.

During the period from July 1962 to April 1966, stomachs of 4,572 billfishes captured around Hawaii were sampled. Thirty-six juvenile albacore (<40 cm long), 855 juvenile skipjack (<40 cm long), and smaller numbers of other species of tunas were found. As of April 1966, 1,760 billfish stomachs had been sampled from the Samoan longline fishery. One hundred and two juvenile albacore (<40 cm long) and 677 juvenile skipjack (<40 cm long) were found. Smaller numbers of other species of tuna were also found, including seven juvenile Gymnosarda unicolor.

Training, Education, and Exchange (III-(7))

Albacore Data Exchange

The albacore fisheries in the Northern and Southern Hemispheres offer interesting contrasts: The North Pacific fishery is relatively old and well developed, that in the South Pacific is relatively new and rapidly growing; the North Pacific fishery harvests the immature segment of the North Pacific population, the South Pacific the mature segment of the southern population(s). Such contrasts offer an ideal opportunity to conduct a comparative study of the population dynamics of albacore in the two hemispheres.

For such a study, it is necessary that data from all of the various Pacific albacore fisheries be available. Data collection from the Samoa-based South Pacific longline fishery was started by the Laboratory in Honolulu in early 1963 and is continuing. Data from the California and Oregon fisheries have been compiled and are available for study. What was needed most, and was not available to scientists outside Japan until recently, were the Japanese albacore data, particularly data from the North Pacific fisheries.

Several years ago the Laboratory in Honolulu discussed this need with Hiroshi Nakamura, then Director of the Nankai Regional Fisheries Research Laboratory, Kochi, Japan. Through his cooperation, arrangements were successfully concluded in 1964 for Tamio Otsu, Chief of the Albacore Ecology Program, to visit the laboratory in Japan to work with Japanese scientists and acquire catch and effort data. Japanese albacore data were made available by Aiji Takashiba, successor to Dr. Nakamura at the Nankai Laboratory (Dr. Takashiba is presently Director of Research of the Japanese Fishery Agency), during Mr. Otsu's visit between September 1964 and March 1965. Mr. Otsu discussed with Japanese scientists possible approaches to cooperative analysis of albacore data by scientists of the two laboratories.

Mr. Otsu's visit to the Nankai Laboratory has served to foster the close working relationship enjoyed by the two laboratories for many years. The data made available to us have now been prepared for automatic data processing and analysis is scheduled to begin shortly.

Climax Predators of Indian Ocean

The Bureau of Commercial Fisheries Biological Laboratory, Honolulu, was assigned the responsibility for the fisheries phase of the United States Program in Biology of the International Indian Ocean Expedition (IIOE). The primary mission was to study the biology of the large pelagic fishes such as tuna, billfishes, and sharks in the central and western Indian Ocean. Two longline cruises were carried out in 1963 and 1964 under the direction of Richard S. Shomura of the Laboratory in Honolulu.

In order to study effectively the relationship between the climax predators and the environment, arrangements were made to pool our large amount of environmental data with the Indian Ocean fisheries data collected from Japanese commercial and prefectural vessels by the Japanese Government.

Shoji Kikawa, scientist of the Nankai Regional Fisheries Research Laboratory in Kochi, Japan, arrived in Honolulu on March 24, 1966 to spend 6 months at the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, on a cooperative investigation with Mr. Shomura. This visit was the result of an agreement between the Honolulu Laboratory and the Nankai Laboratory to study the distribution and abundance of the climax predators in the Indian Ocean and the relationship of these organisms to the environment.

Subpopulations Workshop

In May 1965 plans were initiated to hold a Workshop on Subpopulation Identification from November 8 to 19, 1965 at the Bureau of Commercial Fisheries Biological Laboratory, Honolulu under the leadership of Kazuo Fujino. The tentative agenda included:

1. Presentation and discussions of current work, by each participant, on tuna blood groups, electrophoresis, and other techniques based on genetic concepts useful to tuna subpopulation identification.

2. Comparison of reagents prepared in the laboratory of each participant for standardization.

3. Comparison of techniques used in the laboratories of the participants.

4. Discussions on general problems, and on the establishment of future cooperative agreements.

Expressions of interest were received from 10 of 14 scientists invited. The workshop had to be postponed, however, because appropriate financial support was not available to the majority of the scientists.

Planning Meeting on Hematological, Immunogenetic and Serological Studies of Fish (United States-Japan Cooperative Science Program)

In the early part of 1963 Lucian M. Sprague, Deputy Area Director, Bureau of Commercial Fisheries, Honolulu, initiated preliminary correspondence with Yasuo Suyehiro, Department of Fisheries, Faculty of Agriculture, University of Tokyo, on the possibility of cooperating actively on hematological, immunogenetic and serological studies of fish under the auspices of the United States-Japan Cooperative Science Program. It soon became apparent that a meeting was desirable between Japanese and American scientists conducting research in this area. In May 1964 Dr. Sprague agreed to organize a general meeting in Hawaii in the autumn of 1964. The meeting was to develop concrete proposals of cooperative work and their implementation and to lay the groundwork for future meetings to discuss scientific progress of the work carried out under the U.S.-Japan Cooperative Science Program.

The meeting, called the "Planning Meeting on Hematological, Immunogenetic and Serological Studies of Fish" was held in Honolulu, Hawaii, during November 16-20, 1964, under the auspices of the National Science Foundation of the United States. The participants were:

John E. Cushing	Professor of Immunology Department of Biological Sciences University of California Santa Barbara, California
Kazuo Fujino	Chief, Subpopulations Program U.S. Bureau of Commercial Fisheries Biological Laboratory Honolulu, Hawaii
Takashi Hibiya	Assistant Professor Department of Fisheries Faculty of Agriculture University of Tokyo Bunkyo-ku, Tokyo, Japan
James Joseph	Inter-American Tropical Tuna Commission c/o Scripps Institution of Oceanography La Jolla, California

Nobuyuki Kawamoto	Professor, Department of Fisheries University of Nihon Setagaya-ku, Tokyo, Japan
Heihachiro Miyayama	Science Supervisor Higher Education and Science Bureau Ministry of Education Kasumigaseki, Chiyoda-ku Tokyo, Japan
Norman P. Neureiter	Acting Program Director Office of International Science Activities National Science Foundation Washington, D.C.
Ichiro (Mike) Nishimura	c/o Languages Services Department of State Washington, D.C.
George J. Ridgway	Assistant Laboratory Director U.S. Bureau of Commercial Fisheries Biological Laboratory West Boothbay Harbor, Maine
Lucian M. Sprague	Deputy Area Director, Hawaii Area U.S. Bureau of Commercial Fisheries Honolulu, Hawaii
Yasuo Suyehiro	Professor, Department of Fisheries Faculty of Agriculture University of Tokyo Bunkyo-ku, Tokyo, Japan
Akimi Suzuki	Technical Officer Tokai Regional Fisheries Research Laboratory Chuo-ku, Tokyo, Japan
Andrew M. Vrooman	Director, Subpopulation Program U.S. Bureau of Commercial Fisheries California Current Resources Laboratory La Jolla, California
James E. Wright	Professor of Genetics College of Science The Pennsylvania State University University Park, Pennsylvania

A paper which reports on the results of the meeting has been published: Sprague, 1965, Science, 148(3674):1252-4.

Collection, Collation, and Dissemination of Catch and Effort Statistics (III-(8))

Hawaiian Fisheries

Catch statistics from the skipjack pole-and-line fishery as well as the longline fishery in Hawaii are collected by the Division of Fish and Game, Department of Land and Natural Resources, State of Hawaii. The Aku (Skipjack) Catch Report, which is required of pole-and-line fishermen,

provides information on days fished, area fished, port of landing, number and pounds of skipjack and other species taken, and bait catches. Longline fishermen use the Flagline Catch Report, which furnishes information on date of landing, number of days at sea, area of catch, port of landing, and catch by number and pounds of various species of tuna, billfishes and miscellaneous fishes.

Upon receipt of these catch reports at the end of each month, the Division of Fish and Game enters the information on IBM cards, prepares monthly summaries by species, and distributes mimeographed copies to interested agencies. Annual summaries of the catch by species, by areas of fishing, type of fishing, and port of landing are also prepared.

Both print-outs and punched cards are made available to the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, for analysis. Such data have been used in the past for several studies[1/][2/][3/] and are being used for studies now in progress.

Since the past skipjack catch reports did not provide data on zero-catch trips, effort was measured only on the basis of productive or effective trip and productive fishermen-trip. The catch report form was revised in July 1964 to include data on zero-catch trips.

In the Hawaiian longline fishery, catch per 100 hooks, catch per trip, and catch per 100 baskets of gear per day's fishing, have variously been used as indices of apparent abundance in describing the condition of the fishery. The difficulty in defining effort in this fishery (hook days is the most suitable effort unit for longline fishing) stems from the lack of consistent and accurate data. Revision of the report form is being considered to obtain information on number of hooks per basket, number of baskets fished, and number of days fished.

The Laboratory has been collecting data on size and sex of tuna and billfishes by regular sampling of the landings. Skipjack caught by pole-and-line vessels are randomly sampled each week night at the cannery or on the vessels as they unload their catch. Every 5th, 10th or 15th fish is measured, depending on the size of the fish and the amount caught. In addition to length data, weight and sex data from as wide a size range as possible are collected from about 150 fish throughout the month. Longline-caught tuna and billfishes are sampled every week day at the auction markets.. Data collected include weight and sex of all tunas and billfishes, lengths of all albacore, and when time permits, lengths of randomly selected bigeye and yellowfin tuna.

1/ Yamashita, D.T., 1958. Analysis of catch statistics of the Hawaiian skipjack fishery. U. S. Fish and Wildlife Service, Fishery Bulletin 58:253-78

2/ Shippen, H.H., 1961. Distribution and abundance of skipjack in the Hawaiian fishery, 1952-53. U.S. Fish and Wildlife Service, Fishery Bulletin 61: 281-300

3/ Uchida, R.N. (MS) Catch and estimates of fishing effort and apparent abundance in the fishery for skipjack tuna (Katsuwonus pelamis) in Hawaiian waters, 1952-62. Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii.

Information on size and sex of tuna is routinely entered on IBM cards for processing by computers. Length-frequency distributions have been used in studies on age and growth, on migration, and on population structure.1/2/

Operations Analysis, Hawaiian Skipjack Fishery

Arrangements have been made, with Vernon E. Brock, University of Hawaii, for a study of the operations of Hawaiian live-bait sampans. In brief, the study will include: (1) quantification of the time spent in each aspect of the operational process (i.e., baiting, running to fishing grounds, scouting, fishing, running to port, unloading, etc.); (2) identification of those parts of the process in which improvements could lead to the greatest increase in efficiency; and (3) program design to effect such improvements in efficiency.

Fishery in Palau

A sampling station was established in Palau Islands, Trust Territory of the Pacific Islands, by the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, in May 1965 in order to collect catch statistics of the Palauan pole-and-line fishery. Data are collected on length, weight, and sex of skipjack and yellowfin. Every nth fish, where n is some multiple of 10, is examined. Length, weight, and sex data are obtained from about 100 skipjack and up to 100 yellowfin every two weeks. Representative samples of baitfish and of skipjack ovaries are collected, preserved, and shipped to Honolulu for examination. Blood samples will be collected when methods of keeping the samples properly refrigerated in transit are worked out.

Several species of baitfish have been identified. Body lengths of the predominant bait species are now being measured. Studies of size distribution, length-weight relationship, and sexual maturity of skipjack and yellowfin tunas and baitfishes are planned for the future.

Samoa-based Longline Fishery

Recognizing the importance of documenting the rapid growth of the longline fishery based at Tutuila, American Samoa, the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, in April 1963 established a field station in American Samoa.

Detailed catch and effort data are collected with the aid of a log-book system. With this system it is possible to determine the amount of effort expended (number of hooks fished), the geographic area fished, and the corresponding catch in numbers of fish by species, on a daily basis. Other ancillary data are obtained by personal interviews with vessel operators. About 85 percent of the fishermen cooperate.

1/ Shomura, R.S. and B.A. Keala. 1963. Growth and sexual dimorphism in growth of bigeye tuna (Thunnus obesus), a preliminary report. Proceedings of the World Scientific Meeting on the Biology of Tunas and Related species, 2-14 July 1962, FAO Fisheries Reports (6):2:1409-17

2/ Rothschild, B.J. 1965. Hypotheses on the origin of exploited skipjack tuna (Katsuwonus pelamis) in the eastern and central Pacific Ocean. U.S. Fish and Wildlife Service, Special Scientific Report-Fisheries 512, 20 p.

The field station personnel also obtain data on the weight, sex, and fork length of 50 randomly selected albacore from each of as many vessels as it is possible to sample each day.

All these data are entered on IBM cards for automatic data processing. Print-outs of all the data summarized by 1 degree and 5 degrees of latitude and longitude are also prepared. Copies of these data will be made available to the Japanese, with whom we have arranged for a data exchange.

A preliminary report describing the history and status of the Samoa-based fishery has been prepared on the basis of these data.[1/] A more detailed report covering the period 1954-65 is presently in preparation.

Research on North Pacific Albacore and Bluefin (III-(11))

North Pacific Albacore

As mentioned under our report on Mr. Otsu's visit to the Nankai Regional Fisheries Research Laboratory in Kochi, Japan (Training, Education, and Exchange (III-(7)), the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, was recently provided with copies of the Japanese North Pacific albacore data through the cooperation with the Japanese Fishery Agency. These data, along with catch and effort data from the California and Oregon albacore fisheries, constitute full set of data necessary for advanced studies of the population dynamics of the North Pacific albacore.

Oceanography and Tuna Ecology (III-(12))

International Indian Ocean Expedition

Two of the cruises of the R/V Anton Bruun during her participation in the International Indian Ocean Expedition in 1963 and 1964 were devoted to a study of the pelagic fishes of the Indian Ocean, principally the tuna species of commercial importance. On Anton Bruun Cruise 2 (May 22-July 23, 1963) longline fishing was carried out along long. 70° and 80° E. On Anton Bruun Cruise 5 (January 26-May 4, 1964), longline fishing was again carried out in the western Indian Ocean along long. 55° and 75° E.

The fishing data from the two cruises have been prepared for submission as a contribution to the 12th Session of the Indo-Pacific Fisheries Council. Oceanographic data from the National Oceanographic Data Center in Washington, D.C., have been analyzed along with data from the cruises of the Anton Bruun. The analyses have primarily been directed to the identification of water masses and water types at the surface and the immediate subsurface layers. In a joint study with the Japanese (see report of Mr. Kikawa's visit to the Honolulu Laboratory, III-(7)) we are presently examining fishing data of the two Anton Bruun cruises and results of Japanese commercial fishing during the period September 1952 through August 1964. This ecological study is expected to be completed by October 1966.

1/ Otsu, T. (In press) The South Pacific long-line fishery for albacore tuna, 1954-64. (Scheduled for publication in the July 1966 issue of Commercial Fisheries Review).

Trade Wind Zone Oceanography

The Trade Wind Zone Oceanography (TWZO) Investigation is conducting a pilot study to test sampling and processing techniques and methods of analysis to be used in a time-sequence study in the area which extends from the Equator to Lat. 30° N. and from long. 130° W. to 180°.

In the Hawaiian area the availability of skipjack tuna has been shown to be materially affected by the water type at the surface within the fishing grounds. The TWZO study is attempting to determine the mechanisms which change the distribution of properties (temperature, salinity) and water masses, including the water types in the surface layer.

The Trade Wind Zone Oceanography pilot study is now in the descriptive phase of data collected by the R/V Townsend Cromwell February 1964 to July 1965, from an area bounded by lat. 10° and 26° N., and long. 148° and 157° W. A grid of oceanographic stations was occupied at monthly intervals.

Results show that within 300 m of the sea surface in the North Pacific trade wind zone three major water masses can be found that have their origin from lat. 45° N. to 40° S. The water masses are the high salinity North Pacific Central Water, the low salinity North Pacific Intermediate Water, and the Equatorial Intermediate Water. Relatively large salinity gradients define these boundaries in the trade wind zone. Subsurface boundary displacements are as large as those at the sea surface. Geostrophic current sections show that the North Pacific Equatorial Current is not a broad smooth stream but one in which eddies and easterly components of flow are superimposed upon a generally westerly flow.

Six data reports are in press. Descriptive reports and analytical papers will be prepared.

Results of the pilot study set the stage for PROJECT PORPOISE which will begin in the summer of 1967. PORPOISE is an integrated, time-sequence investigation of the oceanography, meteorology, and biology of the North Pacific trade wind zone. The multiple-ship field operations are expected to last approximately two years. PORPOISE will provide the first opportunity to interrelate meteorological events with those in the ocean and their effects on diverse biological facets from primary productivity to the reproduction and distribution of the commercially important tuna. Many agencies and institutions will be involved whose interests include the distribution of birds, oceanography, prediction of tropical storms and fisheries.

Oceanographic Atlas of the Pacific Ocean

An atlas summarizing several million observations made between 1917 and 1964 at approximately 50,000 oceanographic stations in the Pacific Ocean is now in press. Its 156 charts, sections, and graphs show:

1. Densities of observations;

2. Temperature, salinity, and density near the surface (10 m depth) by quarters;

3. Quarterly and annual charts of salinity, oxygen, and depth along 11 selected sigma-t surfaces, covering a range of depths from 10 m to 2,000 m;

4. Sections at intervals of approximately 20 degrees in longitude and 10 degrees in latitude, showing the salinity, oxygen, depth, and density; and

5. Frequency distribution histograms which show the statistical characteristics of the data.

Taken together, the charts and sections provide a complete three-dimensional summary of what is now known about average conditions of the upper mile of the Pacific Ocean. In addition, the frequency histograms provide information on variability: ranges of values, means and modes, dispersions, and other pertinent statistical data.

The figures and charts complement each other in another sense: each set provides a different degree of resolution in space and, to some extent, in time. The charts retain a maximum of resolution and detail through the use of quarterly averages based upon data within areas of 1 degree of latitude by 1 degree of longitude. The sections sacrifice detail to provide more stable averages, since they combine data from 2-degree by 2-degree areas on an annual basis and thus represent some 10 times as many stations per average value. Finally, the frequency histograms include all available data from 10-degree by 10-degree areas, with as many as a thousand stations in a single area, so that the statistical nature of the data is well represented.

The atlas therefore represents a source of information on both the average environment and on extremes in the environment. Many features are revealed for the first time, or are placed in their ocean-wide context in a way which has not been possible before. These features should make the atlas a valuable tool for the ecologist when analyzing existing biological knowledge or planning future work.

One major future use for the atlas data is a study, now under way, of the three-dimensional distribution of currents and mass transport in the Pacific Ocean north of lat. 20° S. This study, when completed, will make it possible to synthesize the data on currents and distributions of properties into a consistent whole, including estimates of mixing coefficients, rates of biological consumption of oxygen, and rates of water mass formation and dissipation.

Tuna Ecology Studies off South America

In early 1966, scientists of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, participated in one of a series of biological cruises carried out by the R/V Anton Bruun in the southeastern Pacific off the coast of South America under the auspices of the U.S. National Science Foundation. We conducted a series of longline fishing stations on Anton Bruun Cruise 14 (February 14-March 16, 1966). Twenty fishing stations were occupied along several east-west transects and one north-south transect. The westernmost station occupied was located at lat. 30°30' S., long. 89°32' W., and the northernmost station was at lat. 7°39' S., long. 82°21' W.

The results of longline fishing were extremely disappointing. The catches were very low in numbers. The total tuna catch consisted of only two yellowfin, two bigeye, and one skipjack. A detailed study will be made of the environmental data collected on the cruise to determine if a hypothesis can be developed to relate the low availability of the large pelagic fishes to the environment.

Prior to the cruise on the Anton Bruun, an extensive trolling survey for albacore was carried out in waters off Valparaiso, Chile. A report on this experiment is given under Tagging (III-(5)).

Cooperative Study of the Kuroshio and Adjacent Areas (CSK)

The CSK, as originally planned, was an oceanographic study, coordinated by UNESCO, of the area lying roughly between long. 155° E. and the mainland of Asia and the Equator and lat. 43° N. The plans called for oceanographic observations appropriately spaced over the entire area four times a year for two years, at the end of which time additional study of specific problems revealed as a result of the broad study would be carried out.

Owing to limitations on facilities (primarily ship time), the broad surveys have been restricted to twice a year and largely (although not entirely) to the area north of lat. 30° N. to the west of Japan and lat. 5° N. to the west of the Philippines.

Provision has been made to include in CSK fishery studies coordinated by FAO. Plans for these fishery studies will be made at the Third Meeting of the CSK Coordinating Group (Tokyo, August 1966) and, especially, at the Joint IPFC/IOC Meeting (Honolulu, October 1966). It appears likely that there will be included studies of subpopulation identification of skipjack, and the relation of subpopulation distribution to oceanographic features.

Behavior (III-(13))

Tuna Behavior Investigations

Investigations at the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, of the behavior of tuna have followed and expanded the recommendations of the EPFTR. These recommendations called for work on the feeding behavior of tuna at sea, development of acoustic apparatus to study the distribution, dimensions, and abundance of tuna schools, development of more precise methods of measuring the reaction of tuna to fishing gear, studies on the sensory capabilities of tuna, and the development and improvement of large facilities for the study of live tuna in captivity. Our investigations may be summarized as follows:

Sonar. The first continuous-transmission, frequency-modulated (CTFM) sonar designed for tracking tuna schools was placed aboard the R/V Townsend Cromwell during April and May 1966. The first of a series of cruises in Hawaiian waters to (1) "debug" the equipment, (2) train sonar operators, and (3) study skipjack tuna behavior was then immediately begun. It has been possible to track schools of skipjack tuna (Katsuwonus pelamis) continuously for periods up to 71 minutes and at ranges up to 650 m. The sonar has also been used to locate tuna and other large predators caught on longline fishing gear. The sonar will be used to investigate both the horizontal and vertical dimensions of tuna schools and to assess their abundance, especially subsurface schools and schools without bird flocks overhead. It has already been noted, for example, that the distribution of individuals in skipjack tuna schools does not always correlate with their distribution as deduced by the movements of bird flocks. In one instance the school seemed to be made up of discrete pods or groups of skipjack.

The CTFM sonar uses a different mode of operation from the conventional pulsed sonar, which operates on a single frequency and transmits sounds and

receives return echoes on an interrupted basis. The CTFM sonar projects and receives acoustic energy continuously, thus lessening the possibility of losing a target such as a fast moving tuna school. In its high resolution mode, the CTFM sonar should be able to distinguish between tuna 18 cm apart at a distance of 100 m. A variety of research studies utilizing this sonar have been planned under the following general categories:

1. Mechanisms affecting the vertical distribution of tuna schools.

2. Factors determining the organization and behavior of tuna schools.

3. Factors controlling the patterns of movement of tuna schools.

Raft Nenue; a study of the behavior and ecology of animals associated with floating objects at sea. Fishes collect around logs and other flotsam at sea. This habit is commonly exploited in recreational fishing, and some commercial fisheries have been based upon it. Various hypotheses, such as protection from predators, cover from the sun's rays, and use as a focal point for parasite "cleaning" stations have been advanced to explain why marine animals congregate under and near floating objects. In 1962, one of the Laboratory's biologists designed and built the raft Nenue, a floating object that would allow scientists to study the community of animals under floating objects. The observation raft is 3.6 by 3.6 m square, and contains a dry underwater caisson with windows allowing a 360° vision to the observer inside. A small hut on top provides storage space for scientific equipment and protection from the weather. The observation raft was first tested and found seaworthy in a series of short drifts off the island of Hawaii. Early in 1964, it was shipped aboard the R/V Charles H. Gilbert to equatorial waters. There it undertook two drifts, one 8 days, the other 9, for a total distance drifted of 1,650 km. From dawn to dusk, it was continuously manned by two observers, who spent almost 300 hours filming and recording the behavior of the animals that swarmed underneath. When the raft was first put in the water, no fish were seen. However, within 10 minutes the first fish appeared under the raft. Usually it was the small rudderfish Psenes cyanophrys. These were followed by the dolphin (Coryphaena hippurus), pelagic triggerfish (Canthidermis maculatus), schools of mackerel scad (Decapterus pinnulatus) and of young Mugilidae (Mulloidichthys samoensis) that were hotly pursued by the dolphin. Larger animals, such as individuals and schools of tuna, marlins, sharks, and porpoises also were observed. Often several thousand fish were swimming within sight of the Nenue. Another series of drifts was conducted during 1965 off the lee shores of the island of Hawaii for further studies on the behavior of the dolphin and pelagic triggerfish and to use the raft for the introduction of olfactory and acoustic stimuli in order to attract fish. Data from these studies are now being analyzed. While the raft was designed for research on pelagic animals, it has many applications for studies on the behaviour of inshore or estuarine species. It is described in a report by Reginald M. Gooding.1/

Vision. The first measurements of the visual acuity of three species of tunas have been obtained as part of the Laboratory's program of studies on the comparative sensory physiology of the tuna. Visual acuity is defined as the reciprocal of the minimum visual angle measured by minutes of arc.

1/ Gooding, R.M. 1965. A raft for direct subsurface observation at sea. U.S. Fish and Wildlife Service, Special Scientific Report-Fisheries 517, 5 p.

Such information is highly desirable, since tuna are thought to be primarily sight feeders, and in some instances have demonstrated remarkable ability to dodge almost invisible monofilament gill nets. In the visual acuity experiments, the fish are conditioned to respond to a pattern of black-and-white stripes presented on a square of illuminated glass. Reward (food) follows one pattern, and punishment (a very mild electric shock) follows the other. Results have shown that skipjack tuna (Katsuwonus pelamis) has better visual acuity than little tunny (Euthynnus affinis). Yellowfin tuna (Thunnus albacares) appear to have a better acuity than either species. This difference, however, may be the result of the comparative size of the individuals tested. This aspect of the work is now being investigated.

Hearing. Studies on the response of tuna to underwater sound are carried out to determine the role sounds play in the life of a tuna. Since sounds are propagated more efficiently in water than are light rays, it might be expected that tuna utilize their well-developed acoustico-lateralis system to take advantage of the information contained in this form of energy. Such information might be used to detect prey outside visual range or to maintain school formation at night or under conditions of low illumination. Experiments with yellowfin tuna (T. albacares) in captivity have shown they perceive sounds from about 50 cycles per second to slightly more than 1,000 cycles per second. Their response to sounds is most sensitive from 300 to 500 cycles per second. Many sounds in the sea that might be expected to have biological significance for tuna fall in these ranges. Examples are the sounds made by small fish swimming and by schools of squid. Yellowfin tuna also produce several sounds besides the splashes made by jumping and hydrodynamic noises made by swimming. Two such sounds have been named the "snap" and the "unh". The "snap" is made by rapid closings of the jaw, and the "unh" occurs when the yellowfin bends its body sharply to avoid an obstacle. It may be produced by muscle-skeletal action. These studies are being extended to other species of tuna and also into the ability of tuna to directionally locate an underwater sound source and to determine the signal to noise ratio required for their detection of underwater sounds. A report on this work by Robert T. B. Iversen entitled "Response of yellowfin tuna (Thunnus albacares) to underwater sound", will be published by Pergamon Press as part of the Proceedings of the Symposium on Marine Bio-Acoustics, American Museum of Natural History, New York City, April 13-15, 1966.

Hydrostatics. Minimum swimming speeds and the sizes of pectoral fins, gas bladder, and dark muscle (chiai) vary greatly among scombrid fishes. This diversity can be explained to a great extent by the interaction between two systems used by the fish to attain hydrostatic equilibrium: approaching neutral buoyancy by a gas bladder and producing hydrodynamic lift by swimming continuously with pectoral fins extended. Little tunny (E. affinis) and T. albacares exemplify the relationships that appear to prevail throughout the family. E. affinis of 35 cm fork length recently placed in captivity at the Honolulu Laboratory's tuna behaviour facility averaged 80 cm/sec swimming speed, but T. albacares the same length averaged only 50 cm/sec. Both species were denser than sea water and obtained lift from their extended pectoral fins as they swam unceasingly in the tanks. Two adaptations made hydrostatic equilibrium of T. albacares possible at the lower speeds; a gas bladder (absent in E. affinis) and pectoral fins with a larger surface than those of E. affinis (30 cm^2 versus 14 cm^2 for 35 cm fish). The gas bladder (less than 2 percent of body volume in 35 cm fish just after death) allowed T. albacares to approach neutral buoyancy. The remaining weight was carried by lift which was obtained primarily from the extended pectoral fins.

This lift is proportional to the area of the fins and the square of fish speed. Thus, the lower weight and larger fins allowed T. albacares to swim at a constant depth at a lower speed than E. affinis. Continuous swimming necessitates continuous muscular activity. The smaller size of the chiai in T. albacares compared with E. affinis (6 versus 8 percent of body mass) correlated well with the different speeds required for hydrostatic equilibrium.

Physiology. In 1964, visiting investigator E. E. Suckling devised handling techniques which permitted the first lengthy physiological studies of live, intact skipjack tuna, for periods up to 3 or 4 hours. He was studying the electrophysiological properties of the lateral line system of the skipjack. This will be reported in a paper entitled "Electrophysiological studies in various species of fish", to appear in the Proceedings of the Conference on Lateral Line Detectors, Yeshiva University, New York City, April 16-18, 1966, and published by the University of Indiana Press.

This work has been extended by Martin D. Rayner, electrophysiologist at the University of Hawaii, who is studying the physiology of tuna under a contract between the Laboratory and the University of Hawaii. Dr. Rayner has discovered that in Katsuwonus pelamis only the dark muscle (chiai) of the trunk musculature exhibited electrical activity at low tail beat frequencies. At high tail beat frequencies all of the trunk muscles displayed electrical activity. This conclusion has been further supported by the results of his anatomical investigations. In studying the function of a skeletal-muscle system it is of fundamental importance to understand the way in which muscle tension is applied to the skeletal parts. This point has not previously been clearly established for the swimming musculature of fish. The results of a study of the tendon systems within the swimming musculature of Katsuwonus pelamis provides not only an adequate mechanism for the functioning of the segmental musculature as a whole, but also demonstrates the functional separation of "deep red", "white" and "lateral superficial muscle areas".

Other. Other research carried out by the Honolulu Laboratory's Behavior-Physiology Program includes a study on the role of olfaction (smell), gustation (taste), and oxygen consumption in several species of tunas. Acoustic investigations have been made of fish associated with the bottom to a depth of 600 feet by using the 16 foot long two-man submarine Asherah in waters off the lee shore of Oahu Island, Hawaii. Recordings were made of sounds produced by fishes of the families Holocentridae and Balistidae. A comparative study of the behavioral traits of several species of baitfish used in the pole-and-line commercial fishery for tuna in Hawaii has also been initiated.

Development of new facilities. Improvements of facilities used for behavioral studies of captive tuna have included use of acoustic insulation in tanks utilized for studies on the response of tunas to underwater sounds, use of observation huts directly overhead to photograph the schooling behavior of scombrid fishes in lateral line studies, placing a sun and rain roof over all our large outdoor tanks, and the preliminary design and planning phase of tuna behavior tanks in the Kewalo Oceanographic Research Center, a proposed joint venture between the Bureau of Commercial Fisheries, University of Hawaii, and several other agencies.

Methods of returning live tunas from the sea to experimental tanks have been expanded and improved with the construction of five fiber glass transfer tanks to replace the original steel transfer tank. The five new tanks when

placed on the R/V Charles H. Gilbert can be used to return as many as 50 tuna 35 cm long or 5 tuna 80 cm long in a single trip. The fish are caught on barbless hooks using pole-and-line fishing. They are swung inboard and lowered on the line into a transfer tank where they shake the barless hook. At Kewalo the transfer tank is removed and lowered into shoreside tanks where the fish are allowed to swim free.

Among the species kept alive at the Kewalo tank facility are skipjack tuna (Katsuwonus pelamis), little tunny (Euthynnus affinis), yellowfin tuna (Thunnus albacares), bigeye tuna (Thunnus obesus), and frigate mackerel (Auxis rochi and A. thazard). A supply of up to 250 specimens has been maintained for as many as six resident and visiting investigators at one time.

Population Behavior and Dynamics (III-(14))

Skipjack Subpopulations

EPFTR has pointed out the necessity of compiling more extensive and accurate data on the population structure of tunas in order that existing theories of population dynamics can be effectively applied on exploited populations. Using genetic techniques, subpopulation studies at the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, have aimed to fill this need in various species of tuna.

An early study using the B blood group system had indicated the existence of several subpopulations of skipjack in the central Pacific (Sprague, Holloway and Nakashima, 1963).1/ Recent studies with an additional blood group system called the Y-system (Fujino, Sprague and Kazama (MS)2/ have shown that at least two different subpopulations contribute to the Hawaiian skipjack fishery. Accumulation of such population data is being continued in Hawaiian waters. Arrangements are also being made to collect tuna blood samples from other areas in the Pacific.

Skipjack Population Model

A model of the population biology of the skipjack tuna of the central and eastern Pacific has been developed by Brian J. Rothschild (1965).3/ The intent of this study was to consider all available information and to develop a model consistent with the data which then could be verified or modified by critical field studies. The abstract of the paper follows:

1/ Sprague, L.M., J.R. Holloway and L.I. Nakashima. 1963. Studies of the erythrocyte antigens of albacore, bigeye, skipjack, and yellowfin tunas and their use in subpopulation identification. Proceedings of the World Scientific Meeting on the Biology of Tunas and Related Species, 2-14 July 1962, FAO Fisheries Reports 6(3):1381-93

2/ Fujino, K., L.M. Sprague and T.K. Kazama. (MS) The Y-system of skipjack tuna blood groups. Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii

3/ Rothschild, B.J. 1965. Hypotheses on the origin of exploited skipjack tuna (Katsuwonus pelamis) in the eastern and central Pacific Ocean. U.S. Fish and Wildlife Service, Special Scientific Report-Fisheries 512, 20 p.

"A set of hypotheses has been formulated to account for the origin and movement of exploited groups of skipjack tuna (Katsuwonus pelamis) in the eastern and central Pacific Ocean. The hypotheses take into account the available evidence on larval distributions, gonad indices, size distributions, tag recoveries, catch predictions, and immunogenetic studies. The evidence suggests that most skipjack taken by the eastern Pacific skipjack fisheries originate in the central Pacific. It is likely that the equatorial region of the central Pacific contributes a major portion of the recruitment stock for the eastern Pacific. Large proportions of the Hawaiian catch also may originate in the Equatorial Zone. Skipjack catch predictions are discussed in the context of evidence which indicates that year-class-strength phenomena affect the Hawaiian landings. The need for more evidence on the origin and movements of harvested skipjack is emphasized."

Governor's Conference on Central Pacific Fishery Resources

A Conference on Central Pacific Fishery Resources, called by Governor John A. Burns, State of Hawaii, U.S.A., brought together 12 biologists to consider past and present studies on central Pacific fisheries in February and March 1966. The group concentrated on three species of tuna: skipjack (Katsuwonus pelamis), which is widely believed to be the most plentiful of the tunas, yellowfin (Thunnus albacares), and bigeye (T. obesus).

The participants agreed that data are too sparse to permit estimates of the total potential catch of skipjack tuna from the Pacific as a whole. Minimal estimate of yield from one segment of it, the eastern half of the central Pacific, was about 150,000 metric tons. This would be in addition to the 70,000 tons now caught in the eastern Pacific off the coasts of the Americas. The conferees estimated that the central Pacific could yield 30,000 to 50,000 metric tons more yellowfin tuna than the present 100,000 metric tons caught by the Japanese longline fleet (the surface fisheries of the eastern Pacific were excluded from consideration). Little increase was seen in the present bigeye tuna catch of 100,000 metric tons.

Four scientific problems of approximately equal importance must be attacked with even more vigor than at present if the subsurface tuna yield of the central Pacific Ocean is to be greatly increased, the group agreed.

These problems are: (1) investigations of the sensory capabilities and behavior of the tunas and the linked problem of their vertical distribution and schooling; (2) attempts to elucidate the relation of the tunas to their physical environment, with a view toward determining areas of abundance associated with differing oceanographic regimes; (3) further investigation of the subpopulation structure of each species by use of genetic techniques; (4) refinement of estimates of the magnitude and the potential yield of the resources.

Co-Chairmen of the conference were John C. Marr, Director, U.S. Department of the Interior's Bureau of Commercial Fisheries, Hawaii Area, and Michio Takata, Director, Division of Fish and Game, Hawaii Department of Land and Natural Resources.

Proceedings of the conference will be published by the State of Hawaii. A group of background papers reviewing various aspects of current knowledge of the tunas was prepared for the conference and will appear in the Proceedings.

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APPENDIX 8

PARTICIPANTS AND OFFICERS OF THE MEETING

PARTICIPANTS

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FAO

Mr. H. Rosa, Jr.
Fishery Liaison Officer (International Organizations)
Department of Fisheries

OFFICERS OF THE MEETING

Chairman	M.B. Schaefer (U.S.A.)
Vice-Chairman	H. Nakamura (Japan)
Rapporteurs	A. Suda (Japan) E. Postel (France) J. Hamre (Norway)1/
Technical Secretary	H. Rosa, Jr. (FAO)2/

FISHERIES AGENCY OF JAPAN

Mr. T. Hisamune
Director, Fisheries Agency

Mr. S. Oishi,
International Economy Section

Mr. A. Takashiba
Director, Fishery Research
Division

Mr. K. Tanaka,
Chief, First Research Section

Dr. T. Matsushita
Assistant Director
Research Division

Mr. T. Homma
First Research Section

Mr. A. Takashima
First Research Section

Mr. K. Mimura
First Research Section

Mr. R. Oyama
Second Ocean Section

Mr. S. Kume
Nankai Regional Fisheries
Research Laboratory, Kochi

Miss M. Watanabe (Typist)

Miss T. Ikeura (Typist)

1/ At present FAO.
2/ As from October 1966 D. Sahrhage, Chief, Marine Biology Section, Marine Biology and Environment Branch, Fishery Resources and Exploitation Division, FAO Department of Fisheries was appointed Technical Secretary.

EPFTR:2/INF/3 Annual Report of Effort and Catch Statistics by Area on Japanese Tuna Long Line Fishery, 1963
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APPENDIX 9

LIST OF DOCUMENTATION AT PANEL

Working Papers

EPFTR:2/WP/1	Provisional Agenda
2	Working Parties (Appendix 10)
3	Report of the First Session of the FAO Expert Panel for the Facilitation of Tuna Research (FAO Fish.Rep. 18)
4	Instructions for Collecting Blood and Serum Samples from Tuna Fishes (FAO Fish.Circ. 26 Rev.1)
5	A Guide to Marks Used for Tunas and an Inventory of Tuna Marking Projects (FAO Fish.Circ. 101)
6	Observations from International Oceanographic Expeditions Relevant to Tuna Ecology (FAO Fish. tech.Pap. 62)
7	Draft Interim Report of the Working Party for Tuna Length Measuring and Tabulation
8	Activities of FAO's Fishery Statistics and Economic Data Branch in the Field of World-Wide Tuna Statistics
9	Working Group Report on Methods of Collecting Larvae (Appendix 5)
10	Identification of Tuna Larvae
11	Catch and Effort Statistics in East Asian Countries (Appendix 2)
12	Report of the U.S. Bureau of Commercial Fisheries Biological Laboratory, Honolulu, to Second Session of the FAO Expert Panel for the Facilitation of Tuna Research (Appendix 7)
13	Report of Working Group on Taxonomy
14	Recent Actions on the Research of North Pacific Albacore and Bluefin Tuna in Japan (Appendix 3)
15	Tuna Tagging Experiments in Recent Years in Japan (Appendix 4)
16	Subpopulation Identification by Genetic Techniques (included in the text of the Report)
17	Echo-Survey of Tuna Fishing Ground
18	Draft Report of the Second Session of the FAO Expert Panel for the Facilitation of Tuna Research

Information Papers

EPFTR:2/INF/1	I. Nakamura and K. Mori 1966 Morphological Study on the Slender Tuna Allothunnus fallai Serventy Obtained from the Tasman Sea. Report Nankai Regional Fisheries Research Laboratory, 23
2	I. Nakamura and S. Kikawa 1966 Infra-Central Grooves of Tunas with Special Reference to the Identification of Young Tunas Found in the Stomachs of Large Predators. Report Nankai Regional Fisheries Research Laboratory, 23

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FI/R25		Informe de la segunda reunión de la comisión asesora regional de pesca para el Atlántico sudoccidental; Mar del Plata, Argentina, 27-30 abril 1964	1965
FIe/R26		Programa de desarrollo pesquero para el Uruguay. (Distribución limitada)	1965
FIb/R27	(En)	Report of the second session of the FAO working party for rational utilization of tuna resources in the Atlantic Ocean, Rome, 6-13 July 1965	1965
FIb/R27	(Fr)	Rapport de la deuxième session du groupe de travail FAO sur l'utilisation rationnelle des ressources thonières de l'océan Atlantique, Rome, 6-13 juillet 1965	1965
FIb/R27	(Es)	Informe del segundo período de sesiones del grupo de trabajo de la FAO sobre aprovechamiento regional de los recursos atuneros del océano Atlántico. Roma 6-13 julio 1965	1965
FIt/R28	(Tri)	Fishing vessel data. Données sur les navires de pêche. Datos de buques de pesca	1965
FIt/R29	(Tri)	Research vessel data. Données sur les navires de pêche. Datos de buques de pesca	1965
FIe/R30		Report of the seminar on fishery development planning and administration for selected English-speaking countries in Africa	1965
FRv/R31		Report of the FAO/Swedish training center on fishing boat design, Göteborg, Sweden, 2 August-31 October 1965	1966
FEe/R32		Rapport et compte-rendu du séminaire sur l'administration et la planification du développement des pêches, Abidjan, Côte d'Ivoire, 8-27 mars 1965	1966
FIp/R33		Report of the first session of the committee on fisheries, Rome, 13-18 June 1966	1966
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FEe/R35		Fisheries education problems in Ghana, Sierra Leone, Nigeria, Tanzania, Kenya and Uganda	1966
FIe/R36		Landing and marketing facilities at selected sea fishing ports	1966
FRm/R37	(En)	Report of the second session of the FAO expert panel for the facilitation of tuna research, Tokyo, 15-21 August 1966	1966

Unserialized reports dated earlier than January 1962 and earlier documents in this series are listed in the FAO Catalogue of Fisheries Publications and Documents (1965). Certain unserialized reports may be reprinted in this series as the unserialized versions go out of print.

APPENDIX 10

LIST OF WORKING PARTIES

1. TAXONOMY

Dr. R.H. Gibbs (U.S.A.) Convenor
Dr. B.B. Collette (U.S.A.)
Mr. J.E. Fitch (U.S.A.)
Dr. T. Iwai (Japan)
Dr. E. Postel (France)
Dr. B.J. Rothschild (U.S.A.)
Dr. E.G. Silas (India)
Dr. F.H. Talbot (Australia)
Dr. H. Vilela (Portugal)

2. TUNA LENGTH MEASUREMENTS AND TABULATION

Mr. J. Hamre (Norway)[1/] Convenor
Mr. E.B. Davidoff (U.S.A.)
Dr. A. Suda (Japan)
Mr. R. Wilson (U.S.A.)
Dr. E. Postel (France)
Mr. J.A. Gulland (U.K.)[1/]
Dr. G.L. Kesteven (Australia)
Mr. L.K. Boerema (FAO)

3. TUNA ECOLOGY

Mr. G.V. Howard (U.S.A.) Convenor
Dr. T.S. Austin (U.S.A.)
Mr. J. Hamre (Norway)[1/]
Dr. H. Nakamura (Japan)
Mr. A.G. Nicholls (Australia)
Dr. E. Postel (France)
Dr. K. Terada (Japan)
Dr. M. Uda (Japan)
Mr. H. Rosa (FAO)

4. METHODS OF COLLECTING LARVAE

Mr. W. Matsumoto (U.S.A.) Convenor
Mr. W.L. Klawe (U.S.A.)
Mr. W.J. Richards (U.S.A.)
Mr. S. Ueyanagi (Japan)

5. RESEARCH ON NORTH PACIFIC ALBACORE AND BLUEFIN TUNA

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1/ Presently working for FAO