

employ many more persons than at present and feed thousands more people.

To carry out the re-organization of West Indian fisheries first requires on-the-spot expert advice, fishery administration, legislation, better boats and gear.

With determined programs of fishery development, calculated to bring a better type of living to the active fisherman, the islands would advance in fishery production beyond their fondest dreams. The fish species of the Caribbean only have to be seen to be believed, and man's job should be to devise ways and means to produce such species as food. This cannot be done without the tools. To quote Sir Winston Churchill—"Give us the tools, we'll do the job."

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## The Survey of Living Aquatic Resources

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THE DETECTION, appraisal and measurement of living aquatic resources is a sequence of development and refinement of information in which all sections of the industry and Government have deep interest. Unfortunately it is a process which is sometimes allowed to stop before completion; it is also one which some people believe can be telescoped. For those to whom fishing is little, if anything, more than hunting, it may seem sufficient if a resource is discovered, for them the scientist's work ends with the discovery. However, it is generally recognized that some estimate of the magnitude of the resource is desirable, and that the scientist is best equipped to make this. Nevertheless, whatever the prevalence of such views in some sectors of the "fishery" community, the main trend of thought on fishing theory is that effective conduct of fishing operations, let alone practice of fish-culture, requires detailed analysis of the resource, identification of its components and of the relations between these components, *per se*, and between the resource and its environment, and measurement of the influences exercised through these relations. In consequence, a theory of resources is evolving for the description of resources, *in situ*, for measurement of their response to simple exploitation and for identification of the opportunities they offer for positive intervention.

FAO has been informing regional fisheries councils and commissions of its work and plans in connection with resources survey, the term "survey" being employed to signify the whole range of theory and practice indicated above. The purpose of the present note is to give a detailed account of these plans which, naturally, have been developed in the last two years, and to report the progress that has been achieved in this work.

The FAO survey is, in a manner of speaking, a survey of surveys. It is an examination of information already accumulated concerning resources, of what is being done at present to increase and improve upon that information, and of the uses being made of the information. FAO does not carry out field or laboratory survey work, except in its Technical Assistance Programme, and even here its role is chiefly advisory and pedagogic. Some people have thought that FAO would commission sea-going vessels, carry out survey work and measure resources of particular areas. This thought derives from a misconception of the functions enunciated in Article I of the Constitution of the Organization.

FAO's first function is to collect, analyze, interpret and disseminate information. Its second function is a many-headed one relating to resources, primary production, marketing and distribution of food and agricultural products, agricultural credits, and agricultural commodity arrangements the Organization must promote and, where appropriate, recommend national and international action with respect to these matters. The Organization's third function is to furnish such technical assistance as may be requested, to organize missions, to assist member governments to fulfill obligations arising from their acceptance of the recommendations of FAO, and generally to take action necessary and appropriate to implement the purposes of the Organization. Under these terms the Organization is to assist member governments in the formulation and conduct of national programmes, and to supplement those programmes by appropriate international action. The position was well stated by the Chairman of the first FAO Conference, Mr. Lester Pearson, as follows: "FAO will bring the findings of science to the workers in food and agriculture, forestry and fisheries everywhere; and it will bring the practical problems of these workers everywhere to the attention of the scientists. It will assemble, digest and interpret information to serve as a basis for the formulation of policy, national and international. It can suggest action, but only through the activities of governments themselves can the objectives be finally won." It is in this sense that the FAO work on aquatic resources has been conceived.

#### ***Purposes of the Survey Programme***

The primary purpose of the survey programme is to provide a continuous operation for the compilation and appraisal of what is known about the living aquatic resources of the world. This operation must bring information together in systematic and useful ways in order to serve a number of subsidiary purposes.

Firstly, to yield that increment of knowledge which derives from a synoptic view of data, especially if that view should be in new dimensions.

Secondly, to reduce great masses of data to tractable, more easily understandable form, so that governments should be enabled to obtain a clearer and more useful understanding of their country's resources; since their policy towards these resources, and their programme with respect to the industry exploiting these resources, are based upon this understanding, the importance of this purpose is self-evident.

Thirdly, to provide accurate identification of the significant gaps in this knowledge so that further research may be planned with greater efficiency. By the term "gap in knowledge" we refer to simple deficiencies in the description of resources required by present techniques of exploitation; we also refer, although the term is scarcely suitable for the purpose, to the indications which might be given of lines of research which might lead to the invention of new ways of intervening in the resource. The latter possibility relates more particularly to the field of fish-farming, and to such particular matters as the breeding of new varieties.

The secondary purpose of the survey programme is to furnish a sound basis for the promotion of national field survey work. It is clear that recommendations, made by regional fishery councils and commissions, for work of this kind, will be most effectively formulated if based upon correct appreciation of existing information.

The third purpose of the survey programme is to secure the best use of resources information in planning and conducting the exploitation of these resources.

The fourth purpose is to secure the constant development and improvement of the methods of investigation of resources. The constant review of available resources information, against the requirements stated by those responsible for exploitation, must from time to time indicate points where available research techniques are inadequate and unable to secure the data required.

### **Methods**

This programme calls for operations falling roughly into two phases. On the one hand there are the bibliographic and other operations carried out by the Biology Branch in its offices at Rome; on the other hand, there are the consultations which the Branch enters into with fishery workers, either at the meetings of regional councils and commissions, or at special meetings convened by FAO, alone or (as in the case of the meeting proposed for Lisbon)<sup>1</sup> in collaboration with other bodies.

The central element of the Branch operation is the creation and maintenance of a series of thesauri. A thesaurus is a house of treasure and, in the present use, signifies a store of information. The thesauri, as a set, are encyclopaedic in scope, providing accommodation for all kinds of information relating to resources. The operation of the thesauri calls for rigorous selection and reduction of data. It employs all kinds of cartographic and diagrammatic systems of synoptic presentation of data; it calls for constant appraisal and re-appraisal of synopses and conclusions, in the light of latest researches; and it provides a machinery to make these possible.

There are five thesauri.

The first, the Country and Regional Thesaurus, is an accumulation of information about the resources of each country and region, viewed from the point of view of current exploitation; it leads, on the evidence of what is yielded at present, to an estimate of the nature and magnitude of these resources. The thesaurus is sub-divided according to a decimal geographic classification, and within each sub-division information is stored on the species fished, methods of fishing, catches taken, and interpretation of technological and economic information relating to the nature and intensity of fishing. It will perhaps be recognized that this array of information corresponds to that which has usually been presented in the past as representing the account of the fishery resources of a country.

The second, the Species and Stocks Thesaurus,<sup>2</sup> is a system of accumulation of information concerning species already brought under exploitation, and therefore of economic significance. It may be expected to accommodate species of potential economic importance at some later date. The arrangement of this thesaurus is basically according to a decimal codification of taxonomic groups; within each compartment information is arranged for each species according to a schedule described in a recent paper (Roscoff)<sup>3</sup>. The point of view dominating work in this thesaurus is that the organism of economic importance is a machine for the conversion of materials into form useful for man and therefore information must be sought on the operation of the machine and on the availability of materials to it.

<sup>1</sup>Workshop on Population Dynamics and the Selectivity of Fishing Gear (Joint ICNAF/ICES/FAO Meeting) Lisbon, Portugal, 1957.

<sup>2</sup>See Appendix 2.

<sup>3</sup>A Note on Abundance and Distribution of Marine Organisms of Economic Importance. International Conference on the Comparative Biology of Marine Species studied in Different Districts of their Area of Distribution, IUBS/UNESCO, Roscoff, France, 1956.

The third, the Oceanic Thesaurus, treats of oceanic areas and regions ecologically as units, and properly speaking is dominated by the concept of the resource as ecosystem. Its task is to identify natural ecological units and to accumulate relevant meteorological, and oceanographic information from the resources point of view.

The fourth, the Inland Thesaurus, is a companion piece to the Oceanic Thesaurus, and deals with inland systems, chiefly as river basins, from the ecological point of view.

Both the third and fourth thesauri are concerned with questions of production and productivity, but not only with basic, phytoplanktonic production, but also with secondary and tertiary production, and with the dynamics of these processes.

The fifth, the Methods and Subjects Thesaurus,<sup>2</sup> is concerned with the methods of resources investigation and with the principal subjects occupying the attention of workers in this field, for example, basic production and population dynamics.

Material for these thesauri is drawn from many sources, but probably the greatest is the wide range of literature which is searched by the Branch; much information is drawn, however, from correspondence, manuscript reports, and similar sources. The thesauri are supported by the index of sources, a collection of notched cards carrying standard bibliographic citations and such annotations or abstracts as may be found necessary.

Each piece of relevant information is transferred in the form of a brief text, a tabulation, diagram or map, into the appropriate thesaurus; it is to be emphasized that this operation is subject to strict rules of relevance, recency and authority. It must also be emphasized that this system is still in process of evolution: the Branch is still engaged on what is virtually research in the development of these thesauri. As material accumulates, a review is to be made from time to time of the status of each compartment of each thesaurus and according to agreed plan of priority, or to demands made upon the system, the accumulation in each compartment will be further reduced into standard synoptic form.

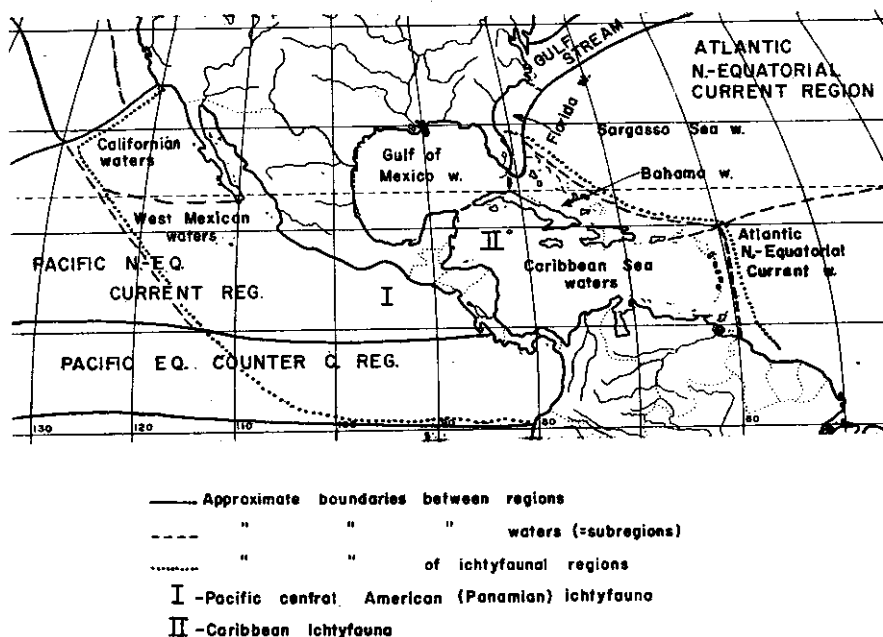
It will be recognized that there are close connections between the several thesauri and that generally three or more will be drawn upon for statements sought for special purposes. Thus, if a statement is requested with respect to the resources of a particular country, a beginning will be made with the material from the Country and Regional Thesaurus; this will indicate the species taken by the fishery of that country and a further reference will then be made to the Species and Stocks Thesaurus for information on each of these species, for information, for example, on maximum and average sizes to which the species grows in this and other waters. Again, reference will be made to the Oceanic and Inland Thesaurus for information on the ecology of the waters. On the other hand, if the starting point of the inquiry should be a species, the operation would commence with the Species and Stocks Thesaurus and then refer to the Country and Regional Thesaurus for information on current exploitation, wherever that might take place, and to the Oceanic or Inland Thesaurus for information on the habitat of the species.

The preceding description will have made clear that the work of the Biology Branch is essentially a derivative operation; it is one which is concerned with the treatment of data produced by programmes to which the Branch can make

little, if any, direct contribution, programmes which may have little relation with the general plan of the resources survey. This matters little so far as the first purpose of the survey is concerned, since, with respect to that purpose the survey must take all information, however haphazardly gathered, and test its relevance and value. Yet, it is these facts that make the second phase, of consultations with regional councils, of considerable importance. In this phase, the Branch prepares for each council or commission a synopsis of resources information relating to its area. Generally speaking, these synopses endeavor to make an appraisal of what is known of the resources of the area, and to offer a diagnosis of those resources, by a composition of three approaches. One: by examination of the evidence, chiefly from current exploitation, of the nature, composition and approximate magnitude of the resources of stocks of current economic importance. Two: by deeper analysis of the dynamics of these stocks for the purpose of determining the approximation of current exploitation to limits of yield from these stocks. Three: by way of examination of evidence on the basic productivity of the area and on the efficiency of the food chains through which this material passes to the economic species.

Preliminary papers have been prepared on the ICES, ICNAF and GFCM<sup>4</sup> areas and work is now proceeding for their revision and development. For the

Fig. 1 Natural regions in Central American  
(Caribbean American) waters



<sup>4</sup>ICES—International Council for the Exploration of the Sea.  
ICNAF—International Commission for the Northwest Atlantic Fisheries.  
GFCM—General Fisheries Council for the Mediterranean.

Gulf and Caribbean area only preliminary compilations have been made; these are represented here as a means of illustrating the lines along which the work is developing and the matters on which the Branch wishes to secure the advice and assistance of workers in this region.

The first of these figures presents a division of the Central American area, very broadly defined, into natural regions and sub-regions. The divisions, made on hydrological, ecological and ichthyofaunistic grounds, probably conform to accepted ideas; revision of these divisions in the light of more recent data and of newer interpretations, is essential to the development of this work, for it seems to us that the correct identification of ecological entities must be as important in this broad field of resource appraisal as it is in ecological work on smaller scale, and that it has a correspondence with the current identification of unit stocks (racial investigations) in fishery biology.

The second figure summarizes the information thus far reviewed on the nature of the coasts and continental shelves within the area. From the fisheries point of view a figure such as this has obvious relevance to such matters as (1) the extent of ground on which demersal stocks might be found; (2) the nature of these grounds insofar as this is a determinant of the fishing gear that may be used; (3) the nature of the coast insofar as this influences the in-shore fishing and affects the design of fishing craft; (4) the existence of brackish water areas that may be nursery grounds for shrimp and other fauna and which may offer opportunities for fish-culture.

Fig. 2: THE NATURE OF THE COAST AND CONTINENTAL SHELF OF THE CARIBBEAN AMERICAN WATERS

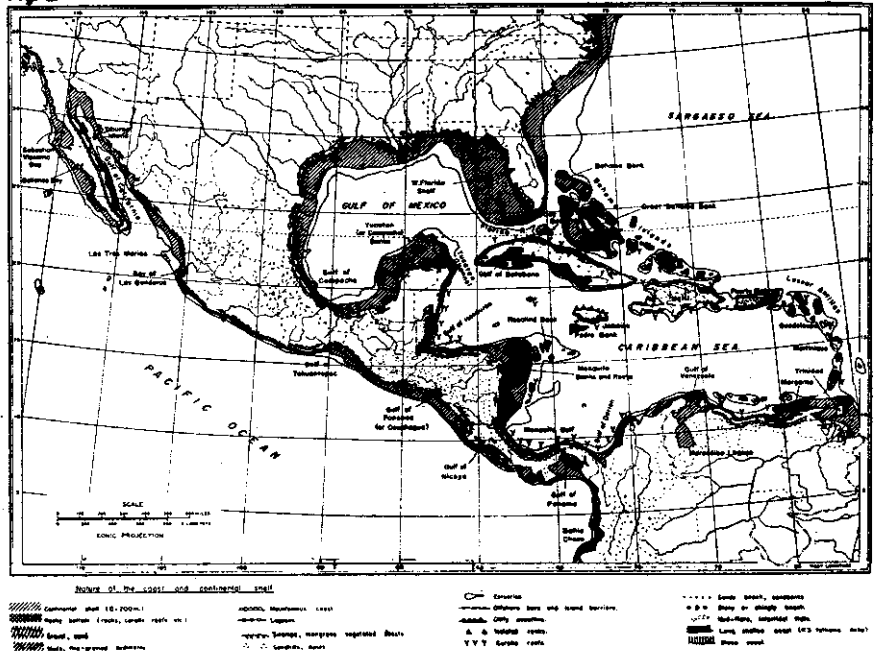
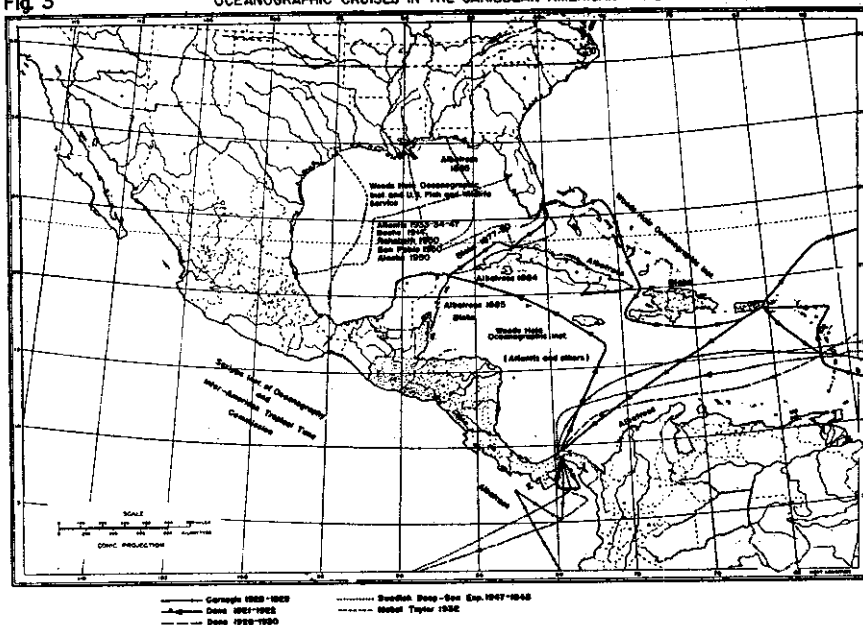


Fig. 3

## OCEANOGRAPHIC CRUISES IN THE CARIBBEAN AMERICAN WATERS

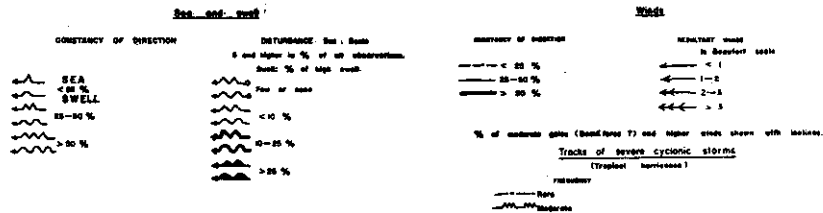
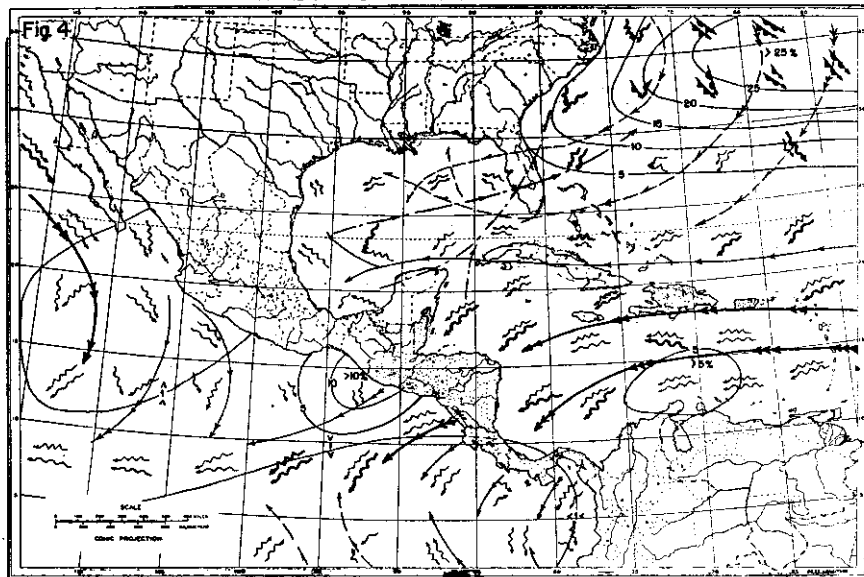


The next figure, which shows the tracks of some of the oceanographic and experimental fishing cruises that have crossed the area, represents that part of this work that is concerned with maintaining intelligence on the nature and scope of investigational work in each area.<sup>5</sup>

The main features of the meteorological regime of the area are summarized in the next two figures, and the surface currents and temperatures are summarized in the two figures which follow. Figure 8 shows the computed thickness of the wind-produced homogeneous layer and by implication refers to depth at which the thermocline is located. The figures of the final set exemplify the distribution in depth of important other features of these waters. Figures 4 to 14, quite apart from the inaccuracies they may contain, are, of course, a most inadequate summary of the characteristics of the area; they will, however, serve to illustrate two points relevant to the theme of this paper. Firstly it is intended in presenting these diagrams to emphasize the view that the full understanding of living aquatic resources can be achieved only by a thoroughly ecological approach. The second point, which is perhaps only an aspect of the first, is that as yet it is generally impossible to approach diagrams such as Figures 4 to 14 with the same confidence as we can Figure 2: in looking at Figure 2 we can make a number of useful, albeit simple, interpretations of the features it presents with respect to fisheries. We now need to be able to identify features, similar in significance, in hydrological and other diagrams.

<sup>5</sup>See Appendix 1.

SEA AND SWELL, WINDS, FREQUENCY OF MODERATE GALES AND HIGHER WINDS AND THE TRACKS OF TROPICAL HURRICANES IN THE CARIBBEAN AMERICAN WATERS IN FEBRUARY



SEA AND SWELL, WINDS, FREQUENCY OF MODERATE GALES AND HIGHER WINDS AND THE TRACKS OF TROPICAL HURRICANES IN THE CARIBBEAN AMERICAN WATERS IN AUGUST

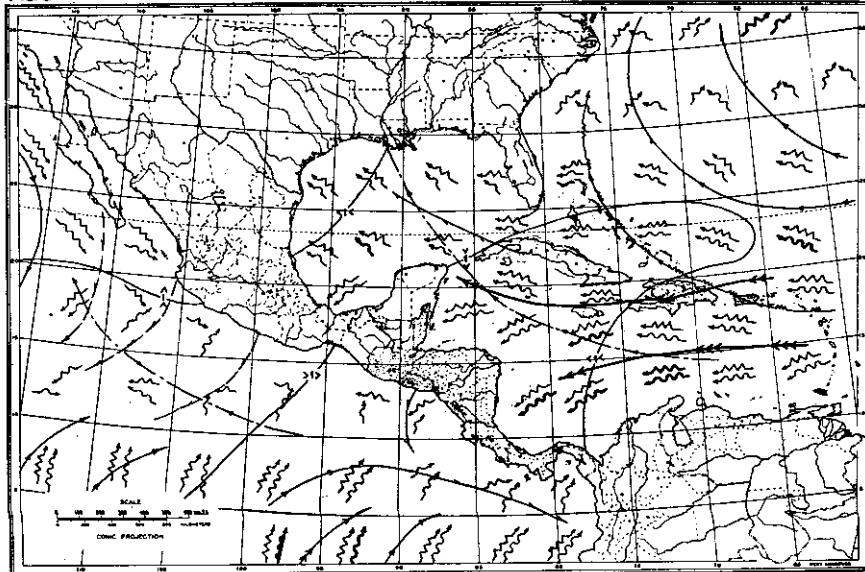




Fig. 6 SURFACE CURRENTS AND TEMPERATURES IN THE CARIBBEAN AMERICAN WATERS IN FEBRUARY



Surface currents

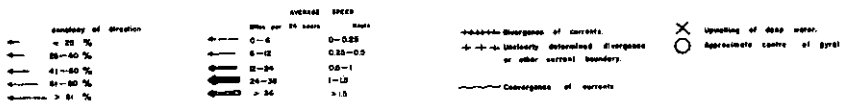
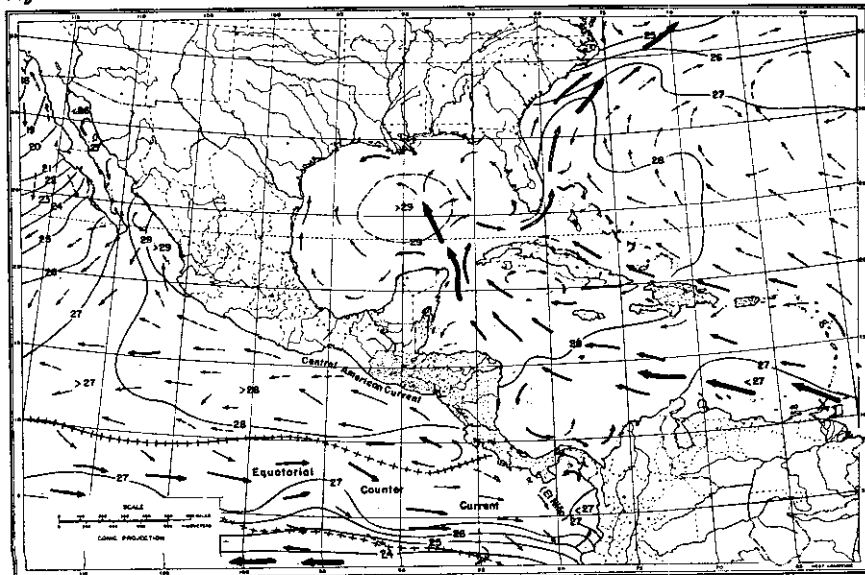
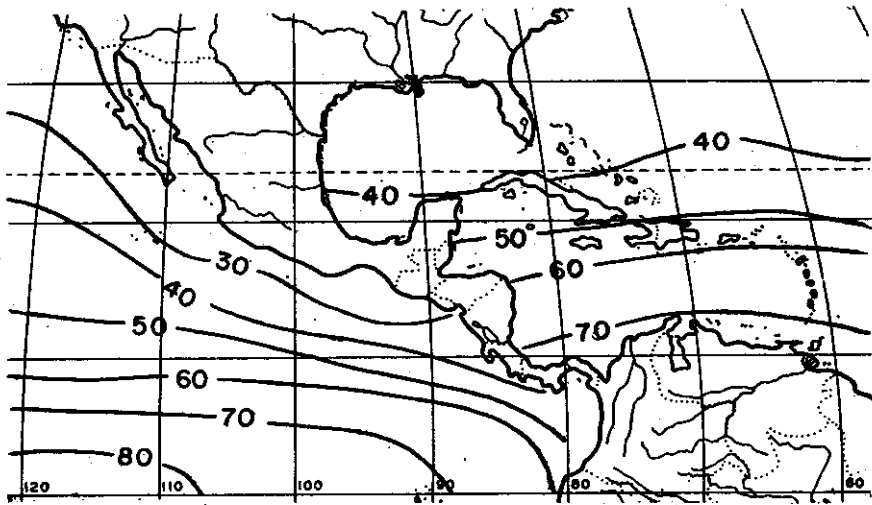


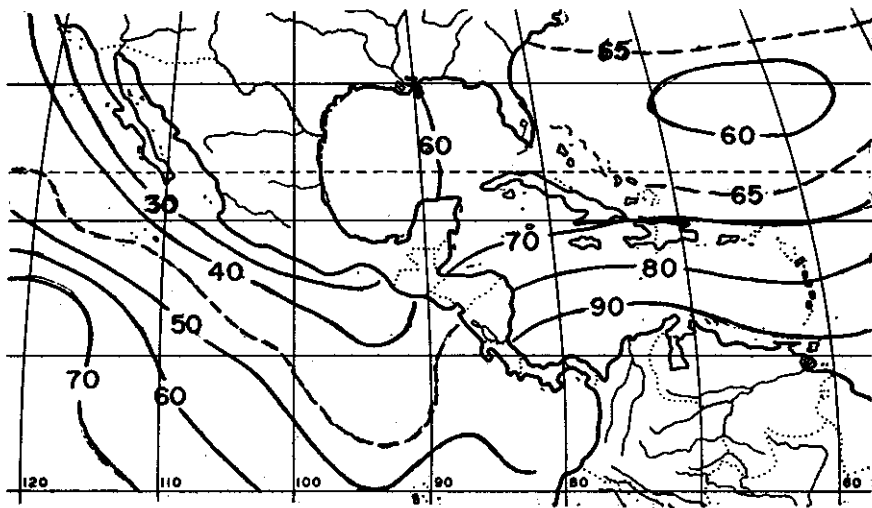
Fig. 7 SURFACE CURRENTS AND TEMPERATURES IN THE CARIBBEAN AMERICAN WATERS IN AUGUST



**Fig. 8** Thickness (m) of the wind-produced homogeneous layer  
(after Lumby)



In January - March



In July - September

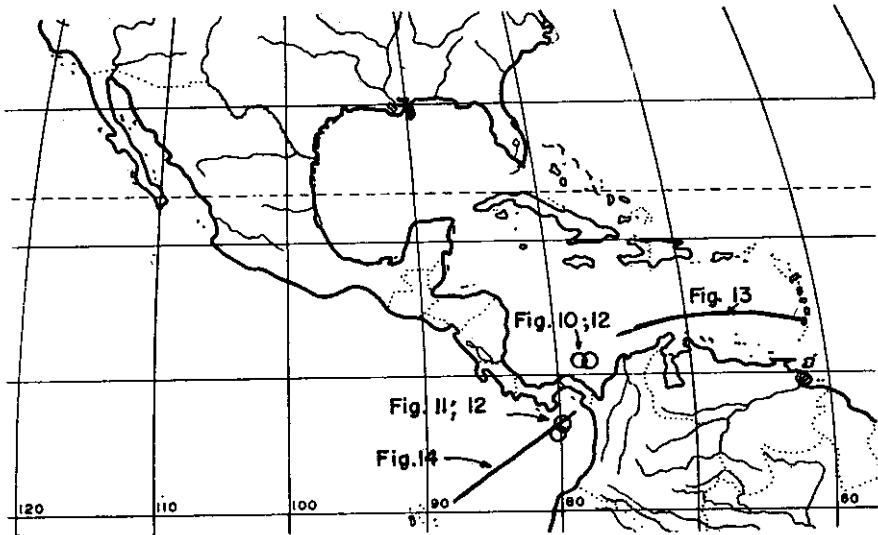


Fig. 9

Location of stations and sections presented on figures 10-14

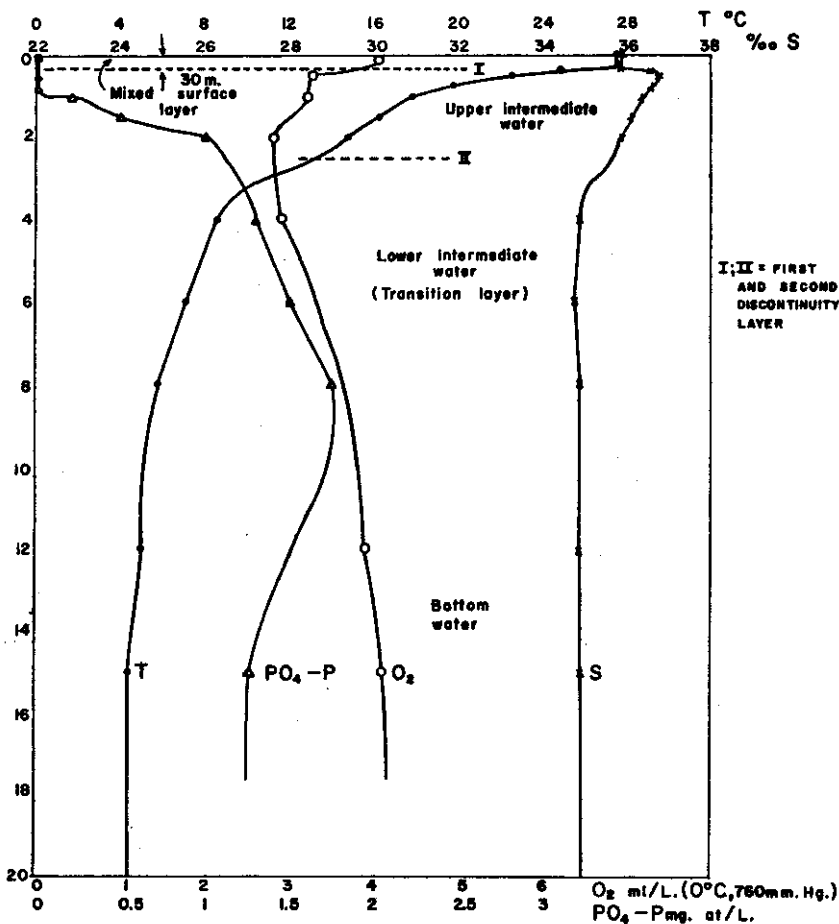


Fig. 10 Depth distribution of temperature, salinity, dissolved oxygen and phosphates in Caribbean Sea, off Gulf of Darien. Data from:  
 1) Dana St. No 3547 24.XI 1928 Lat. 11° 00' N. Long. 77° 40' W.  
 2) Carnegie St 34 9.X 1928 Lat. 11° 18' N. Long. 78° 34' W.

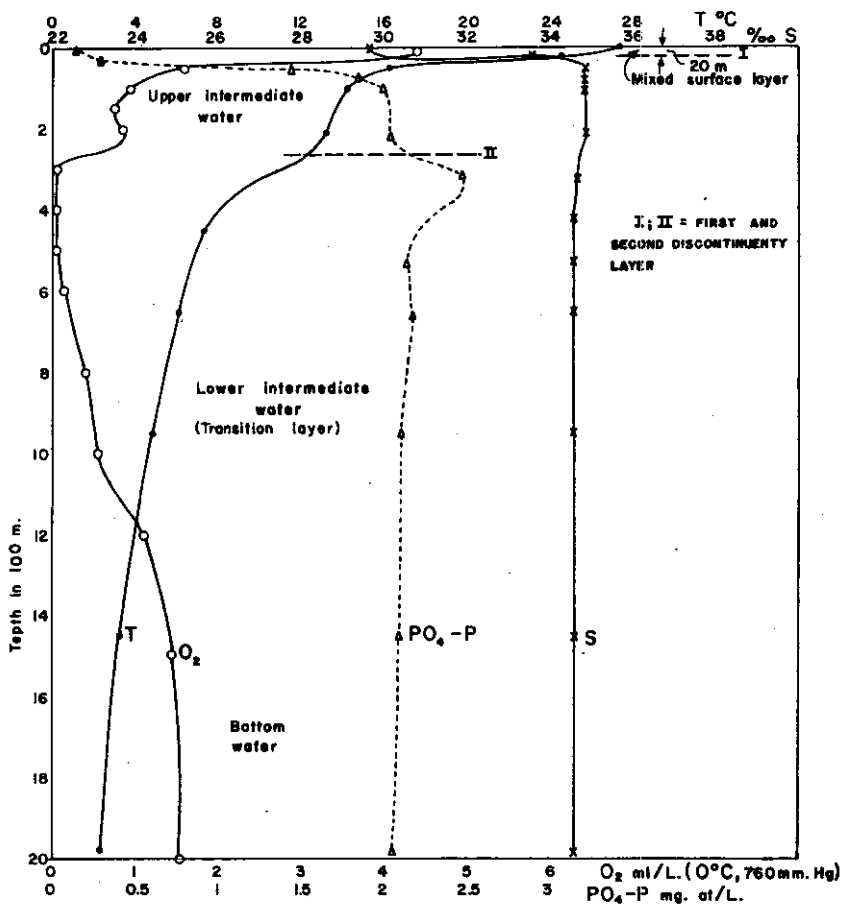


Fig. 11 Depth distribution of temperature, salinity dissolved oxygen and phosphates off the Gulf of Panama. Data from:

- 1) Carnegie St. No. 35; 26X 1928 Lat. 6° 32' N. Long. 80° 04' W.
- 2) Dana St. No. 3548; 3.II 1928 Lat. 7° 06' N. Long. 79° 55' W.

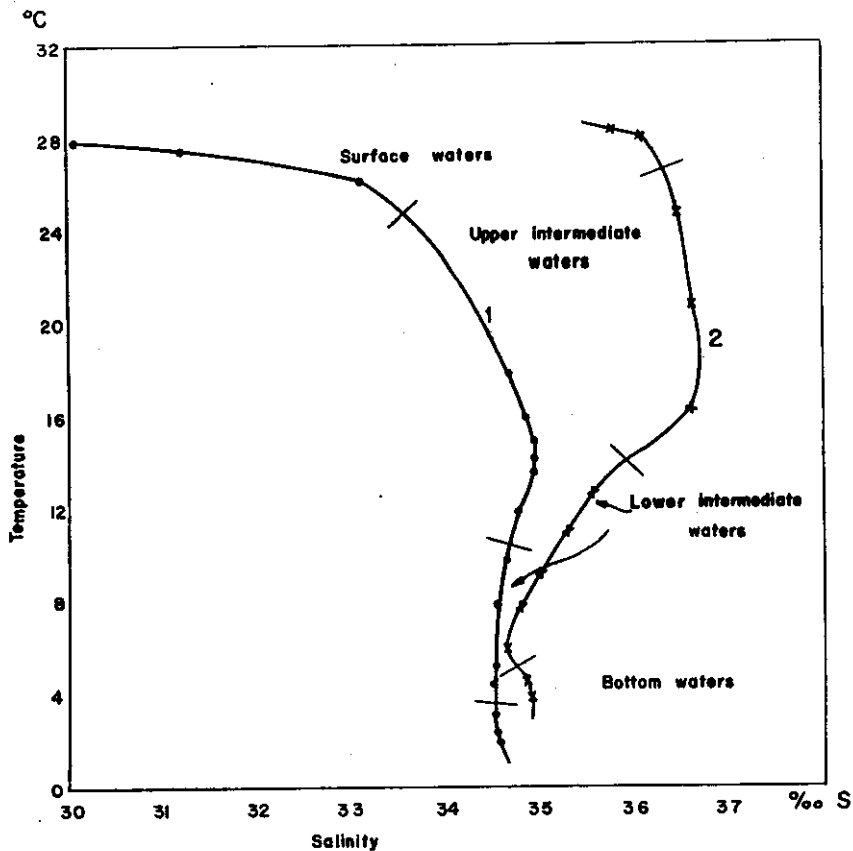


Fig. 12 T.S. diagrams.

1. — Pacific Ocean off Gulf of Panama. Dana St. No. 3548 3. III 1928  
Lat. 7° 06' N. Long. 79° 55' W.
2. — Caribbean Sea off Gulf of Darien. Carnegie St No 34 9. I 1928  
Lat. 11° 18' N. Long. 78° 34' W.

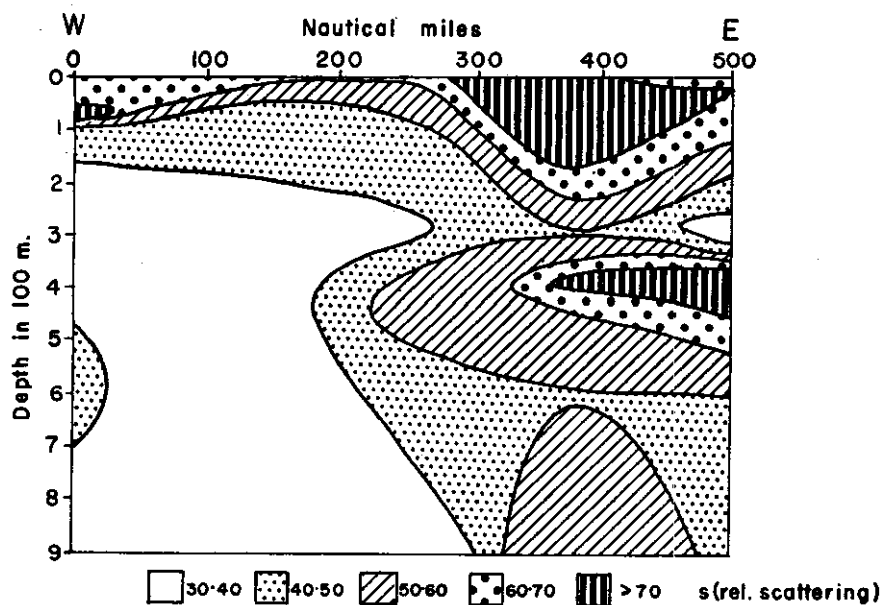


Fig. 13 Particles in a vertical section in Caribbean Sea.  
(For location of the section see Fig. 9) After N.G. Jerlov.

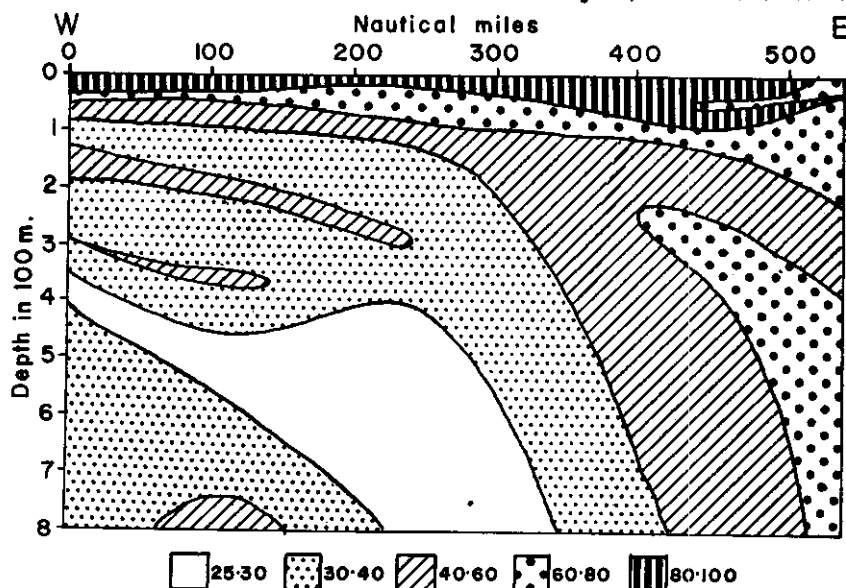


Fig. 14 Particles in a vertical section in the Gulf of Panama  
(For location of the section see Fig. 9)

After N. G. Jerlov.

## APPENDIX 1

### QUESTIONNAIRE ON OCEANOGRAPHICAL AND MARINE BIOLOGICAL EXPEDITIONS IN THE MEDITERRANEAN SEA

- Country
- Name of ship
- Name and address of Institution
- Area of investigation and number of stations occupied (please include map if possible)
- Date and duration of cruise
- Oceanographical observations (Mark with X)
  - Temp., salinity                      Oxygen
  - Phosphates, Nitrates
- Other oceanographical investigations (specify)
- Plankton investigations (specify)
- Experimental fishing
- Bottom investigations (specify)
- List of publications issued or address where unworked materials or unpublished results are available

## APPENDIX 2

### SYNOPSIS OF DATA TO BE ASSEMBLED IN THE SPECIES AND STOCKS THESAURUS AND METHODS AND SUBJECTS THESAURUS

1. Identity
  - 1.1 Taxonomy
    - Definition
    - Description
  - 1.2 Nomenclature
    - Valid scientific name
    - Synonyms
    - Vernacular names, standard common names
  - 1.3 General variability
    - Subspecific fragmentation (races, varieties, hybrids)
    - Genetic data (chromosome number, protein specificity)
2. Distribution
  - 2.1 Delimitation of the total area of distribution and ecological characterization of this area
  - 2.2 Differential distribution
    - Areas occupied by eggs, larvae and other junior stages: annual variations in these patterns, and seasonal variations for stages persisting over two or more seasons.
    - Areas occupied by adult stages: seasonal and annual variations of these.
  - 2.3 Behavioristic and ecological determinants of the general limits of distribution and of the variations of these limits and of differential distribution.
3. Bionomics and life history
  - 3.1 Reproduction
    - Sexuality (hermaphroditism, heterosexuality, intersexuality)



Maturity (age and size)  
Mating (monogamous, polygamous, promiscuous)  
Fertilization (internal, external)  
Fecundity  
    Relation of gonad size and egg number to body size  
    and to age  
    Coefficient of fecundity

Spawning  
    Spawning seasons (beginning, end, peak)  
    Number of spawnings per year, frequency  
    Spawning time of day  
    Induction of spawning

Spawning grounds  
    Coastal (surface, vegetation, shore, shoal, sand,  
    shelter); bottom  
    Oceanic (surface, bottom)

Egg—structure, size, hatching type, parasites and predators

### 3.2 Larval history

    Account of embryonic and juvenile life (prolarva, larva,  
    postlarva, juvenile)  
    Feeding  
    Rates of: development and survival  
    Periods of: development and survival  
    Parental care  
    Parasites and predators

### 3.3 Adult history

    Longevity  
    Hardiness  
    Competitors  
    Predators  
    Parasites and diseases

### 3.4 Nutrition and growth

    Feeding (time, place, manner, season)  
    Food (type, volume)  
    Relative and absolute growth patterns and rates  
    Relation of growth to feeding, to other activities,  
    and to environmental factors

### 3.5 Behavior

    Migration and local movements  
    Schooling  
    Reproductive habits

## 4. Population (Stock)

### 4.1 Structure

    Sex ratio  
    Age composition  
    Size composition

### 4.2 Size and density

    Average size  
    Changes in size

- Average density
- Changes in density
- 4.3 Natality and Recruitment
  - Natality
  - Natality rates
- 4.4 Mortality, morbidity
  - Rates of mortality
  - Factors or conditions affecting mortality
  - Factors or conditions affecting morbidity
  - Relation of morbidity to mortality rates
- 4.5 Dynamics of population
- 4.6 Relation of population to community and ecosystem, biological production, etc.
- 5. Exploitation
  - 5.1 Fishing equipment
    - Fishing gear
    - Fishing boats
  - 5.2 Fishing areas
    - General geographic distribution
    - Geographical ranges (latitudes, distances from coast, etc.)
    - Depth ranges
  - 5.3 Fishing seasons
    - General pattern of fishing season
    - Duration of fishing season
    - Dates of beginning, peak and end of season
    - Variation in time or duration of fishing season
    - Factors affecting fishing season
  - 5.4 Fishing operations and results
    - Effort and intensity
    - Selectivity
    - Catches
  - 5.5 Fisheries regulations
  - 5.6 Fish farming, transplanting and other intervention.

Basic maps prepared by Henry M. Leppard  
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