Research on the Anchovy ~ models and reality

INSTITUTO DEL MAR, PERU

The adult anchovy is a fish of beautiful colours whose flanks and belly are silvery and whose back is a brilliant green, the fins are of clear colours excepting the tail fin which is almost black. It is a species of short life, each anchovy lives 3 to 4 years or only a little more.

It reproduces throughout the year but the principal spawning seasons are at the end of winter and at the end of summer.

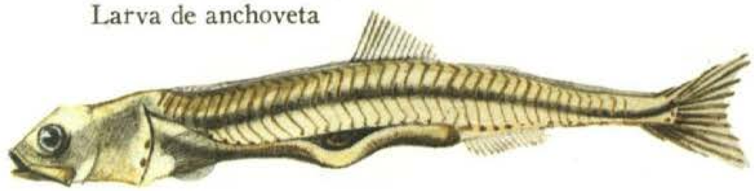
An adult female produces thousands of eggs during its life, spawning in the upper 50 metres of the sea.

After 50 hours from fertilization the eggs transform into larvae and 7 days later into post-larvae; 4 or 6 months later, when the juveniles have grown to about 7cm., the body becomes covered with scales. Then when they measure 8 to 14 cm. the young fish join the population of adult anchovy which can be caught-that is, at that time they belong to the group of recruits entering the fishable stock.

Adultos - tamaño real (actual size)

Huevos de anchoveta

Larva de anchoveta



ANCHOVETA

Engraulis ringens Jenyns

Introduction

Man obtains exact information about himself and that which surrounds him through scientific research - observations, measurements and precise and controlled experiments - whose results describe how the systems and phenomena (living or not) of the universe are formed and develop. This information allows him to foresee and to predict systems in nature which are beyond his control - for example hurricanes - and to know what will take place in certain systems he controls and modifies, as in agriculture and cattle raising.

The application of scientific methods of research to living marine resources (fish, algae, oysters, etc.) brings a knowledge of the manner in which these resources change their distribution and composition in response to changes in the environment. Given that these changes cause effects in the fish catch it is necessary to have regular information about them and to be able to predict them.

All this has considerable importance for the Peruvian anchovy fishery, which exploits the greatest fisheries resource of the world because this species is subject to notable environmental changes which cause changes in the catch whose effect is felt not only in Peru but in the entire world.

This booklet describes briefly the anchovy resource and its fishery as well as the scientific research being carried out on both, based on the model which appears in the central pages of this booklet.

Complete development of research requires considerable national effort and international collaboration. The greater part of it is carried out by the Peruvian Marine Institute (IMARPE) with help from the United Nations Development Programme (UNDP) United Nations Food and Agriculture Organization.

Contents

The fishery for the anchovy

A fishery is formed by a group of fishing-units which exploit a single resource of the waters of some defined area, operating the same kind of boat and fishing gear.

The description of a fishery gives information on: the resources being exploited; the fishing-unit - boat, gear and crew; it also describes the fleet physically and economically, how the fleet changes, where and when it fishes, and how much it catches.

The description also carries information concerning infra-structure – jetties, roads, etc. – which serve as base to the fishery, the landings, and the processing and handling of the product until it reaches the consumer.

The Peruvian fishery described here is that of the anchoveta, *Engraulis ringens* J. This species inhabits waters off Peru and Chile from the coast out to 50 miles during summer and out to a hundred miles in winter and sometimes even further. Since it is pelagic – inhabits the 'surface' of the sea – it moves between the surface and a depth to 50 m, but sometimes it goes deeper.

In favourable years the population of juvenile and adult anchovy weighs 15 to 20 millions tons but when the stock is fished excessively and the environmental conditions are adverse the biomass diminishes to about 4 million tons. Both of these aspects occured in 1972, when in addition to the high exploitation of the preceding years an "El Niño" phenomenon occurred which brought an invasion of warm water, causing displacement of the anchovy and probably interfering with reproduction and survival.

This fishery operates with boats (bolicheras) with non-refrigerated holds which can store 220 tons of fish; they measure 90 to 100 feet in length and are driven by diesel motors of 500 HP. The schools are detected by echosounder, sonar or visually and are captured by a purse-seine net 300 fathoms long and 35 fathoms deep.

The boats of the fleet - numbering some 700 - leave port at 4 a.m. and return between midday and midnight, having made 2 or 3 shots in which they take some hundreds of tons of fish. Almost all the catch is converted into meal and oil. From each 100 kg of fish 22 kg of meal and 6 of oil are obtained. The fishery, now nationalized, is managed by Pesca-Peru which is the owner of the fleet and of the processing plants.

The fishing regime – duration of the fishing season, the number of fishing days per week, the number of boats to operate, the mean and total catch of the season – is fixed by the Minister of Fisheries taking into account the results of research by the Marine Institute.

The resource

The quantity of anchovy which can be taken in a particular time depends only on the biomass of the fishable stock and the fishing capacity of the fleet. If the capacity of their fleet is such that it could take, and indeed it does take, all the fishable stock, then of course the stock will be exterminated.

However what truly should be caught (permissible catch) depends on many circumstances and factors (variables). To calculate the permissible catch, consideration must be given to the characteristics of the fishable stock its – biomass, reproductive, growth and survival capacities – and the present and future characteristics of the environment.

The objective of a calculation of this catch is to ensure in some degree that there will be sufficient spawning, growth, and survival that in the following years it will be possible to continue taking something like the same level of catch and at least to prevent that the catch should become so great that it would endanger the possibility of maintaining the fishery.

In order to decide how much should be taken in a particular fishing season it is necessary to construct a model which will show how to relate variables in the present time with those of the past and with new changes which will occur in the anchovy population as a consequence of the removal of fish by the boats.

Three sets of processes determine the biomass of the population: reproduction, growth and mortality.

Many of the spawned eggs remain unfertilized or serve as food for other organisms and only some individuals survive through larval, post-larval and juvenile stages to become adults. As they grow, the survivors increase in weight. The summation of the weight of all the anchovy together gives the population biomass.

However, since population fecundity changes with the age and composition of the stock and survival is subject to many variations, the number of individuals which reach maturity varies from one generation to another and therefore the biomass of the adult population is constantly changing. Moreover the fishable stock of almost all fishery resources is composed of more than two generations (grandparents, parents, children, grandchildren, etc.); in whales there can be up to 50 generations, of the anchovy there are five to seven.

Because of this the anchovy population in composed of individuals in different stages of growth and of different sizes.

The weight of all spawned eggs is relatively small and that of post-larvae is even smaller, but as the survivors go on growing their increase in weight comes to exceed the loss from mortality, with the result that the total biomass increases.

But there comes a time in the life of each generation when growth is retarded and the additions by growth are less than the loss from mortality and its biomass diminishes. Eventually the generation is eliminated with the death of the few surviving old individuals.

The greater part of the deaths in a fishery resource occur because of changes in the habitat but more especially because individuals are eaten by other fishes, birds, etc. this is known as natural mortality; that which takes place in the catch is known as fishing mortality. Biologists calculate the number of deaths by each cause and summing these they obtain a measure of total mortality.


$S_2 = S_1 + (G+R) - (C+M)$
Disponibilidad
Accesibilidad
Vulnerabilidad
S_1
G
C
R
G
G
M
M

The background to the resource

The processes of reproduction, growth and mortality which takes place in a population of organisms are controlled and determined by factors and elements of its habitat; these are physical, chemical, biotic and, when the species is commercially fished, technical.

The physical and chemical factors form an aquatic climate, including temperature, oxygen and, instead of winds, the movement of currents of water. Moreover the water carries dissolved minerals; some of these minerals serve as nutrients for small plants (phytoplankton) on which various species feed; others are silica and calcium which are materials from which the skeleton of organism are formed; and there are many other dissolved minerals whose effects as yet are unknown.

The climate of a water mass in any season of the year is determined both by the forces which drive currents and other water movement and by the interactions between water and atmosphere, including the influence of the sun.

The waters that lie off the Peruvian coast are driven by two systems: the Peruvian Current, which carries some waters northwards and some south; and upwellings which carry waters vertically, from deep strata to the surface. The interaction of the movements produced by these currents gives rise to different aquatic climates and makes the temperature maps very complex; nevertheless, these resemble those made by meteorologists for the air.

The organisms of each species have preference for some particular climate and generally are able to keep within waters of that climate. They can survive slightly different conditions but die under extremely different conditions. An adult fish is able to cover considerable distances by swimming but eggs, larvae and post-larvae are not able to move so and if current carries them into unfavourable climate the mortality among them is great.

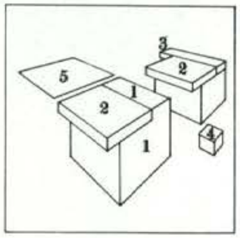
Even if adult anchovy manage to keep themselves in waters of preferred climate the volume of this water sometimes becomes reduced and obliges the anchovy to concentrate, which can have damaging effect. Also it can happen that the quantity of food is deficient in preferred water.

But since every cause appears before its effects, the changes that would take place in the anchovy population could be forecast if the characteristics of the aquatic climate could be kept under constant observation. The advance notice could be further lengthened if it should become possible to predict climatic change.

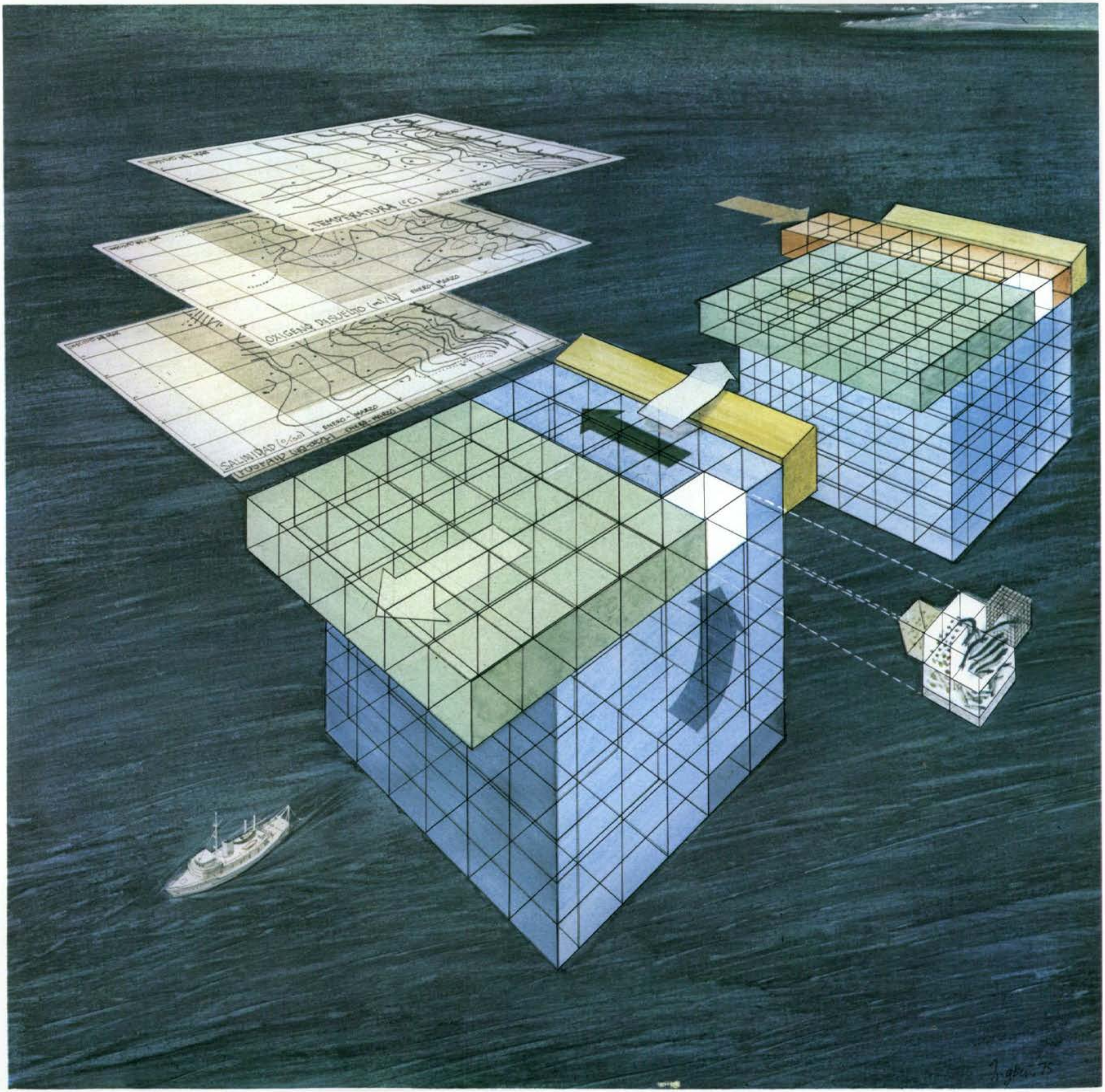
Naturally the characteristics of the water masses that lie off the Peruvian coast determine both the limits of distribution of the species and the physiology and survival of the population.

For this reason it is necessary to develop a system of constant observation and measurement (monitoring) of the aquatic environment through which to show the relation between the processes of reproduction, growth and mortality and the changes of climate.

Once this has been accomplished it should be possible to create effective systems to predict the changes taking place in the anchovy population and how and when and for what reason they take place.



1. Cool upwelling water
2. Warm oceanic water
3. Warm equatorial water
4. Anchovy resource
5. Oceanographic record


TEMPERATURA (°C)
OXIGENO DISUELTO (ml/l)
ENERO - MARZO
SALINIDAD (‰)
ENERO - MARZO

Socio-economic setting for the fishery

The purpose of any fishery is to obtain raw material to serve directly or indirectly as human food. However the decisions to initiate, develop and maintain a fishery consider also factors such as the creation of opportunities of work, for fishermen and for persons to work in processing and marketing the catches; economic effects in activities related with the fishery with respect to the building of boats, and motors, fishing gear and apparatus, the supply of ice; the possibility of obtaining foreign currency by exporting products. An understanding of all these aspects of a fishing industry requires information about each of the elements – resources, boats, gears, processing plants, as well as the organizations which administer the fishery and the industries associated with it.

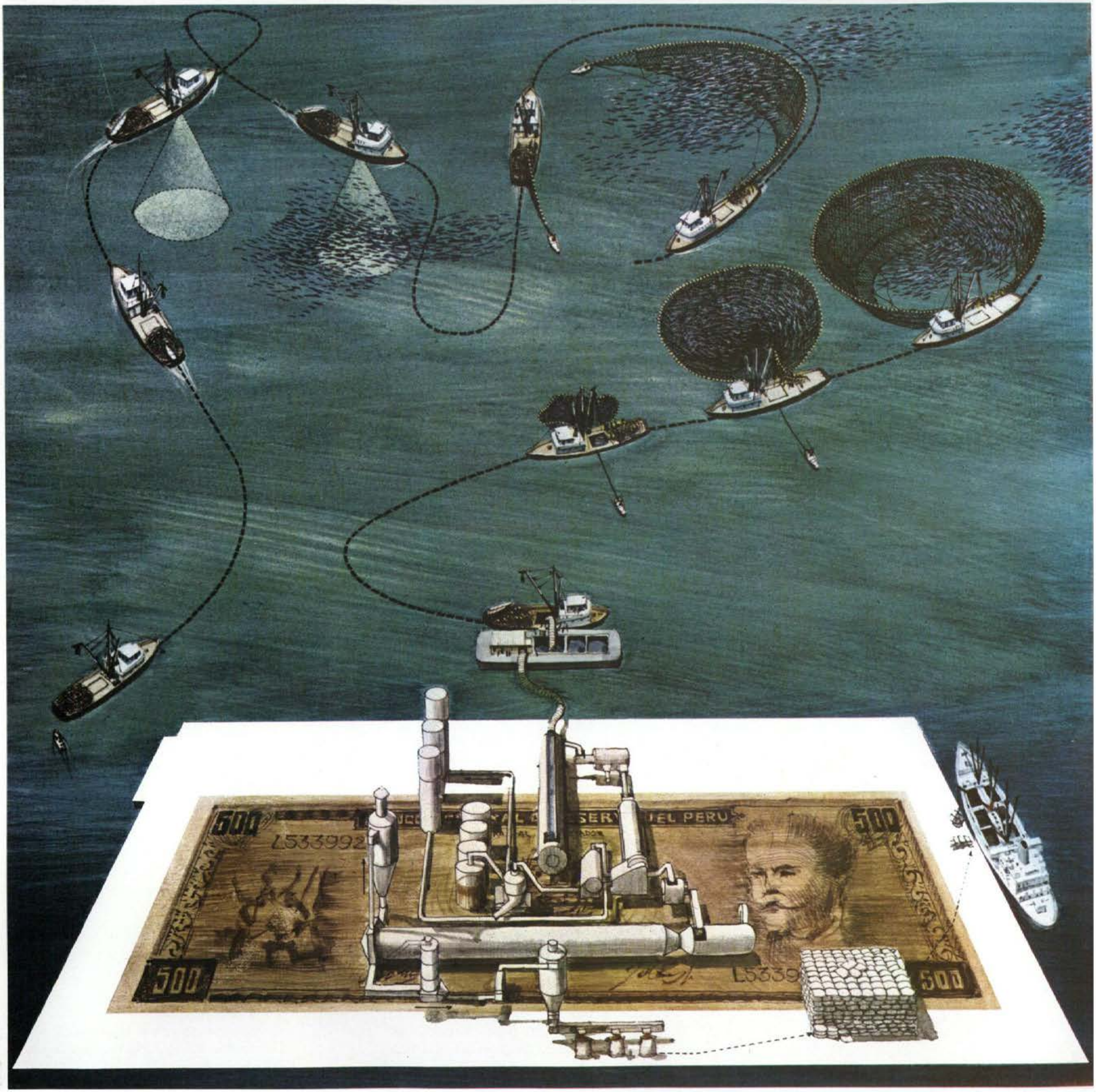
When the fishery began in 1953 the bolichera had a capacity on the average of 20 tons of catch; at present the capacity is 175 tons. The fishing power has grown by increasing the size of the boats and their number.

In 1970, the fleet made up of 1,250 bolicheras was theoretically capable of taking 200,000 tons of anchovy in a single trip. However, the power of the fleet is not given simply by the size of the boats but also by the dimensions of the gear, the type and efficiency of the equipment for fish searching, the efficiency of interchange of information between the boats and between them and the management on land. The nationalization of the anchovy industry, the reduction of the fleet to 700 boats, the concentration of management into a single enterprise – all of which has been carried out by the Government of Peru – has permitted effective management of the operations through a fishing regime rationally based on the permissible catch and on economic objectives. For this reason it is indispensable to maintain a monitoring system which will constantly verify the estimates of the stock of anchovy and predict its changes with the objective that the regime can be modified when this is necessary for conservation of the resource.

If the first objective of the administration is to ensure rational utilization of the resources the second is to secure optimum utilization of the catch with minimal losses. This implies that the catch should be delivered in best condition and in the least time possible to the plants and converted into meal, oil, or products for direct human consumption without much loss. In the first years of the fishery each 100 kg of fish yielded not even 20 of meal and almost nothing of oil; now the efficiency of the plants ensures more than 20% of meal and 6% of oil. The demand for fishmeal and oil is high in the international market and the price obtained is good, especially for oil.

The greater or lesser demand for these products is linked with fluctuations in stocks of them and with the development, stabilization and maintenance of many industries, throughout the world, which utilize these products as raw material.

Expansion of the anchovy fishery was promoted by the great demand for meal and oil which prevailed during the 1960's, but it gave rise to over-capitalization.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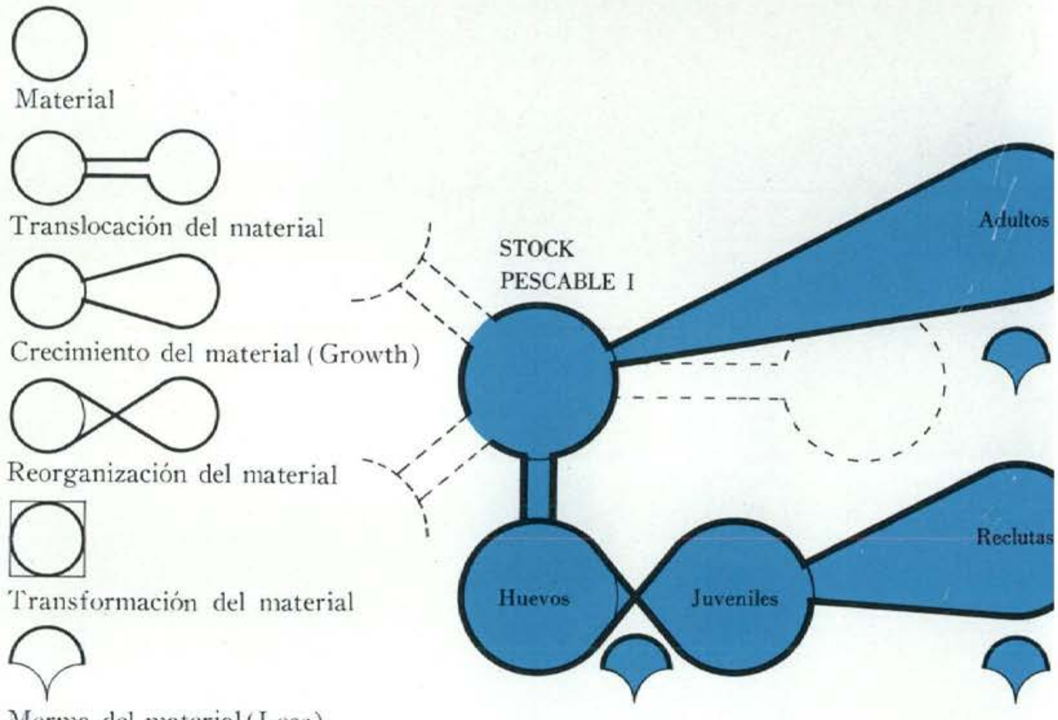
The model

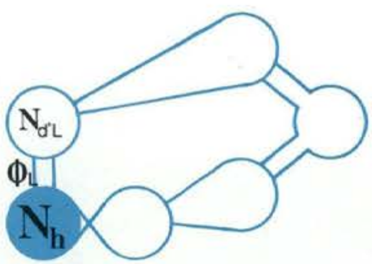
The model presented here has two phases. The upper part represents the components of the total system and the transformation and transfers of material through it. This is a map which describes the path, but says nothing about the traffic that moves along it: it shows neither quantity, nor rate nor time scale.

The amount of material which flows along the path depends initially on the system producing it; the amount varies from one period to another. The speed of its movement, and the proportion of material carried on through the system depend on the capacity and efficiency of components along the path, and these characteristics, too, are variable.

Measurement of flow, and especially of its variation, is a primary objective of this research. Data from such measurements can be summarised in statistical terms describing what has been observed in the past, and what is likely to be observed in the future. But what will occur in a particular period can be reliably predicted only if the behaviour of the factors that cause variation can be observed (or, still better, predicted) and taken into account.

The second phase of the model, the equations below, attacks this problem.





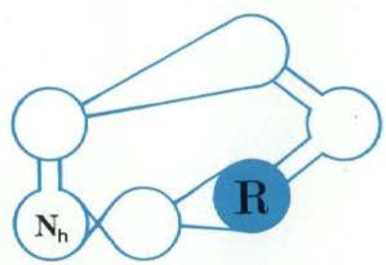
$$N_h = \Sigma N_{d',L} \cdot \Phi_L$$

N_h = Number of eggs produced

$N_{d'L}$ = Number of spawning adults at each length

Φ_L = Number of eggs produced by each female of length (L)

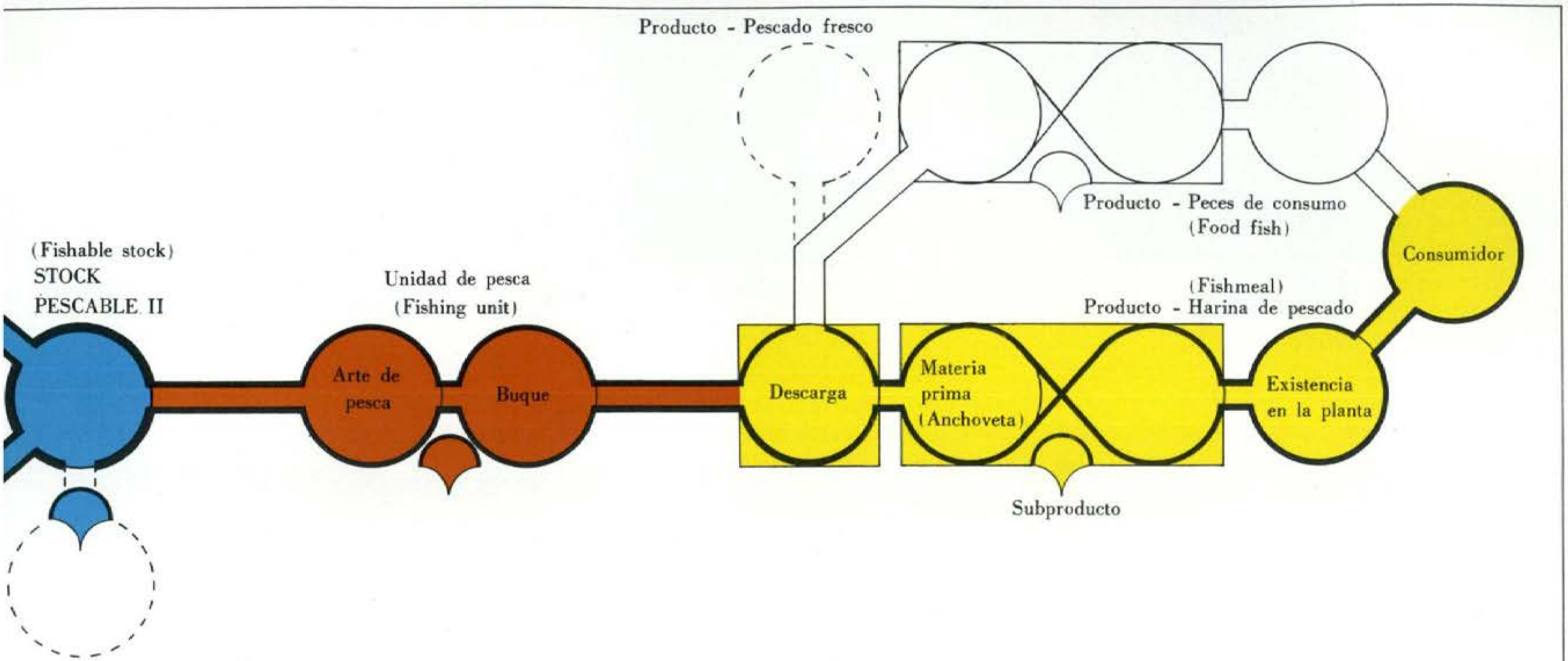
The number of eggs produced in a spawning season depends on the number of spawning individuals, and of eggs produced by each. These characters are variable: a predictive equation will take account of what determines them.

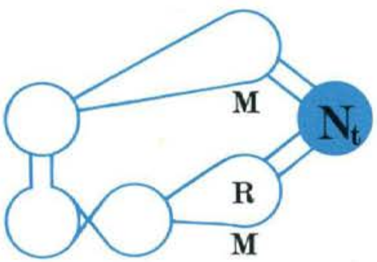


$$R = 1/(a + b/N_h)$$

R = Number of recruits

The number of recruits cannot exceed the number of eggs produced, a predictive equation will take account of factors that kill eggs, larvae, post-larvae and young fish.





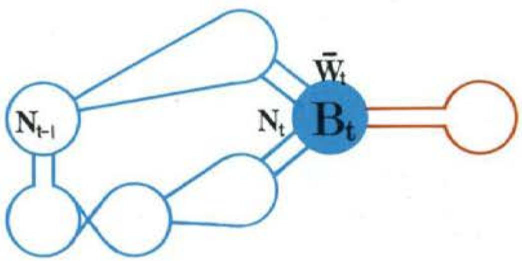
$$N_t = Re^{-M}$$

N_t = Number of individuals at time (t)

M = Natural mortality

e = Base of natural logarithm

The number of recruits which become adult fish depends on the rate at which recruits are killed by predators, fishermen and other factors. This rate varies, and should be measured for each brood.

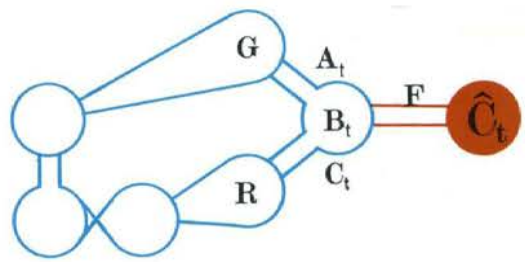


$$B_t = \Sigma(N_{t-1} - N_t)\bar{w}_t$$

B_t = Biomass at time (t)

$\bar{W}_t$ = Mean weight in time interval of fish of age (t) at the beginning of period

The biomass of a stock is calculable as the product of the number and mean weight of the individuals in each group. Prediction of biomass will involve measurement of food supply and of factors affecting nutrition.



$$\hat{C}_t = f(B_t, F, G, R, (B_t - C_t)(A_{t+1}, A_{t+2}))$$

$\hat{C}_t$ = Estimate of permissible catch

F = Fishing effort

G = Growth

C_t = Catch taken

A_t = Climatic conditions at time (t + 1)

In calculating permissible yield the new element will take into account the effects that environment will have on the survivors and on off-spring, based on prediction of environmental conditions.

Research strategy

Constructing the model

Scientific research requires many observations and physical measurements of nature, and experiments with controlled conditions; the observations and the analysis and interpreting of results follow a general strategy in accord with the concept which is held of the system under study. This concept is vague at the beginning of an investigation but sharpens as the research progresses, and the development is reflected in the representations the scientist can make of the system: diagrams which represent its separate parts and how these are related one to the other; graphs which represent the changes that particular characteristics undergo in the course of time, and of the manner of which these variations affect other characteristics. Each of these representations is a model of some part of the real system. But the scientist aspires to combine them into a single representation which helps him to clarify his ideas about the system he is studying. When he achieves this he can visualise the system as a whole, from the past into the future, and foresee the changes it will show under determined conditions.

A very simple example of a model is a regression line calculated for a series of periodic observations. Figure 1 in the illustration shows weekly mean values of an index, over a period of 6 weeks. Projection of this line suggests that the index will have a value of 0.315 in the ninth week and would imply that the situation from the seventh to the ninth week would continue to be as it was in the previous weeks: verification, that in fact the conditions. will remain unchanged, is a critical part of this work.

This type of graph usually represents one or two characteristics of the system but the Peruvian anchovy fishery is a system composed of many parts each of which presents various characteristics and many of these are related one to the other. A representation of this fishery can be made only through careful construction of a model whose terms correspond to the structure and dynamic of the real system. In the first place the components of the system and the relations between them must be identified; then the association of characteristics is assessed and the most significant associations are identified. In a fishery each most significant component can be represented by its dominant dynamic characteristic: changes of biomass in the case of resource; the variation in effort expended in the case of the fleet; fluctuations in the catch taken, in the case of the combination of these two components; and in the case of the processing and marketing, the variations in utilization of the catch. Each of these dominant characteristics is the result of various processes taking place in the separate parts of the components. Thus, for example, growth, reproduction and mortality are processes within the resource which reflect interactions between the parts of which it is composed (each individual fish) and the environment; certain characteristics of the environment reflect the behaviour of other systems, for example the atmosphere.

Construction of a model is an intellectual activity which divides a total system into parts progressively smaller and smaller, with the objective of identifying particular processes which when measured can be described or represented in mathematical equations. These equations are assembled to constitute the model which describes, quantifies and predicts the response to variations in its components, even to the very smallest part of it.

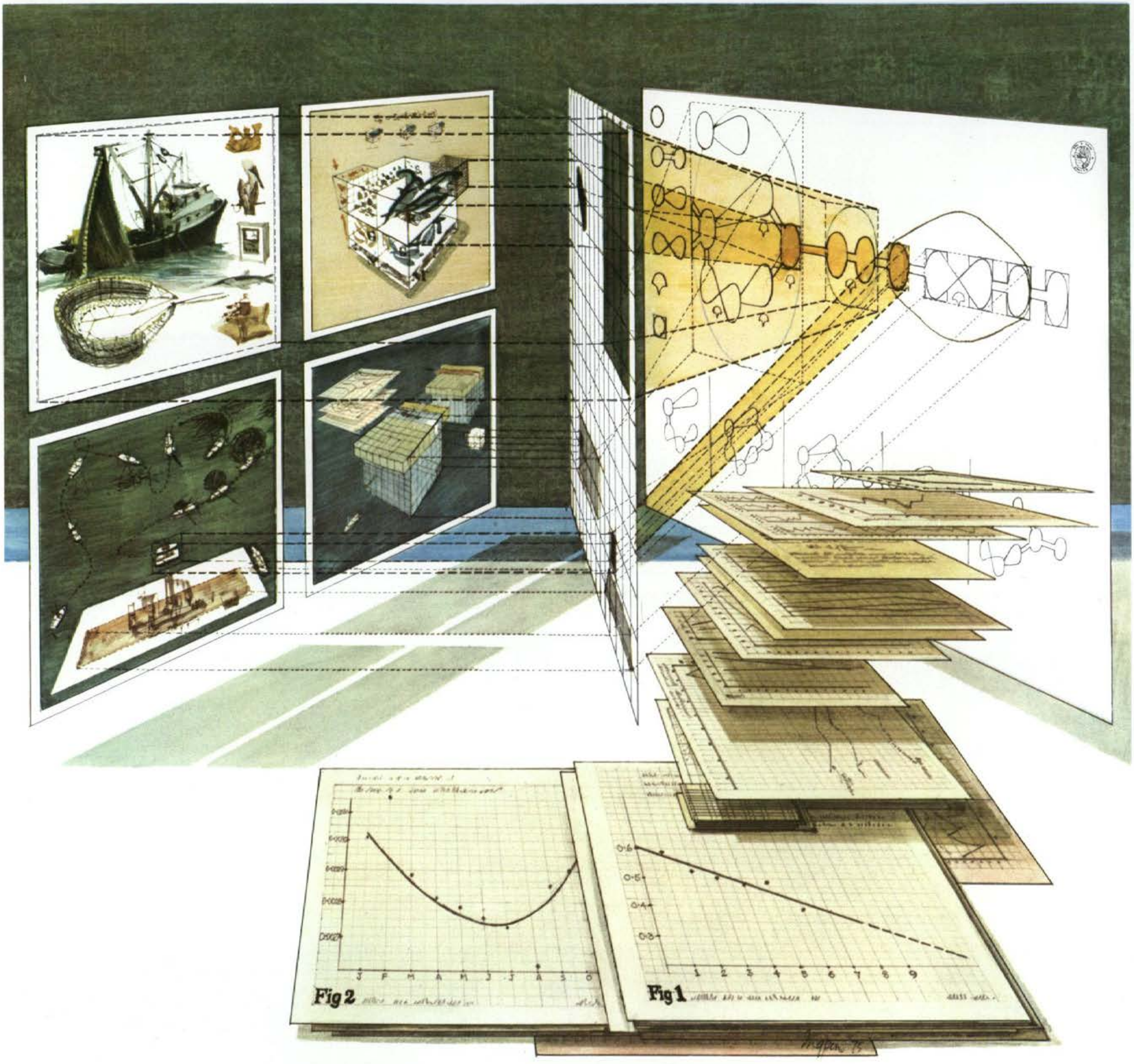


Fig 2
Fig 1
0·6
0·5
0·4
0·3
1 2 3 4 5 6 7 8 9
J F M A M J J A S O

Monitoring the real system

Obtaining the facts

Detailed measurement is the central activity of all scientific work. In marine research it results in multiple data with respect to the different components of a system; data of a wide variety, from the weight and length of fish, through temperature, salinity and movement of water masses, to the number of eggs and planktonic organisms living in a definite area. Information about all aspects of a marine environment flows through a research laboratory where it is analysed by the researchers, who draw conclusions and when possible, make predictions.

An important feature of scientific research is the speed and depth with which the available data can be analysed, whether this relates to summarising the activities of a fishing fleet – which offers the population–researcher a possibility of assessing the state of the stock - or tabulating data which serve the oceanographer in predicting when abnormal environmental conditions will appear.

The advance of science and the development of new techniques of measurement generate constantly greater quantities of data and this makes it indispensable to use complex computing equipment in making the thousands of calculations necessary to be able to understand the different elements of the marine environment.

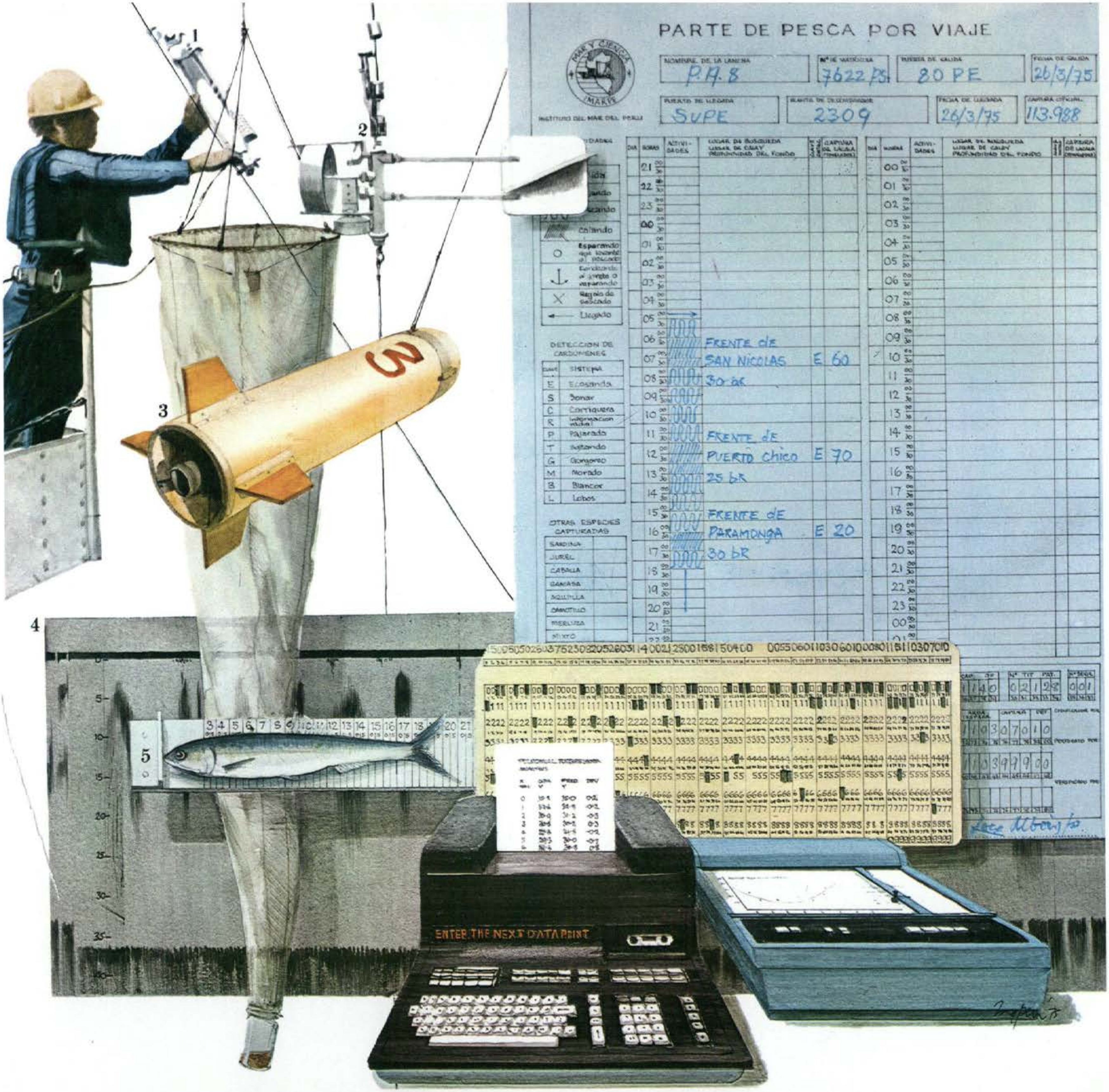
Some of these calculations are simply a summation of data organised in tables which display particular features; others involve complicated mathematics or statistical operations to measure associations between variables of considerable range.

The computing capacity of an institute such as IMARPE must be able to manage all classes of problems: from the production of statistical tables of catch and effort, derived from fleet operations, up to simulation studies with intention of establishing a model of a process which takes place in the sea. This requires specialised personnel trained in analysis of systems and reduction of data in programming the computer.

These persons code the data and record it on cards to be fed into the computer which makes the calculations; then the group operates the necessary equipment; the group assists the scientific staff in resolving problems, related with obtaining and analysing data, which can be done by manual methods only slowly and with difficulty.

Each element represented in the general model of the central pages is an object system for which two types of information are required: those of inventory and those of operations. The inventory of a boat, for example, is a list of all its characteristics and of all the equipment it carries. The operational statistics of a boat are the records of the hours of operation of each motor and item of equipment, as well as of the times in which it has been fishing. A programme is designed through which to compile data for each element of the model, but the methods of observation and measurement vary according to the nature of the unit being studied.

1. **Temperature and salinity sampling**
2. **Current measurement**
3. **Plankton collection**
4. **Fish locating by echosounder**
5. **Fish length measurement for age**



1
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3
4
5
PARTE DE PESCA POR VIAJE
INSTITUTO DEL MAR DEL PERU
P.A. 8
7622 PS
80 PE
26/3/75
SUPE
2309
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113.988
Calando
DETECCION DE CARDUMENES
SISTEMA
Ecosonda
Sonar
Pajarada
Morado
Blancor
Lobos
OTRAS ESPECIES CAPTURADAS
SARDINA
JUREL
CABALLA
FRENTE de SAN NICOLAS
E 60
30 br
FRENTE de PUERTO Chico
E 70
25 br
FRENTE de PARAMONGA
E 20
30 br
ENTER THE NEXT DATA POINT

New directions for research

The calculations of the catch which should be taken from any resource during a fishing season, a year or a series of years vary in exactitude according to the type, scope, and level of confidence of the information on which they are based.

The simple calculation is obtained by summing the catches for various years and taking an annual average. This method gives a value of 6.7 million tons for the anchovy fishery and probably the catch taken in the next few years will be in the order of 7 million although in some years the catch will be greater than 7 and in other years less. This figure serves as a general guide for management to the fishery but not as a basis for deciding how much to take in a particular year or season.

Working with models constructed by fisheries scientists, it is possible to arrive at better calculations than this single figure, but even these models offer a result derived from means based on assumptions of constancy of some of the characteristics. With these models calculations could be made of what could be taken in previous years, by adjusting the real catch data for variations in fishing power and effort. The calculations gave estimates of maximum sustainable yield between 7 and 10 million tons but these figures also do not relate to a particular period of time or season.

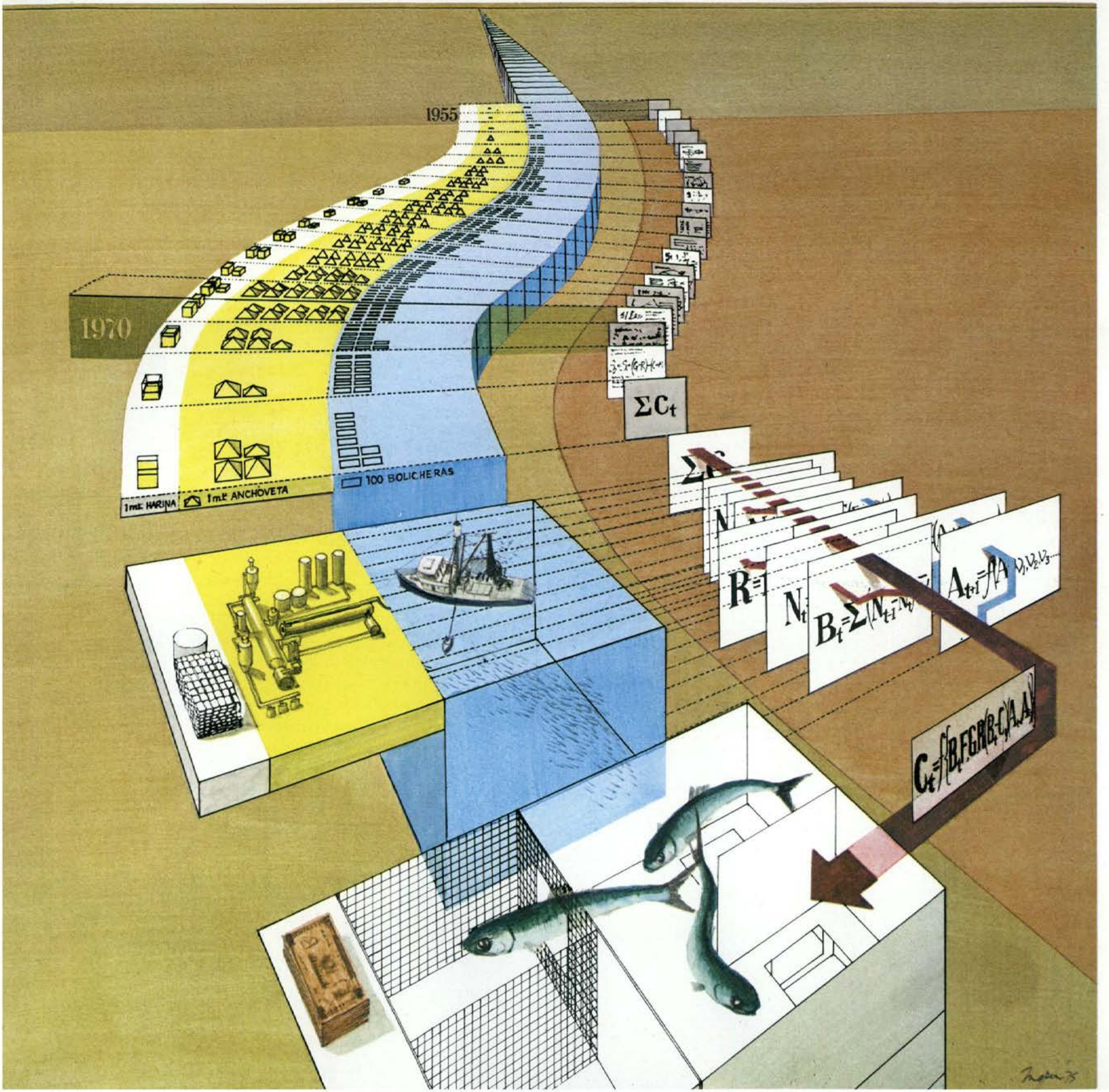
If the fishery bases its operations on this calculation, the catch in some years will be less than it could be and in others more than it should be. To avoid this result it is necessary to direct the research programme to obtain an estimate of permissible catch according to the volume of stock truly available and the situation it will be in after fishing.

Since the catch which can be taken in a given period of time depends on: the size of the stock (availability), its distribution and accessibility to the fleet, and its behaviour and vulnerability to the fishing gear, and improvement in estimate of permissable catch requires investigations to be carried out in order to obtain a better knowledge of the processes which determine these characteristics.

It is extremely important on the one hand to make the estimates from current data of the distribution and composition of the stock, which will include a measure of accessibility and vulnerability, and on the other hand to obtain the constants of growth, reproduction, recruitment and mortality by an immediate measure of the critical features of this process: and these values should in fact be predicted from a measurement of what causes them.

Growth could be measured with greater precision with the use of better equipment, but a knowledge of variations of growth which will serve as basis for prediction implies the conduct of basic research on nutrition. This will include not only what the anchovy eats but also what it digests and the manner in which digestion is affected by variations in the quantity and quality of the food, and in environmental variables.
A system for prediction of changes in the supply of food is also necessary and this implies being able to make a detailed description of the entire planktonic system with which the anchovy is associated.

At the same time it will be necessary to undertake deep studies of reproduction, recruitment behaviour and mortality. The results of these studies, with data obtained from the environmental frame, will permit a correct estimate of permissible catch taking into account predictions of environmental events.


1955
1970
ΣCt
100 BOLICHERAS
1mt HARINA
1mt ANCHOVETA

Reporting

Diagnosis and prognosis

The object of any programme of research such as described in this book is to provide information which can be useful in real time to industrialists and administrators in taking decision. Whether it is in the form of data or advice (which is an interpretation of data) information becomes of value when it is timely, exact and relevant to real problems; it must be directly related to the problem of a particular place and time and should not offer merely generalizations or mean values which have only slight relation with the particular situation. The information must be of a kind that can assist those who must take decisions to choose between different courses of action, taking due note of events beyond their control so as to avoid serious errors. The information must inspire confidence in the source that provides it.

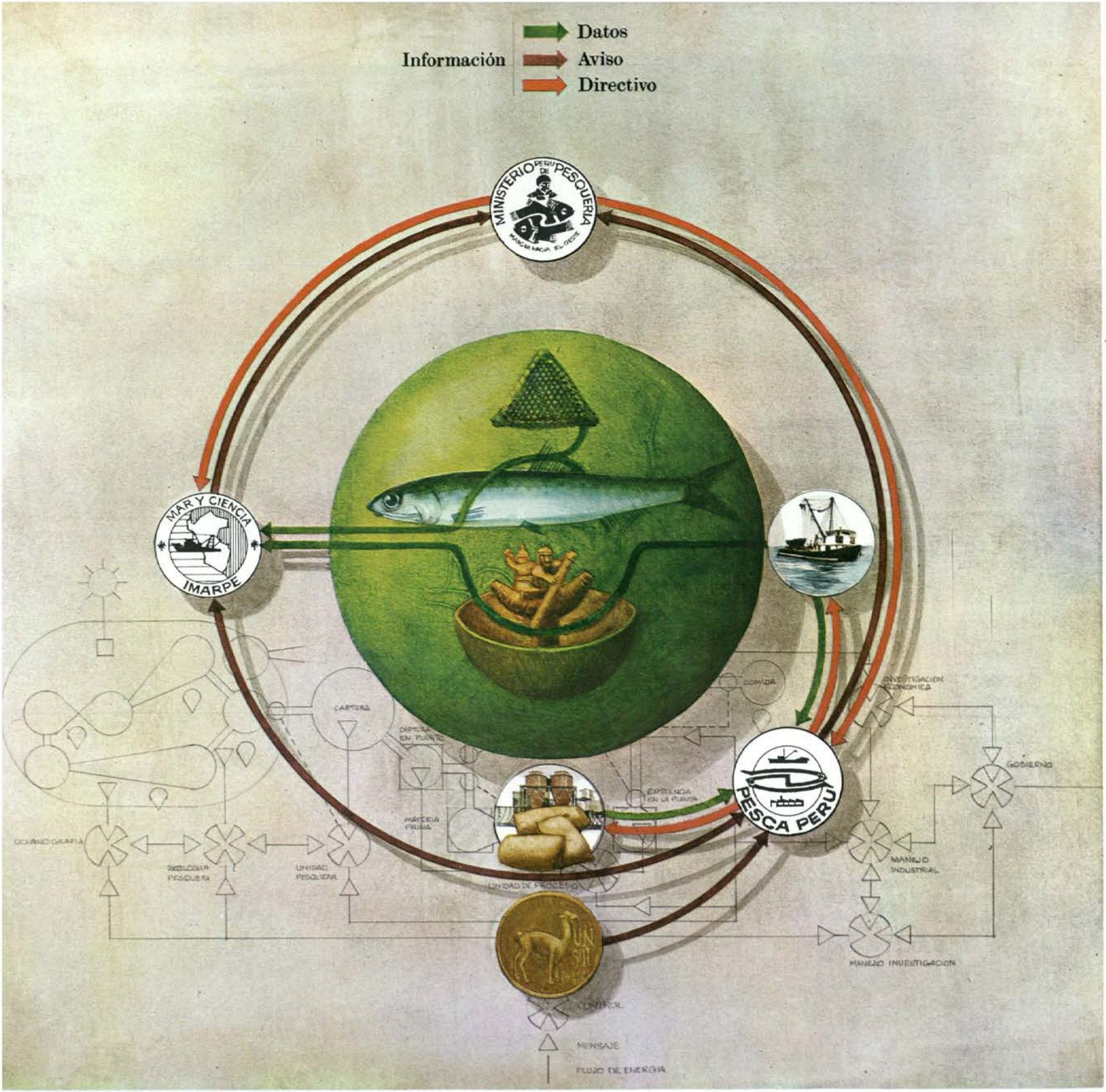
Also it is necessary to create special techniques for the transmission of information because each user is interested in distinct aspects of the one system. The skipper of a fishing boat wishes to know where he might find the anchovy stocks, their density in the area in which the boat will work during the fishing season. For his part, an administrator is specially interested in the total catch that can be taken and in the cost of fishing. Therefore in preparing a report of the research, information must be interpreted so as to answer directly the questions of each particular group. Only when the information is directed to the scientific community should it be detailed, for it must then permit of testing the conclusions.

Since it is impossible to communicate all the data on which some result of research is based, selection of particular aspects of the results must be made; this however is not a distortion of facts but a delivery to each user of the information he requires. This means that each user should be assisted to understand the research result with an interpretation and explanation of the facts, especially when it is a matter of transmitting to fishermen information which implies a limitation of their activities.

Few fishermen like to limit their activities, to respect a closed season, or to refrain from taking a catch composed of small fish. Therefore it is necessary to explain to them clearly and convincely the reason for the control measure and the benefits they can expect in the future if they respect the control. Moreover when a control is experimental, those who participate in the experiment (principally the fishermen), should be informed of the results of the experiment, whether it is a success or a failure. In many cases the fishermen should contribute with their own observations and a record of essential characteristics of their operations (time spent searching for fish and the hours of fishing) and for this they must understand the importance of their cooperation and of the accuracy of their information.

In principle a report of research work is a diagnosis, of the situation in which it was carried out, followed by a prognosis of the alternative courses of action and of the probable consequences of each such course of action. Resources research can indicate a series of fishing regimes each of which can impose different conditions on the stock by the end of the fishing season.

Given that each action taken within a fishery has effects on other parts of the industry the reporting system should communicate information to all participants. The illustration shows the general information network relating to the model of the anchovy fishery described here. Although this book deals principally with research on the resource, other similar studies should be made of other parts of the total system, and related through a communication system.


Información
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INVESTIGACION ECONOMICA
GOBIERNO
MANEJO INDUSTRIAL
MANEJO INVESTIGACION
UN SOL
CONTROL
MENSAJE
FLUJO DE ENERGIA

Peruvian researchers have always recognized that they could achieve little understanding of the wealth of the sea if their work was not carried out systematically.

In the 1950's the General Staff of the Navy, gathering suggestions from its personnel, proposed to Government the creation of a Council for Hydrobiological Research whose principal mission would be to coordinate and intensify those studies. This suggestion was formulated in D.S. 390 of the Naval Branch.

In 1958 the Peruvian Government obtained assistance in the field of marine scientific research from the Specialised Agencies of the United Nations. With the assistance of the Special Fund and of FAO, a Plan of Operations was signed in Lima on 21, April 1960 which defined the objectives of an Institute for Research on Marine Resources. The Institute would study the oceanographic, biological, economic and technical factors which determined the level of exploitation of renewable hydrobiological resources, especially of the anchoveta, as well as prepare Peruvian personnel, and advise to the Government on the country's fisheries policy.

The Institute began its work on July 1, 1960 with FAO assistance, and achieved very significant results, presented in reports to the Government with respect to rationalising fishing.

In 1964 the Council of Hydrobiological Research and the Institute for Research on Marine Resources were combined to create a Peruvian Marine Institute charged with planning, directing, executing and coordinating research, aimed at completing and improving this important field of action.

The Peruvian sea is the great geographic frame in which the most favorable and at the same time the most exigent conditions exist for the full realization of the participatory and humanistic characteristics of the Peruvian Revolution as nationalist and independent process.

The scientific investigation of this sea is a genuine element of the historical and cultural heritage of our people - expressive of our intense curiosity, of our determination to make good use of the wealth of this part of our territory, of our willingness to bear the hardships of work upon it, and of our intention to discharge all our obligations toward it.

The prosecution of research exercises the intellect of our people; its results guide our utilization of its resources; and by this the international community can be assured that we are conscious of our responsibility to this area and capable of dishcarging it.

The emphasis placed on the anchovy fisheries, almost since the beginning of that fishery, made it possible not only to organize a system for the regular collection of statistical data of catch and effort, size composition, life - cycle and environment, but also to apply theoretical models for interpretation of population dynamics and to establish particular methods of investigation, all of which made it possible to establish a scientific basis for exploitation. Parallel investigations carried out on other pelagic resources and on demersal resources have made it possible to estimate even only provisionally that the fishery potential will allow an annual catch of 600,000 tons including the squids.

In order to accomplish its objectives the Marine Institute has a modern central building in Callao, 4 coastal regional laboratories, one fisheries research vessel and periodic use of an oceanographic vessel belonging to the Peruvian Navy, 3 regional laboratories in the interior of the country, a research vessel on the Amazon and another on Lake Titicaca. Its scientific personnel consists of 141 specialists in fisheries biology, taxonomy, population dynamics, planktology, chemistry of the sea, physical oceanography, acoustics, statistics and mathematics, and technologists of nets and processing.


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