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GUIDELINES FOR COLLECTION AND COMPILATION OF FISHERY STATISTICS

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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GUIDELINES FOR COLLECTION AND COMPILATION OF FISHERY STATISTICS

by

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CONTENTS

1. INTRODUCTION

The need to collect data arises when attempts are made to manage the economic and social activities of a society. For example data on population size and distribution are used in planning the building, of houses, schools, roads and hospitals. The raw data which appear on the source document (e.g., a census form filled in by the head of a household) are collected and processed to provide statistics of, among other things, the number of children of primary school age in each district of each town. Instead of the wealth of individual detail which exists on the source document about age, family size, occupation, income and activities we may, for the purposes of the types of planning listed above, devise a simplified description or model of the population. In our model there may be only four age classes pre-school, school age, child bearing age and post-child bearing and we may use this as a basis for estimating the number of school places or hospital beds needed in five years time, given certain information about numbers of children born per family per year and rate of hospitalization for different age groups. This model describes the age structure of the population in a simple way which helps us to make predictions about the changes likely to take place in the population.

The collection of such data is not strictly essential - it would be possible to provide enough schools and hospitals simply by building a very large number, or by waiting until the existing ones were obviously overcrowded but either of these courses of action would have greater costs than if the right number could be predicted. Collecting date, producing statistic, and developing a model costs money and the cost of collection and modelling must be related to the benefits expected, whether they are expressed as money saved or more general social well-being.

The construction of models which describe some aspect of population, economics or industrial development requires research into the relationships which exist within the system being studied. How, for example, is family size related to income level? How does the likelihood of going to hospital change with age? Such research is usually based on statistics collected over a long period of time and these long-term statistics are essential for predictive modelling.

Once these simplified relationships are established it is possible to use the model to test the effects of particular courses of action and thereby to make a rational decision. For example, how much would the provision of old, people’s homes, with certain nursing facilities, reduce the demand for mo expensive hospital treatment? If a model were being constructed for this particular purpose it might be necessary to collect additional, short term, information by means of a special survey on, say, the frequency of different types of illness among elderly people. As a result of the study it may be decided to make this information part of the routine census in future and to build up long-term statistics of incidence of illness.

The distinction between short-term and long-term statistics is a useful one when discussing the collection of data even though it is not clearest. Short-term statistics can be collected during the lifetime of the project in hand. They may be useful only to that particular project and they are not kept in the form of permanent records. In the example given above the statistics of illness frequency became long-term when it was decided to store them, presumably because it was felt that records of this kind would be useful to future studies.

1.1. Management of fisheries requires data

The aim of this manual is to outline the types of statistics required for fisheries management, with a general introduction to the methods of collection and processing which can be used in different situations. The emphasis will be on the routine, long-term statistics, which have wide application in the many disciplines used to provide practical guidance to fishermen, fisheries administrators and fishing companies. The primary users of the statistics are fisheries biologists, economists, development planners and gear and food technologists. They are the people who specify what data they think will be needed in order to plan, monitor, control and predict the operation of the fishing industry in a rational way.

The importance of collecting data and the amount of time and money worth spending on it can only be assessed if the objectives of fisheries management are fairly clearly de fined. The ultimate objectives of management of a fishery resource and of the fishing industry based on it are often vague, or there may be several which are not fully compatible, e.g., employment of the largest possible number of people, efficiency of labour utilization, maximization of physical yield (Lawson, 1974). The ultimate objective of management can often be divided into or replaced by simpler proximate objectives and the importance of collecting data evaluated in relation to them. Rothschild (1971) discusses this type of approach to fishery management and points out the dangers of suboptimization - when optimality in the chosen proximate objectives does not lead to optimality of the entire system.

In order to establish more clearly what the objectives might be and what data are needed in relation to them, we need to look at the nature of the fisheries resources and then at the structure and operation of the fishing industries based on them. Because moat fisheries are common property resources one must make a distinction between the objectives of managing the resource as a whole and the objectives pursued by individual countries, fishing companies or fishermen. This distinction and the problem of common property re sources in general have been discussed by Gordon (1954) and Gulland (1974). If a resource is common property then the level of exploitation will increase until the actual yield from each additional unit of exploitation equals the cost of the additional unit. The aim of an individual country or fishing, enterprise in such a situation will be to secure as large a part of the total yield as possible, since anything which it does not take may go to a competitor. The total yield from the resource may then be reduced below the level which could be maintained if the level of exploitation were controlled. Control of the level of exploitation can only be achieved, if all the participants agree to it and the international and regional fisheries regulatory bodies have been established to provide the institutional framework for this kind, of resource management. Subject to the regulation on catch, gear etc. imposed by these regulatory bodies, individual countries and fishing enterprises will have further objectives which give rise to national and local fisheries management measures. There is thus a hierarchy of objectives and arising from them a hierarchy of management measures which are summarised in Table 1.

The table gives only an indication of the kinds of objectives which exist at each level and of the data required to study them and to evaluate me measures. A further breakdown of objectives and of the relationships between then is given by Kesteven (1973). The objectives of resource management are evolving in response to changes in the way that fisheries are exploited (e.g., an increase in large mobile fleets) and to change in the concepts of ownership which are applied. The biological basis of resource management and its objectives are discussed fully by Gulland, (1974). The treatment of these subjects in Section 1.2 of the present work is intended only to serve as a basis for examining the data requirements.

It will be seen from Table 1 that a wide variety of data are required for resource management and management of the fishing industry. Each discipline (e.g., economic, biology, sociology, engineering) which is used to study the fish resource and the industry will have a different approach to the overall objectives and will require different kinds of data. For example, a sociologist may look at the safety records of different group of trawlers and relate then to the structure of authority and the patterns of ownership of the vessels. A technologist or engineer looking into safety would be concerned with the use of machinery on board and the seaworthiness of the boats. This example is also intended to show the need to integrate different approaches in an overall objective such as safety at sea. The present work will nevertheless follow broadly discipline oriented lines in considering data requirements, rather than organising them according to objectives as baa been done in Table 1. It would be impossible for a work of this kind to aim at a comprehensive coverage of the data required by all users and in any case new requirements arises as the methods of study and objectives evolve.

Table 1: A hierarchy of objectives in fisheries management, some of the measure used to achieve them, and the requirements for data, assessments and forecasts

Level	**Objectives**	**Management measures**	**Data assessments and forecasts required**
International Regional Fisheries Commission	Maintaining the yield from resources	International agreement on gear regulation, fishing areas and seasons, catch and fishing effort quotas	Biological data for stock assessment including annual updating of catch quotas. Some economic, social and industrial data in determining national allocations
National Fisheries Management	Development of the fishing industry and balanced growth. Maintenance of employment	Planning and assisting with investment. Subsidies. Control of prices, imports, quality	Economic data of many kinds. Assessment of size of exploitable resources and estimates of catch rates
Management of Fishing enterprises	Maintaining employment and profitability	Improving technological efficiency and marketing of products. New investment	Evaluation of new fishing and processing methods. Short and long term pre dictions of catches and market trends

What we shall aim to cover are the most important kinds of data used, by the main disciplines-biology, economics, development planning, gear and food technology, business management - with the emphasis on the data required for resource management rather than industrial management, although there is a large common ground between the two.

Section 2 lists the basic data requirements with a brief discussion of the qualities the data should have. Section 3 deals with problems of collection and with the relative coats of collection in different types of fishery (industrialized, small scale). The processing and production of statistics are dealt with in Section 4 and Section 5 tries to cover some of the shortcomings which result from imposing a fairly simple structure onto a complex subject. It also tries to anticipate some of the development in fishery statistics.

The definition of objectives and setting up of a system of collection of statistics for studying them is not the end of the process. Once a collection and processing system has been established it limits and influences the kind of question which can be answered by its use. It is therefore essential to keep the objectives themselves under constant review, particularly at times of rapid change in the structure of the industry and in the Inter national law and resource management practices. Following from this it may be necessary to revise the collection system.

Biologists, economists etc. are the immediate users of fisheries statistics, but the justification for collecting them comes from the ways in which the analyses by biologists or economists are used by administrators and fishery managers to make decisions about the fisheries. Close cooperation among immediate users and between immediate users and administrators is needed in setting out the uses and objectives and to avoid duplication.

1.2. The nature of the fish resource and the methods for studying it

The fishing industry is based on a natural resource not controlled directly by man, except in fish farming. Because of the lack of direct control and because the sea is a foreign Environment, there is a relatively greater need to study and monitor its changes and -to collect data routinely than exists on land. Underlying any planned development, management or economic study there must be some understanding of the biology and population dynamics of the resource.

Man’s influence on fish stocks is exerted almost entirely through fishing and there is little attempt, at least in the oceans, to regulate species composition, eliminate disease and predators, control migrations or fertilize selectively, such as has taken place for thousands of years on land. In the sea man is a hunter, not a farmer, but he can and should be a prudent hunter, giving proper thought to the long -term effects of his actions. The resource is renewable, but limited in size and in many fisheries the upper limit of exploitation has been overshot.

The way in which the average yield in weight from a fish stock changes at different steady levels of exploitation (= fishing effort) is shown in Figure 1. Obviously there will be no yield if there is no fishing effort but equally if the fishing effort remains at a very high level the yield will be very low because the fish do not have time to grow or reproduce before they are caught at some intermediate level of exploitation there will be a maximum average yield (known as the maximum sustainable yield or MSY).

To a first approximation the total gross revenue from the resource is directly related to the yield in weight and the total cost of fishing is directly related to the amount of fishing effort. The line in Figure 1 shows where the costs and revenues are balanced and at the point B where it cuts the yield (= revenue) curve, the revenue from one wilt of fishing effort exactly equals the cost of that unit. This is the state towards which a common property fishery will move and at this point the total gross yield from the resource is lower than it would be if the amount of fishing effort (and hence the cost of fishing) were reduced (e.g., to MSY at point A). The difference between cost and revenue is greatest at Point C (maximum net economic yield.), to the left of MSY.

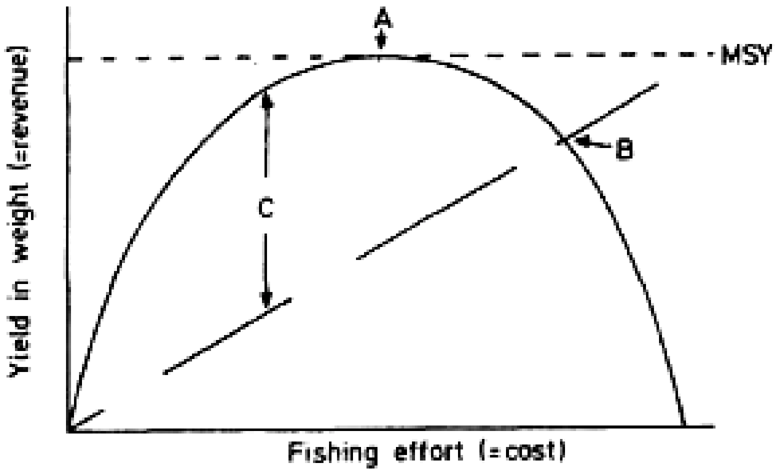


Fig 1: Steady yield at different levels of effort

(A = maximum physical yield,
B = zero economic yield,
C = maximum economic yield).

Without going further into the biological and economic arguments, which can be found in Gulland (1974), Clark *et. al*. (1973) and Roedel (1975), it is clear that MSY cannot be used as an objective of mage but it may be useful as a tool. It provides an indication of the greatest sustained physical yield which can be expected from the resource, and it is useful in explaining the dangers of over fishing and the need to reduce fishing effort.

The simple theoretical concept of MSY ignores the fact that fish resources are not static and unchanging. There are fluctuations in the number of young fish entering the fishery each year and in the species composition of catches in an area. It is the aim of fisheries biology to predict and if possible explain such changes and also to predict the effects of man's activities on the fisheries. Rational management decisions can only be taken if the consequences of such decisions can be predicted.

1.2.1 A general description of the development of a fishery

The development of many fisheries has followed a similar pattern and a generalised description is shown in Figure 2. The first stage begins with either no fishery or a small subsistence fishery and the characteristic, of the stage are increasing investment, modernisation of equipment and increased total catch. The second stage is characterised by a levelling off in total catch followed by a decline. In the third stage the catch is moderate and erratic unless regulation is introduced to rebuild the stock.

An analysis of the biological and economic changes in the fishery shows why things have gone wrong and what steps can be taken during each stage to ensure that the development of the fishing industry is balanced and sustained. At the beginning of the first stage the fish are abundant and even relatively inefficient fishing methods will produce a reasonable catch, i.e., the catch per unit effort is high. Improvements in the gear used and introduction of new boats will increase the catch, but at the same time reduce the abundance. The reduced abundance will be reflected in a decline in the catch per unit effort, but improvements in fishing power may conceal this. The critical period in preventing over fishing occurs towards the end of the first stage. If there are no data on the total catches and fishing effort, then no assessment can be made of the upper limit of the sustainable catch from the fishery and of the trend in catch per effort. The profitability of a fishing vessel depends largely on the catch per effort and if the downward trend is not recognised then future investment and ship building programmes will be based on the high catch per effort during the early years of the fishery and thus lead to over investment in boats. There is a strong optimistic bias among fishermen in a developing fishery, which leads them to gamble on the continuation or return of high catch rates, when it is in fact their own activity which is preventing it. The common property problem enters here. As well as over-investment in boats there may be over-investment in port facilities, processing equipment etc. The investor has risked money on poor information, where the means of improving the information are quite clear and the cost of collecting it can be specified. In a few cases the opposite happens and investors are unwilling, in the absence of information, to risk money on what is in fact a good prospect, i.e., the stock remains under-exploited.

So far we have stressed. the need for collecting data on total catch and fishing effort in order to be able to predict trends in catch per effort and the maximum yield from the resource. These statistics, directed towards "resource objectives" (See Table 1), must underlie any development programme, but an investor will need a wider rang of information in order to plan the strategy (e.g., analysis of demand and sales prices, the technical feasibility of landing, processing and marketing, and the financial feasibility). Some idea of the scope of these needs can be obtained from Table 2, which is discussed in Section 1.3.1.

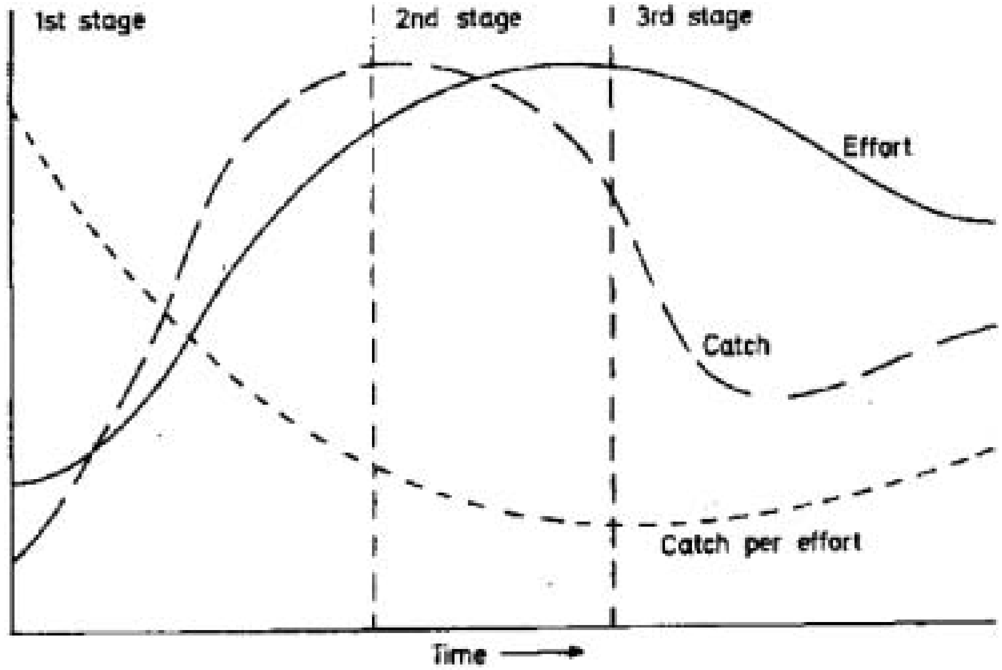


Figure 2: Showing diagrammatically the development of a fishery. In the first stage of development the aim in to increase investment. Total catches rise while catch per effort falls. In the second stage catches start to decline but effort continues to increase, although at a declining rate. The aim is to limit the total effort and stabilize the fishery. In the third stage effort is lower, catch per effort is higher, and the total catch is stable.

If the need to limit the level of fishing effort was not foreseen, either because the data were not collected at all or because they were not acted on, then the signs of stress within the fishing industry begin to show. Total catch declines, the price of fish may rise so that earnings are not greatly affected at first there are demands for the banning of foreign fishing and finally requests for subsidies to maintain the livelihood of fishermen.

The options open to management at all levels can again he evaluated only if sufficient information exists. At the international resource management level the effect of various reductions in total catch or other restrictive measures on the rate of recovery of the stock can be assessed; at the national level the cost of different types of subsidy and of increasing fish imports must be examined., and so on, The severity of the regulatory measures which are needed depends largely on how late these have been left. The history of the regulation of catches of whales, for example, is one of successive regulations coming too late to prevent the situation which they were intended to prevent.

Having analysed rather broadly the underlying biological and economic changes which take place in our general model of development we can clearly recognise the data which are needed to evaluate the options at each stage. One cannot argue that a successful and sustained fishery is only possible if these data are collected, since very few fisheries have to date been developed in this way and some continue to be successful. There are however two important points which should be borne in mind. (1) Fisheries can develop much more quickly now than they have done in the past, particularly when large mobile fleets are involved. (2) The catching power of modern vessels with all their technological side is enormous. The risks involved in waiting to see what will happen are not worth taking, since the means of avoiding them are known.

The data needed initially come from a wide variety of sources. The existing subsistence fishery may furnish some written or oral records of species available, fishing grounds, seasonal fluctuations and types of gear which are effective. Exploratory surveys of various kinds (discussed in FAO Manual on Marine Fishery Resource Surveys, in preparation) can be used to find the best fishing grounds, estimate the likely catch rates and assess, at least approximately, the annual sustainable yield. As the new fishing industry develops the system for collecting information on the landings must be built up, since total catch and fishing effort are the most important statistics of the fishery. The Vital role which statistics of catch and effort from a new fishery play in assessment models will be explained in Section 1.2.2. Another reason for organising the data collection system as early as possible is that the obligation to collect data and the acceptance of management control should be established in the fishing community from the start. The landing information collected from the developing fishery can be used to improve and up-date the original assessments of catch rates and yield and hence to adjust the rate of new investment.

By the time the limits of the resource are reached a good deal should be known about the biological features of the populations involved and more detailed information may be needed on the distribution of catches and effort in order to sake resource- management effective and efficient. The kinds of problems being investigated may include the effectiveness of particular area or seasonal closures as a management measure or the effect of mesh size regulation on a mixture of species. Fish populations are subject to long term and short term changes due -to natural causes as well as man’s influence and the demands of the fishing industry also change. Maintenance of the stocks therefore needs continuing monitoring.

1.2.2 The use of models

We have already described briefly the use of a model for giving advice about the building of hospitals and schools. The model provided a means of simplifying and describing various features of a population of identifying the relationships between these features which needed to be studied, and hence of predicting the outcome of various possible actions. Thus a model links the data available and the advice on a problem, and at the ease time indicates what further data might be, useful to achieve the chosen objective. It may also be used to calculate, at least roughly, the amount of money or time worth spending on the collection of data.

An example of a fisheries model with very simple data requirements is the production model developed by Schaefer. The data needed are the total fishing effort and a measure of the catch per unit effort, which is used as an index of stock size or biomass. If there is no fishing the stock size will be high and will not increase from year to year, because the stock will be at the limit that the environment can support. If fishing effort is very high the stock will be reduced to a small size or eliminated and there will be little or no increase from year to year. In between these levels of fishing effort the stock size will increase from year to year and this is where fishing can take place (see Figure 3 which is just like Figure 1).

The model can be used to predict the yield which will be obtained at different levels of fishing effort, but it is limited because it does not take the age structure of the population into account and because it requires several years of catch and effort information to start with. In particular it needs data from the start of the fishery, when the fishing effort is low and stock size is high. Models which try to explain and predict biological changes in the resource and economic models of the primary phase of the fishing industry are often based on the same or very similar data series as will become apparent in Section 2.

At a simple level the data requirements for such models are:

1. A measure of the catch in weight or value, i.e., the output.
2. A measure of the level of effort put into the fishery which may be in terms of number of fishing boats, hours worked, labour or cost, i.e., the input.
3. A measure of the performance, i.e., catch-per-effort. Since this is simply the output divided by the input, it is obvious that it can be obtained from 1 and 2, and that in general if any two of the three data requirements are met, the third can be obtained from them.

More complex models, which incorporate the age and size structure of the population, are needed in order to assess the immediate and long term effects of regulatory measures such as mesh size restrictions, minimum landing sizes, or catch and effort regulation. Statistics of age and size structure are therefore second in importance to catch and effort for models which test the effect of different management options on the resource.

1.2.3 Statistics of catch

Statistics of the total weight and the total value of the catch are fundamental to all studies of fisheries dynamics. The total output from the fishery must be known and the catch statistics should therefore be complete. Additional information on the breakdown of the catch by species and areas is required for many purposes and biological studies also require a breakdown by age. In practice the statistics which are easily available are of landed weight of fresh, frozen, gutted or filleted fish, because these are recorded by the fish markets or merchants at the time of first sale (sales notes) and are often kept by the fishermen or producer organizations. In order to have a standard unit for all fish pro ducts, these landed weights have to be converted back to the equivalent live weights, by means of conversion factors, to give the “nominal catch”. The actual catch or “gross catch” which case up in the net is greater than the “nominal catch”, because some fish are discarded and others may be eaten on board or lost in handling.

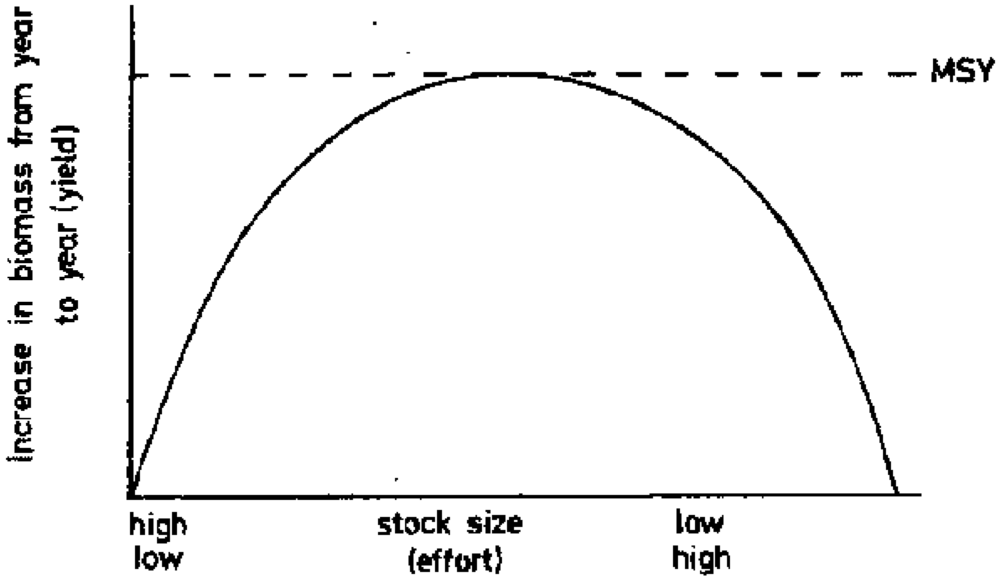


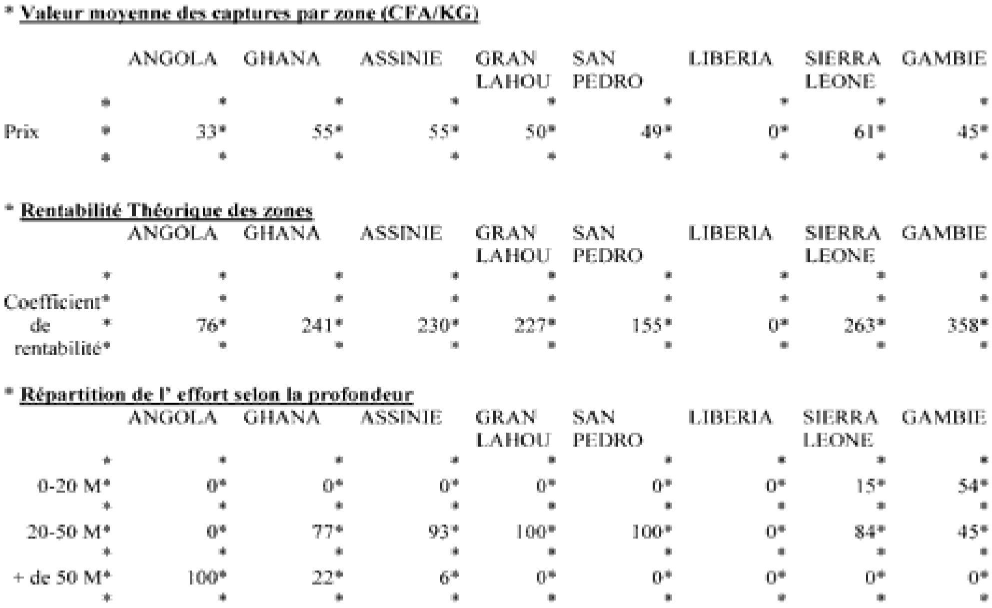
Figure 3: Annual production at different stock levels

If the need to limit the level of fishing effort was not foreseen, either because the data were not collected at all or because they were not acted on, then the signs of stress within the fishing industry begin to show. Total catch declines, the price of fish may rise so that earnings are not greatly affected at first there are demands for the banning of foreign fishing and finally requests for subsidies to maintain the livelihood of fishermen.

1.2.4 Statistics of fishing effort and catch-per-unit-effort

The measurement of fishing effort is one of the most difficult and important tasks in fishery research. Confusion is caused because different groups of people use the concept in different ways: (a) in general terms fishing effort is the amount of time, money, labour, technology and skill applied to catching fish, i.e., the work done or scarce resource used, and it is therefore of great interest to economists and technologists; (b) statistics of effort provide the biologist with a measure of the proportion of fish being caught, of the relative abundance and of the mortality due to fishing; (c) catch per boat or catch per landing is perhaps the most widespread index of performance used by practising fishermen. They often remember that in former times catch rates were higher, and many scientific investigations have had their origin in the need to explain declining catch rates. Cooperation in collecting statistics will usually be greatly improved if the information can be processed rapidly and given back in a form which is of interest to fishermen and the industry. Examples of this are the biweekly or monthly summaries of catches, catch rates and value/hr.fished/HP prepared for the trawl fishery off the Ivory Coast (Figure 4, from Fontaneau and Troadec, 1969).

A further discussion of the concept of fishing effort and its measurement is given in Section 2.2.2. Fishing effort is much more difficult to define end to measure than catch, as it is not a simple physical unit. For this reason biologists have developed techniques which do not require the measurement of fishing effort and many management schemes rely on catch regulations rather than effort regulations. Fishing effort data should nevertheless be collected because they are used in economic and technological studies and because, in spite of imperfections, they are the moat accessible measure of abundance and mortality.



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* Valeur moyenne des captures par zone (CFA/KG)

              ANGOLA   GHANA    ASSINIE   GRAN    SAN       LIBERIA   SIERRA  GAMBIE
                                          LAHOU   PEDRO               LEONE
           *       *        *         *       *         *         *       *        *
Prix       *     33*      55*       55*     50*       49*        0*     61*      45*
           *       *        *         *       *         *         *       *        *

* Rentabilité Théorique des zones
              ANGOLA   GHANA    ASSINIE   GRAN    SAN       LIBERIA   SIERRA  GAMBIE
                                          LAHOU   PEDRO               LEONE
           *       *        *         *       *         *         *       *        *
Coefficient*       *        *         *       *         *         *       *        *
   de      *     76*     241*      230*    227*      155*        0*    263*     358*
 rentabilité*      *        *         *       *         *         *       *        *

* Répartition de l' effort selon la profondeur
              ANGOLA   GHANA    ASSINIE   GRAN    SAN       LIBERIA   SIERRA  GAMBIE
                                          LAHOU   PEDRO               LEONE
           *       *        *         *       *         *         *       *        *
  0-20 M*         0*       0*        0*      0*        0*        0*     15*      54*
           *       *        *         *       *         *         *       *        *
 20-50 M*         0*      77*       93*    100*      100*        0*     84*      45*
           *       *        *         *       *         *         *       *        *
+ de 50 M*      100*      22*        6*      0*        0*        0*      0*       0*
           *       *        *         *       *         *         *       *        *
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Figure 4: example of monthly tabulations of values and profitability for the Ivory Coast trawl fishery . (Transcribed from a computer listing reproduced in Fontaneau and Troadec, 1969).

1.2.5 Other statistics needed for stock assessment

The biologist studying the population dynamics of stocks is trying to determine what level of mortality due to fishing will give the optimum yield in the long term, how the size of the stock is changing due to the currant fishing regime and due to the recruitment of young fish into the stock and how the number of young fish produced each year is affected by changes in the number of adult, spawning fish. All these studies need basic data on the number of fish of different sizes and ages in the stock collected routinely over a number of years, and this basic data comes mainly from sampling of the commercial landings. Except in very new fisheries, which are still in the exploratory stages, the commercial landings will be far greater in volume and wider in coverage than one could expect from research surveys and the cost of obtaining length frequency and age composition data by market sampling will be far lower.

The need for trained staff to carry out such sampling is briefly discussed in Section 1.4 but first the data requirements for a study of the fishing industry will be examined in relation to possible uses.

1.3 The structure and operation of the fishing industry

The distinction made in Table 1 between resource management and national or local industry management is in many ways artificial. The need to distinguish, between them arose because of the problem of common ownership, i.e., the objectives of each individual may not be consistent with the objectives of the group as a whole. If the resource is owned by one individual or management unit then there is no need for the distinction because there will be only one act of objectives. In any case we need to understand the structure and operation of the industry in order to evaluate the possibilities for resource management as well as for-national and local management of the industry.

The fishing industry may be divided into three fairly distinct phases:

Primary phase - catching and landing

Secondary phase - processing

Tertiary phase - marketing and distribution

Within each of these phases one may considers (a) the structure of the sector, for example the fishing fleets, processing plants, and distribution networks; and (b) the operation, divided into inputs of fishing effort, labour etc., and outputs of fresh fish, processed fish etc. The inputs are equated with the costs of the operation and the outputs with the revenues. In general, output from the primary phase is one of the inputs to the secondary phase and so on (Figure 5). This kind of analysis can be extended to looking at the connections of the fishing sector with all other aspects of the economy, e.g., labour, exports etc. For example, how would an increase in domestic production of fishmeal reduce the import bill and could such an increase be need to reduce unemployment in particular regions of the country?

In some cases all three of the phases described may be carried out by one individual, e.g., a fisherman who dries fish and sells it to the consumer or by one firm which owns ships, processing plants and distribution networks. Particularly during development of the industry its structure will be dynamic, and one of the aims of planning will be to en sure balanced growth throughout the industry (e.g., -to avoid having too little processing or ice producing capacity for the catching power of the fleet).

In addition to the vertical division into three phases the differences between large scale, industrialised fisheries and small scale, artisanal fisheries are sufficiently important to be included in the scheme of classification. Although the ultimate objectives and hence data,

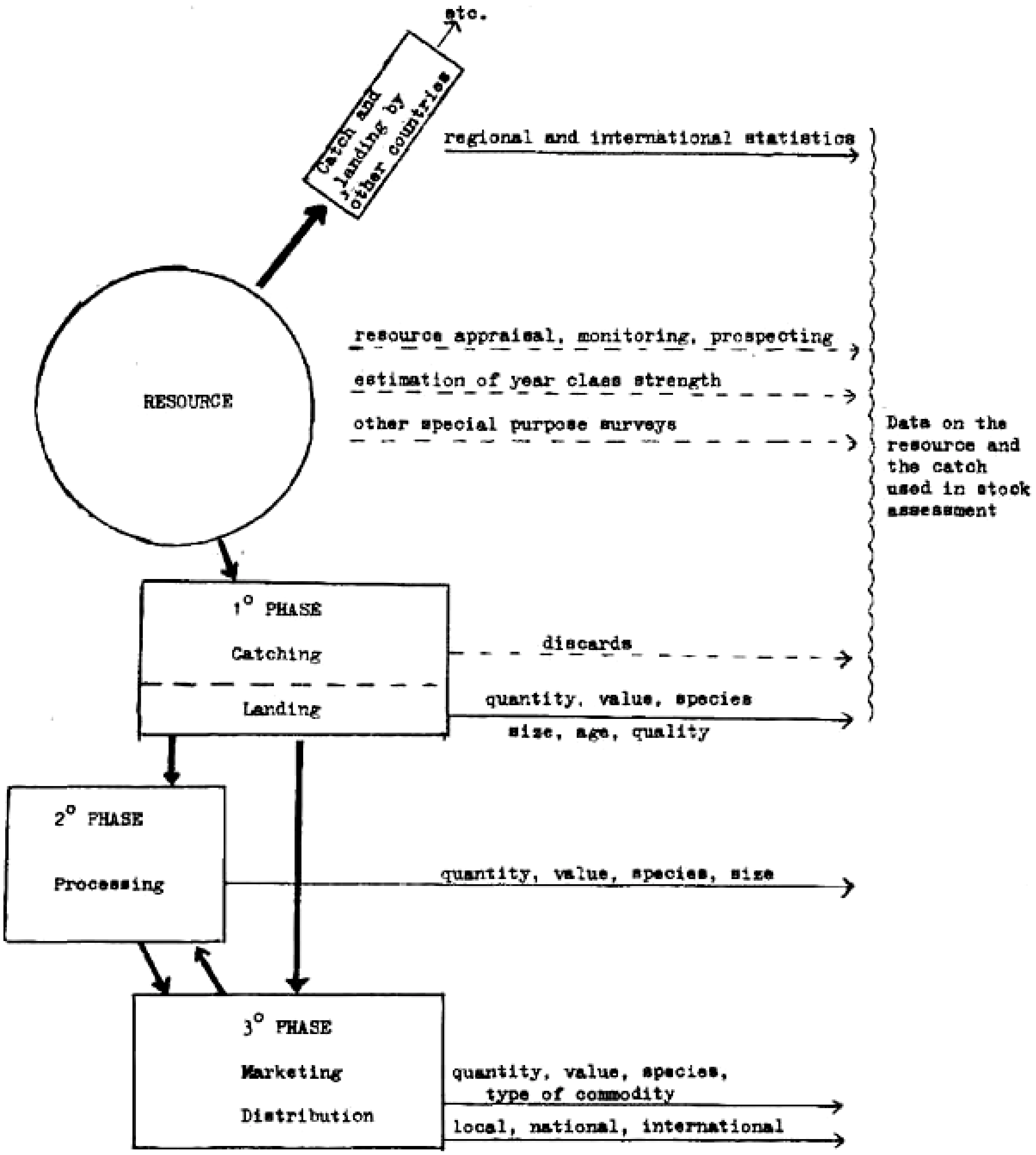


Figure 5: Showing the movement of the raw material through the industry (→) and the points of routine (→) and occasional (→) data collection, mainly for stock assessment

equirements for small scale and large scale fisheries may he quite similar, the problems of data collection are different and they will be dealt with separately in Section 3.

The fishing industry has a number of features which set it apart from other types of industry and from agriculture. The primary phase is a high risk activity in terms of physical safety and: in terms of return on investment. It is often seasonal and a very high proportion of the product is exported, so that there is a well developed world trade. There is direct international competition for limited renewable resources and this gives rise to international control of the activities of the industry. These and other features mean that the methods of studying the fishing industry and the data requirements are in many ways different from those needs in manufacturing and agriculture.

Reviews of the uses of statistics on North Atlantic fisheries by business and government are given by Parrish (1962). A few examples of the uses made of short term and long-term statistics may help to show how varied these are.

Short-term statistics:

(a) Marketing - currant price information is used by vessel owners when directing the activities of their fleets and by processors and distributors planning their buying. Governments may provide such reports on current prices to help fishermen choose where and when to sell and the government may intervene with price controls or import tariffs.

(b) Current fisheries management - already in many fisheries there is regulation based on daily reporting of catches. This is likely to spread as catch and effort regulations are introduced and the activities of fishing fleets are more strictly directed.

Long-term statistics:

(a) Investment planning - this may include studies of market trends and predictions of catch rates expected from different gears and types of vessel.

(b) Government research - studies of employment and income levels in the fishing industry. Contributions to the work of the international and regional regulatory bodies.

1.3.1 The uses of statistics by economists

Up to now economic studies have been concerned mainly with management at the national and local level rather than with international regulation, pertly because of the difficulty of applying economics in international contexts and obtaining agreement. The result has been that the data compiled by the international regulatory bodies have been almost exclusively biological and even at the national level the collection of biological data has been given greater emphasis. Of course catch and effort data can be used in both disciplines and many of the statistics needed for economic studies can be collected ad hoc, but there is a strong case for extending the routine collection to include data series used for economic modelling.

Economic models are used to study, among other things, (a,) how productively the industry uses inputs such as labour, capital and supplies, and (b) what the connections are between the fishing industry and the rest of the economy. They need statistics of the inputs, which include all the costs of the industry, and of the outputs, which include all the revenues. Some of the costs and benefits, particularly social costs, are intangible, but neglecting them limits the validity of the analysis. Inputs may be converted into terms which reflect their usefulness in other sectors of the economy, i.e., opportunity costs. The use of “shadow costs” for this purpose is discussed by Engtrom (1974). A difficulty which is encountered to a greater extent in the collection of economic data than biological data is that fishermen and companies often wish to conceal or distort figures of costs and earnings, and careful checking of data from a number of sources may be needed to detect this. For example, the monthly revenue figure quoted by a company may be compared with the quantity of various species landed at prevailing prices. Since a certain level of confidentiality about current operations seems to be necessary for many businesses this must be respected in the collection of statistics.

Some details of the data on the structure and operation of the fishing industry which are needed far assessing economic performance and for charting flows are given in Section 2.3. To show that the overall data requirement for management of the industry and for fishery development planning may be much wider than this, we can take as an example part of the table of contents of a paper on the preparation of fishery investment projects (Table 2, after Engstrom, 1974).

The fisheries statistics needed for development planning are discussed by Banerji (1975), but much of the information needed for an understanding of the fishing industry is less specific than this. Among the general information used may be population figures and projections, food consumption, gross national product, investment level, interest rates arid exchange rates. More specific information on fisheries may include taxes and tariffs on fish products and on the equipment and supplies used by the industry, subsidies, special loan rates, local labour availability and wage levels. All this information will come from a wide variety of sources and does not need the kind of routine collecting system with which this manual is mainly concerned. What is perhaps needed is an inventory of such requirements and a catalogue of their availability in different countries.

1.3.2 The uses of statistics by gear and food technologists

The objectives on the technological side of the industry are concerned with improving efficiency rather than simply measuring it. Research and development is carried out in order to improve the methods of finding, catching, handling, processing and marketing fish, to assess the technological requirements of different fisheries or countries, and to look for ways of applying technology towards the overall objectives of fisheries management. For example technical improvements in storage of the catch on board, which reduce spoilage, will give the fisherman more saleable fish of better quality. Better use is made of the gross catch and this may help to increase the income of fishermen or to reduce pressure on the stock.

Many of the routine statistical requirements of gear and food technologists are the same as those of biologists, but usually there is also a far more detailed short-term requirement for particular projects. The rout in requirement is for the usual catch and effort data, plus statistics on quantities of each species condemned, and possibly also information on other quality categories. Details of vessel, technological aids and gear are needed, as is information on the availability of ice and the capacity of storage and processing facilities.

At the detailed, short-term level, day by day or haul by haul information on catch rates may be used in order to assess the capacity and work rate of processing equipment on board. Some idea of the potential for fish meal and oil production can be gained from occasional sampling of the proportion of guts, liver and heads in the processing stage. This can be done at the same time as the calculation of conversion factors for “landings” to “nominal catch”. Such detailed, short-term statistics are not usually part of the general statistical collection system because they require special surveys or recording exercises. Because they are often of direct interest to the fishing industry they tend to be easier to collect than statistics whose value is indirect and obscure.

1.4 The institutional framework for data collection and compilation

Even when the objectives of planning, management and development are clearly defined and the importance of the collection of basic data is recognised, the problems of setting up and maintaining a collecting and processing system may be very great. If the need for collection is only recognised as a result of adverse changes in the fishery then speed in implementing such collection is paramount and it will often be too late to prevent a situation which could have been foreseen. There is increasing emphasis on the need for all those participating in a fishery to collect and report the basic data on catches and effort.

Table 2: Information needed for project formulation of fisheries development programme

PROJECT FORMULATION

a) Description of Project and Project Ares
b) Analysis of Fishery Resources and Catch Projections
c) Analysis of Demand and Sales Prices
d) Technical Feasibility
    (i) General
    (ii) Fishing operations
    (iii) Landing facilities
    (iv) Processing end. storage
    (v) Marketing and distribution
e) Financial Feasibility
    (i) Investment cost operating costs and cash flew
    (ii) Financing of the. project
    (iii) Financial profitability-internal financial return
f) Impact on national economy
    (i) Economic profitability
    (ii) Supply of food for domestic consumption
    (iii) Employment creation
    (iv) Income redistribution
    (v) Foreign exchange
    (vi) Regional development
    (vii) Public finance
    (viii) Other objectives

Most countries now have some form of collection of basic data on their fisheries, but the way in which the responsibility for collection and analysis is organised varies greatly. Figure 6 shows two extreme forms which the organization can take, one with all the functions performed within a single ministry, the other with each function separate. While there are disadvantages to having a single ministry with complete control over the sources and uses of information it is obvious that the advantages are very great. Fisheries administrators and planners must have some control over the kind of biological and economic research which is done and these immediate users of the statistics must in turn be directly involved in the setting up, development and evaluation of the data collecting systems. The organization of systems for data collection often has as much to do with the establishment of communication procedures as with direct recording and measuring. As well as basic data on the fishing industry and the resource itself, we have seen that many studies require much wider statistical information on the economy and the population as a whole. A full treatment of the general problems of setting up and maintaining a national statistical system are dealt with in a “Handbook of Statistical Organization” published by the United Nations, New York (Studies in Methods Series F. No.6). The particular problems of fishery statistical systems are dealt with by FAO, Fisheries Division (1965).

Even in the initial stages of setting up a statistical collection system for national and regional purposes, it is necessary to think ahead in order to design a system that will allow for subsequent growth and refinement. Not only can time, staff and funds be saved in this way, but the system should be capable of responding to change in a way that continues to make management on a rational basis possible. With the present rapid changes in jurisdiction and method of regulation, even the most sophisticated data collecting and processing systems in existence are frequently pushed beyond their capacities. The lag during which they catch up has to be filled with management based on guess rather than data. The scientific disputes which lie behind many recent failures in management are usually about which guess to adopt rather than about methods of work and models.

Because of limitations in the amount of money available for setting up and maintaining a statistical collection system and because it will take time for the organization, skills and facilities to develop in a country, there must be a system of priorities for the data to be collected. As well as specifying the priorities of the different categories of data, the qualities of accuracy, precision and timeliness must be considered. For example, how accurate and precise should the estimates of total catch be before it is worth allowing tires and money for the collect ion of effort data? In practice if a survey is to be carried out to collect catch data then effort and other data can be collected at the same time with little extra cost. Notes on priorities and collection of fishery statistical series for the use of less developed countries are given by FAO, Department of Fisheries (1975).

2. THE BASIC DATA REQUIREMENT

2.1 The qualities of the data related to their use

Fisheries scientists have filled a key role in formulating the objective, of management and hence in setting up the organizations and systems for trying to achieve them. At present they carry a very large responsibility for ensuring the clarity and credibility of their advice, particularly in matters of international regulation. This means that they also carry a large part of the responsibility for ensuring that the basic data requirements are being met and that the case for their collection is presented clearly.

A recent working party of the Advisory Committee on Marine Resources Research (ACMRR) discussed the qualities required for scientific advice, including timeliness, accuracy and precision, clarity and ease of comprehension, scope and relevance,

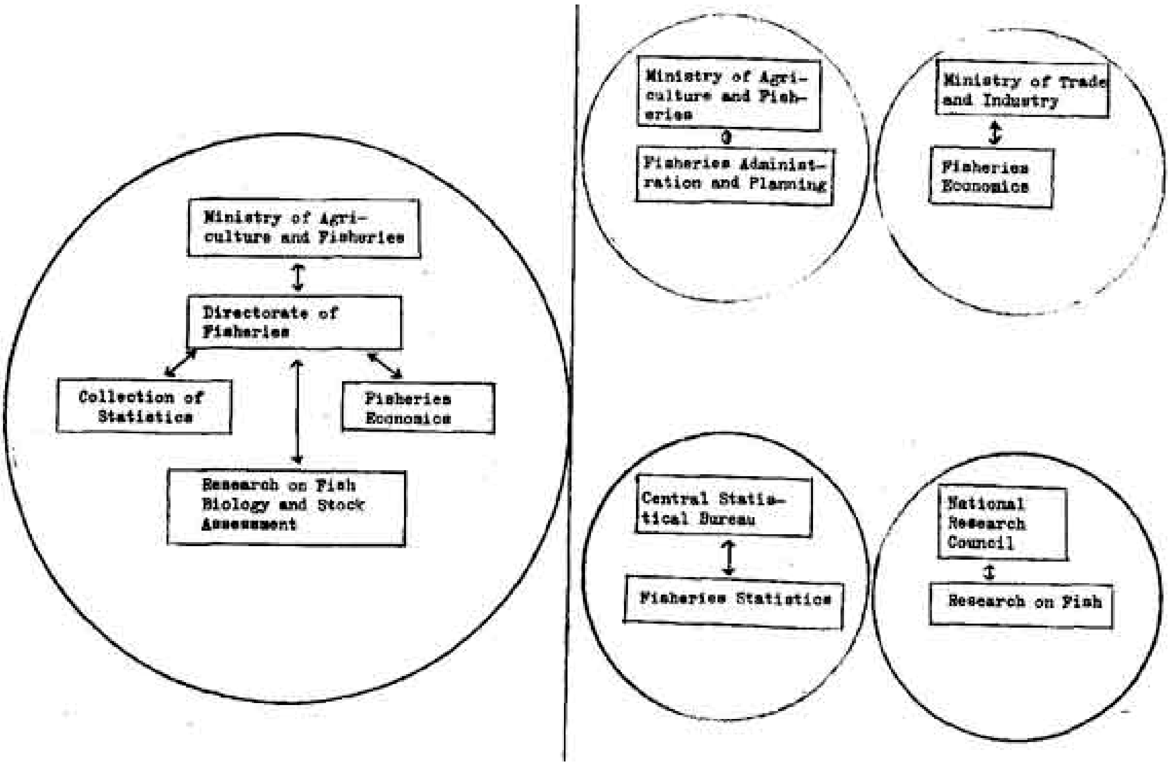


Figure 6: Institutions responsible for collecting, analysing and acting on fisheries statistics

A. Functions all performed within one ministry

B. Functions spread over several institutions acceptability and credibility (ACMRR(FAO), 1974). The same qualities apply to data, and it is very often failure in the supply of data which lead to inadequacies in the scientific advice. It is fairly easy to appreciate from a common sense point of view why these qualities are important if we relate them to a simple example like the one given in the introduction.

A census of population to provide information on the planning of hospital and school building over the next five years will only be useful if the results are available fairly quickly and in a form which the planners understand and trust.

Difficulties arise for a variety of reasons, which can be rectified only if they are made clear and the will to rectify them exists. Perhaps the greatest of these is that the collection and study of data, formulation of advice on specific problems and actual planning and implementation of a management policy are carried out in a number of stages and often by different people or groups of people with different interests. Even if they all work within the same ministry or organization and the objectives of the collection of statistics are laid down, it is vital that the purpose of each step in the process is clearly understood by those undertaking the work. In practice it is more usual to find that the data collection system serves a variety of users and that, for example, the failure to produce a particular set of statistics on time is due not to laziness or incompetence, but to the lack of awareness by all those concerned of the overall functioning of the system.

Although very difficult to overcome once a system has become institutionalised, many of these problems could be avoided by clear planning at the outset and intelligent use of management techniques. The kind of system analysis and flow charting needed in order to implement systems of automatic data processing will also often help to reveal bottlenecks and inadequacies. Automatic data processing itself may provide a cure to some problems of data handling, but only if the necessary clarity in defining objectives has been achieved. Regular reappraisal is needed with all collecting and processing systems, irrespective of their level of sophistication.

As well as these institutional problems it is absolutely essential that the data should be defined clearly and unambiguously in all classifications and tabulations, that totals arrived at by different routes should correspond, and that figures which appear in different places (e.g., exports from country A to country B, imports by country B from country A) should be the same or that any discrepancies should be explained. The prevention of such discrepancies and the use of checks in processing will be dealt with in Section 4.

2.2 Data for stock assessment

2.2.1 Catch

The term “catch” is often used loosely, when what is really meant is “landings”. “Landings” should always be used to mean the actual weight of the fish landed, whether it is gutted, filleted., frozen, reduced to meal and oil etc. “Catch” or “nominal catch” is the live weight equivalent of the “landings”. Factors for converting “landing to “nominal catch” should be calculated for each species or group of species for each way of landing, e.g., frozen whole, frozen filleted, unfrozen gutted. There may even be variations for the same species from different areas caught at different times of year which have to be taken into account. For scientific purposes, international statistics of fish catches should be of “nominal catch”. Since the biologist is concerned with the effect of fishing on the stock rather than with the supply of fish at the port he also needs to know the quantity of fish discarded at sea plus any other losses between catching and landing. Taken al together these make up the total weight of fish

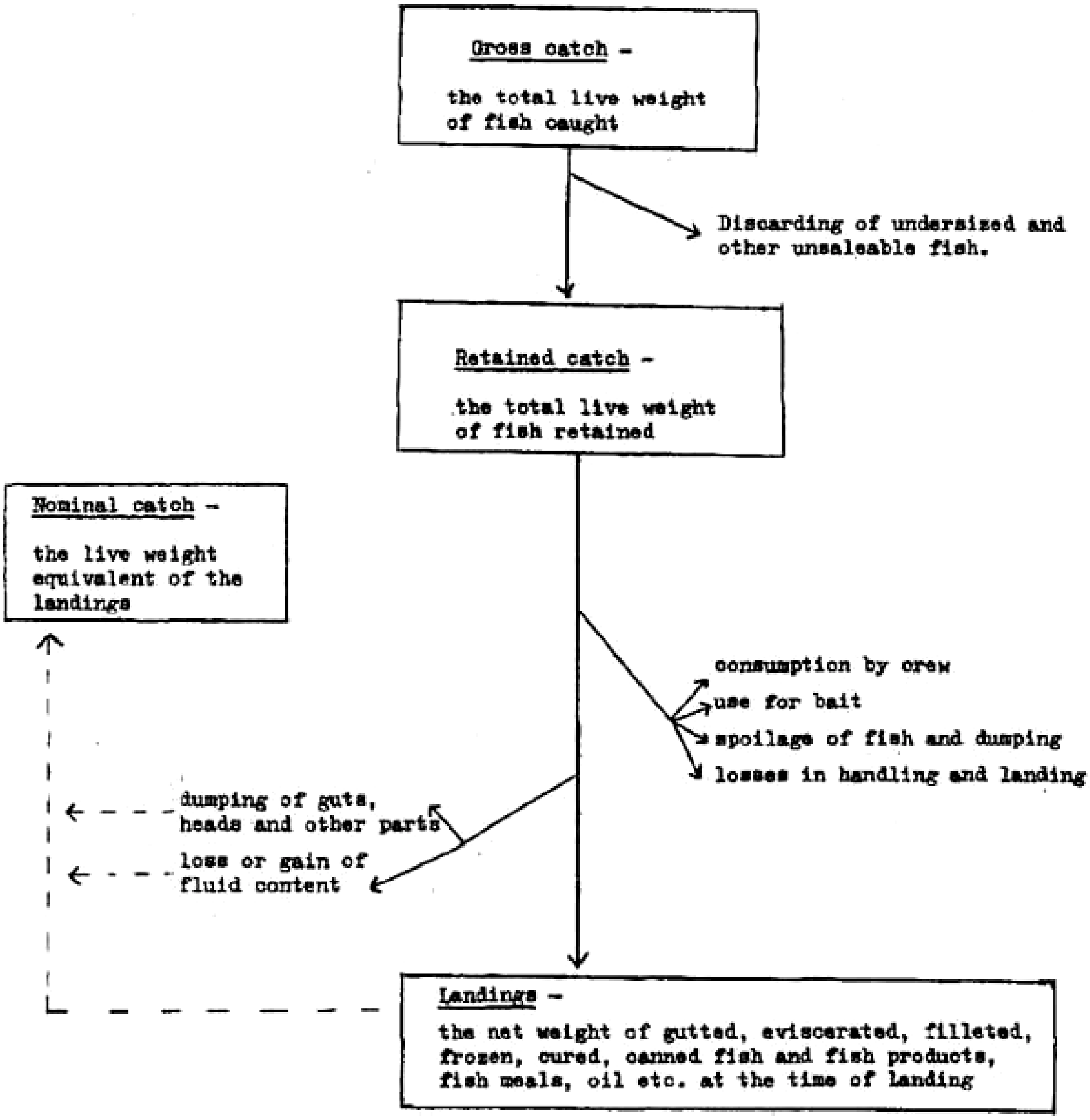
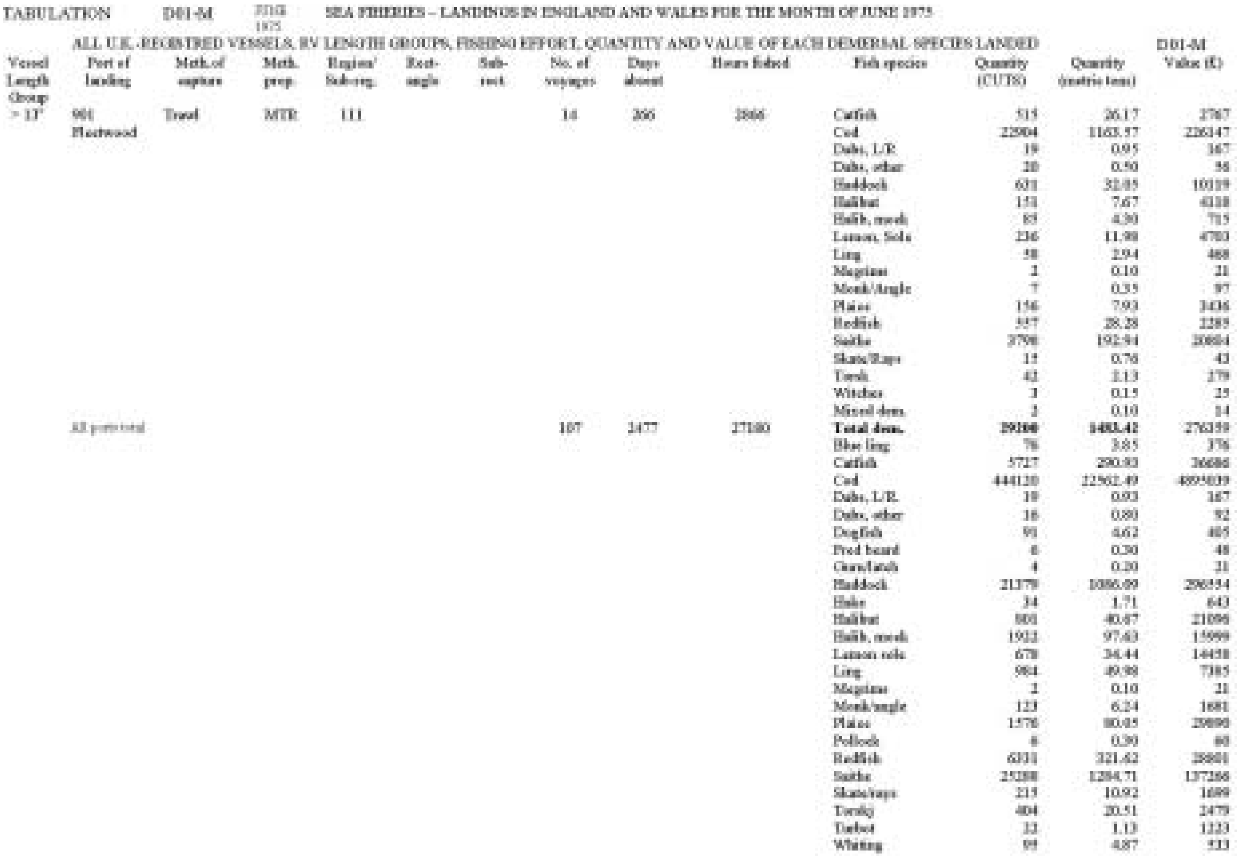


Fig 7: The definitions of catch



TABULATION D01-M JUNE 1975 SEA FISHERIES – LANDINGS IN ENGLAND AND WALES FOR THE MONTH OF JUNE 1975

ALL U.K.-REGISTERED VESSELS, BY LENGTH GROUPS, FISHING EFFORT, QUANTITY AND VALUE OF EACH DEMERSAL SPECIES LANDED D01-M

Vessel Length Group	Port of landing	Meth. of capture	Meth. prop.	Region/ Sub-reg.	Rect-angle	Sub-rect.	No. of voyages	Days absent	Hours fished	Fish species	Quantity (CWTS)	Quantity (metric tons)	Value (£)
> 17'	901 Fleetwood	Trawl	MTR	111			14	266	2866	Catfish	515	26.17	2767
										Cod	22904	1163.57	226147
										Dabs, L/R	19	0.95	167
										Dabs, other	20	0.50	58
										Haddock	631	32.05	10119
										Halibut	151	7.67	4118
										Halib, mesh	85	4.30	715
										Lemon, Sole	236	11.98	4783
										Ling	58	2.94	468
										Megrims	2	0.10	21
										Monk/Angle	7	0.35	97
										Plaice	156	7.93	3436
										Redfish	557	28.28	2285
										Saithe	3798	192.94	20884
										Skate/Rays	15	0.76	43
										Torsk	42	2.13	279
										Witches	3	0.15	25
										Mixed dem.	2	0.10	14
	All ports total						107	2477	27180	**Total dem.**	**29100**	**1483.42**	276359
										Blue ling	76	3.85	376
										Catfish	5727	290.93	36686
										Cod	444120	22562.49	4895039
										Dabs, L/R	19	0.93	167
										Dabs, other	16	0.80	92
										Dogfish	91	4.62	405
										Fred beard	6	0.30	48
										Gurn/latch	4	0.20	21
										Haddock	21379	1086.09	290554
										Hake	34	1.71	643
										Halibut	801	40.67	21096
										Halib, mesh	1923	97.63	15999
										Lemon sole	678	34.44	14458
										Ling	984	49.98	7385
										Megrims	2	0.10	21
										Monk/angle	123	6.24	1681
										Plaice	1578	80.05	29890
										Pollock	6	0.30	60
										Redfish	6331	321.62	38801
										Saithe	25288	1284.71	137266
										Skate/rays	215	10.92	1699
										Torsk	404	20.51	2479
										Turbot	22	1.13	1223
										Whiting	99	4.87	533

Fig. 8: A sample of catch and effort statistics compiled in the U.K.

removed from the sea, or “gross catch”. In some instances the proportion of the “gross catch” which is discarded is very high and since the fish involved are usually small it may represent a very high mortality on young fish. Figure 7 shows the relationship between the various catch definite ions. Notes on conversion factors, time periods, direct foreign landings and classifications into specie are given by FAO, Department of Fisheries, Fishery Economics and Institutions Division (1973). These definitions and classifications must be strictly observed in order to en sure that statistics collected in different places or at different times are comparable.

The degree of subdivision of the catch data by species, area, time period, vessel type etc. will of course depend on the use to which the data are put. A balance must be struck between the degree of subdivision and the cost of collecting and processing. (For example, to assess the effect of proposed. gravel dredging on a small trawl fishery one needs detailed. information on the quantities and values caught near gravel deposits in the area). Since the number of possible species x area x time x vessel type x gear x port combination is enormous it is impossible to produce them all and instead a, small number of the more widely used ones are tabulated. Others can be obtained as required. With a full data storage and retrieval system it should be fairly straightforward to store the original data and reprocess it in different ways when needed. Table 3 gives a list of some of the tabulations of catch statistics for demersal fish available in the U.K. with an indication of those which are most commonly used. An example of one of the tabulation., which are output by a computer line printer, is given in Figure 8.

The major publications of international fishery statistics give catch by species or species group by year for each major fishing area or for sub-areas within them. The Coordinating Working Party on Atlantic Fishery Statistics holds regular meetings to review categories and classifications used and to improve the methods of compilation, processing and dissemination. The report of the 8th session (FAO/ICES/ICNAF/ICCAT/ICSEAF, 1974) deals among other things with the most recent updating of area codes in the Atlantic, classification and codification of species items worldwide and the International Standard Statistical Classification of Fishing Vessels. FAO, Department of Fisheries (1973) provides more dc tails of vessel and gear types and fishing areas. Classifications of species and species groups for statistical purposes are being continuously updated (e.g., FAO, 1974). where certain landings or parts of landings cannot be assigned to a species or species grouping they may be classified as “other”, but any information about the species which are likely to be lumped, together under this heading should be recorded and reported.

2.2.2. Effort and catch-per-effort

We have already stated that in general terms fishing effort is the work done in catching fish, i.e., the input of labour, vessels, skill and technology, but that it does not have a standard physical dimension (e.g., joules). The classifications of areas, ports, vessel categories and time periods used for recording effort should be the same as those used for recording catch so that the effort used for a particular catch is known. The economist is concerned to translate these inputs into terms of money, taking account of the opportunity costs. The biologist is not concerned with the money value or even necessarily with the physical values of the inputs as such. For him one unit of fishing effort (f) removes a constant proportion of the stock and is directly related to the fishing mortality (F) by a constant known as the catch-ability coefficient (q), i.e., $F = q.f$. For example, if the fish in a pond are evenly distributed over the bottom and one takes every fish in 1/4 of the area then one takes 1/4 of the stock regardless of whether there are 100 fish or 1 000 fish in the pond. The numbers of fish taken by one unit of effort, in this case 25 or 250, (= the catch per unit of effort) are art index of the difference in abundance.

Table 3: Some of the tabulation, of catch and effort statistics of demersal fish available in the U.K.

	Items tabulated						**Classified by**						
					Weight + value								
	No. of voyages	**Days Absent**	**Hours Fishing**	**Tonnage**	**By species**	**Total**	**Other**	**Vessel size**	**Port**	**Fishing gear**	**Region**	**Rectangle**	**Other**
					*	*			*				
					*				*				Sales category
					*	*	Unit value						
					*	*		*		*	*		Freezer/Fresher
#	*	*	*		*	*		*	*	*	*		
+	*	*	*		*	*	Catch per effort	*	*	*	*	*	
					*	*		*	*				
+	*	*		*		*		*	*	*	*		Individual vessels
	*	*	*	*				*		*	*		Freezer/Fresher
	*		*	*	*	*				*		*	
+					*	*				*		*	
					*	*					*		
		*	*	*	*				*		*		Individual freezer Fish condition
	*	*	*	*	*						*		

The tabulation marked # is showen in Figure 8

+ Mark those. Frequently used

In practice the use of fishing effort as a measure of fishing mortality or of catch-per-effort as a measure of abundance (given total catch the two are essentially the same thing) is far more difficult than the simple example would suggest for two reasons (1) the catch-. Ability coefficient q is not constant because in a real situation the fish are not evenly or randomly distributed and neither are the fishing boats; (2) what we are able to measure directly is not the proportion of the stock caught, which is our definition of fishing effort, but some or all of the factors which we think may affect the proportion of the stock caught by a vessel or fleet in a particular time period.

Taking the first of these, let us suppose that the fish all come together for spawning at one time of year. At this time one unit of physical input (e.g., one day's fishing) in the spawning area will catch a far higher proportion of the stock and cause far greater mortality than when the fish are scattered. However, if such seasonal changes are a regular annual feature then the catch-per-effort in, for example, a spawning fishery will still be an index of year to year changes in abundance. If such a year to year change in abundance is all that is needed from the effort measurement then it may be sufficient to collect this datum only for a short period each year, during which it can be well and easily estimated. We are thus allowing for a change in the catchability coefficient, q, caused by the regular seasonal migrations of the fish. Short term fluctuations in catchability caused by, for example, diurnal migrations can also be allowed for, but often it is necessary to assume, as the simplest hypothesis, that q has remained constant, in the absence of any evidence to the contrary.

The second difficulty, that of finding an index of fishing effort, has been the subject of a very large body of research (e.g., Pope, 1975). Rothschild (1972) has suggested that the factors which affect fishing effort (e.g., the product of time spent fishing and gear, horsepower and size of vessel, etc.) should be called "fishing inputs". They are also sometimes known as "nominal effort". Fishing effort can be regarded as the product of fishing time and fishing power, which in relation to a uniform density of fish are defined as follows: the fishing power of a vessel or fleet is the quantity of fish which it catches per unit of time, relative to other vessels or fleets, and the fishing time is the time during which catching takes place. In other words if two boats fish side by side for an hour and one catches twice as much as the other then its fishing power is twice that of the other.

The quantity of fish which a vessel catches per unit of time (i.e., its fishing power) will be determined primarily by the size of the vessel, its horsepower and the type and size of gear used, but a large number of other factors can play a part. Among those which have been investigated are the age, storage capacity and method of construction of the vessel; the size and skill of the crew; the use of technological aids such as Decca navigators, echo sounders, sonar, power blocks and in many oases, the particular species sought. Some of these factors cannot be physically measured and the ways in which they affect fishing power are complex and liable to change; nevertheless they provide a framework for dividing a fleet into categories within which fishing power is less variable, and these categories from the basis for the classifications of fishing effort given by FAO, Department of Fisheries (1973).

For each effort category (or more strictly fishing power category) we need a measure of the fishing time. For some gears (e.g., trawls), the quantity of fish caught will depend fairly closely on the time that the gear is actually fishing, and hours fished or number of hauls, if the haul length is constant, will be a good index. The time in the water will not be a good index for gears which become saturated (e.g., a long line on which all the hooks are taken or a drift net with clogged meshes) or for gear in which searching for fish plays an important part (e.g., whaling, purse seining).When deciding on the measure of fishing time appropriate to a particular situation the question to be asked is "would we expect the catch to go up in direct proportion to this time unit, given that fishing power stays the same?" The measures of fishing time used in most fisheries include: number of hours fished; numbers of hauls, drags or sets made; number of days fished.; number of days on ground; number of days absent from port; number of trips made. Since these measures are not mutually exclusive they can all be measured for each vessel if desired and the moat appropriate one selected. For a purse seine fishery it may be useful to know in. addition the time spent handling the gear, the steaming time to and from the grounds and the searching time on the grounds. Even in the situation where the statistics of fishing power and, fishing time available are detailed and appropriate, the biologist will require great skill and knowledge to interpret them in constructing his index of fishing effort.

If no conventional statistics of fishing effort as listed above are available it may be necessary to look elsewhere for data. One example of this is the use of records of fuel consumption, kept by the tax authorities, as a measure of the work done by fishing boats (Levi and Giannetti 1973). This is a rather direct measure of work, but if, over a period, relatively more fuel on a boat is used for refrigeration and ancillary equipment than for fishing, this will give the appearance of an increase in fishing effort. This is also the case with other fishing effort measures used to compare freezer trawlers with fresh-fish trawlers. A fresher has a higher fishing power than a freezer of the same size and engine power and their fishing tactics differ, since a fresh-fish trawler is concerned to fill up as fast as possible, while a freezer has to work more steadily to stay within the capacity of its processing equipment.

In choosing statistics for measuring “fishing effort” or “fishing inputs” for whatever purpose, there are two factors which must always be kept in mind.:

1. The statistic chosen must be widespread, persistent in time, easy to measure, capable of aggregation within each effort category and unambiguous.
2. The concept of “fishing effort” implies maximization of some output (i.e., the work done), whether explicit or implicit, on the part of the deployer, and there must be some idea, however vague, of what is being maximised..

Catch per effort is usually found by dividing the catch for a particular area,/port/vessel category/time unit by the equivalent effort. In many cases only the effort for a small group of vessels within the vessel category or for one vessel category out of the many landings within the aria/port/time unit is known. Provided the equivalent catch is available it is then possible to rise up this partial effort figure by the total catch to give an estimate of total effort. The units in which the total effort is then given will be the units in which the partial effort was given. Similarly the total catch could be calculated if the total effort of the fleet and the catch per effort of part of the fleet were known. The reliability of these estimates of course depends heavily on how closely the catch per effort of the whole fleet resembles that of the known part. In cases where the fleet as a whole is very heterogeneous but there is a sizeable group of reliable and non-varying vessels, the method of deriving total effort from the catch per effort of this group will be the best procedure to follow.

2.2.3 Other requirements for stock assessment

Length frequency distributions are normally the first step in looking at the detailed structure of the fish population, in particular for establishing its age composition and growth and mortality rates. This length frequency distribution of the landings is estimated by sampling, since it is generally impossible and unnecessary to measure every fish landed.

We noted in Section 2.2.1 that the biologist is often concerned with “gross catch” rather than “landings” or “nominal catch”. Estimates of relative length frequency from landings will be biased when discarding is taking place, because it is normally the smallest fish which are discarded to comply with minimum size regulation or marketing requirements, The relative length frequency in the “gross catch” will not be the same as the length frequency in the fishing area because of the behaviour of the fish and the selectivity of the gear. In order to allow for this the mesh size and selection characteristics must be known for nets, and the pattern of avoidance for other types of gear. Finally the population in the area being fished may differ from populations in other arias in its size or age composition. In this case special surveys have to be carried out if data on the whole population are required, lost uses require only length frequency distributions of the "landings" or "gross catches", with some information on the mesh sizes in general use.

Length frequency distributions are mainly important as the first step in obtaining age frequency distribution, i.e., the numbers and sizes of fish of different ages in the "landings" or in the "gross catch". A series of age frequency distributions for a number of years forms the basis of most analytical assessment models. They are used to establish the growth of the various species of fish, the age structure of the population, the age at which young fish become liable to capture and how quickly the fish die off due to fishing and natural causes.

This kind of information, collected over a long period., is vital to an understanding of fish stocks, including the competitive relationships between different species, the relationship between the size of the adult stock of a species and the number of young produced (year-class strength) and the influence of climatic or other factors on year-class strength. These are the most important long term biological problems in rational exploitation of the sea, but the age and size characteristics are also needed by fisheries managers in order to take decisions on mesh size regulation and the closure of a fishery at certain times of year or in particular areas. Precise and effective regulatory measures of this kind can only he taken if sufficiently detailed routine statistics are available to evaluate their effect.

The other type of regulation being applied with increasing frequency is the annual catch quota and this too needs information on year-class strength, particularly of the in coming (recruiting) year classes. In a fishery which depends heavily on the recruitment of a fast growing species the catch for the next year can only be predicted accurately if the strength of this recruitment can be estimated. Up to the present time this has been done by special surveys, if at all, but if catch quotas are to become a regular management tool then estimates of the strength of incoming year classes will have to become a regular statistic. This type of information is obviously also of great interest to fishermen, particularly if presented in a fairly detailed and practical way (e.g., Figure 9 from Fishing Prospects, 1972 – 1973 (Great Britain 1972)). The methods of obtaining routine length and age frequency distributions of the landings are dealt with in Section 3. In situations where the fish cannot be aged it is often still possible to predict future catches from the size frequency distribution by using relative growth and mortality rates.

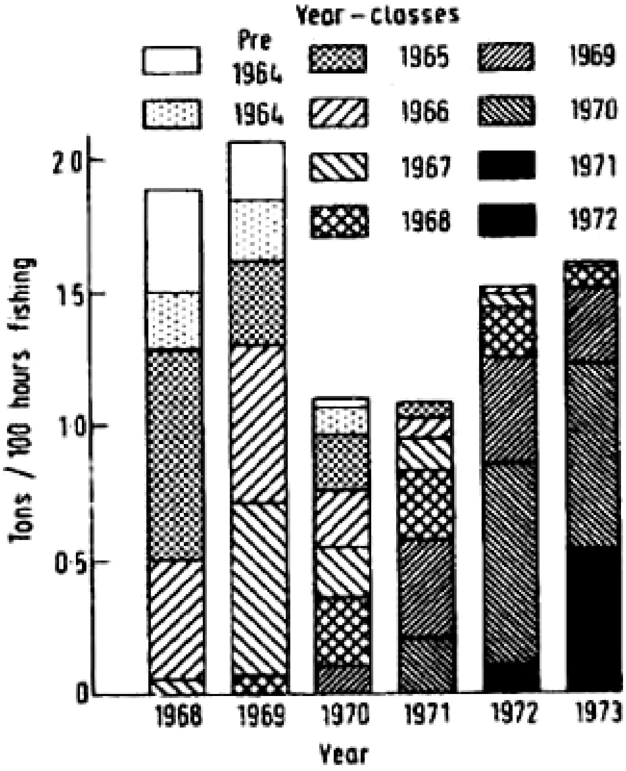


Figure 9: Catch-rates of Irish Sea cod 1968-72, and predicted catch-rate for 1973 (Great Britain, 1972).

2.3. Data requirements for study of the fishing industry

We have already noted that the study of the fishing industry in its broadest sense requires data on many general aspects of the economy of a co as a whole, such as employment, income, population, investment etc. A discussion of all these requirements, important as they are to studies of the fishing industry, is obviously beyond the scope of this work. The collection of each statistics is usually part of the work of comprehensive national statistical systems such as industrial censuses, censuses of commercial establishments, imports and exports etc. To a large extent such system will cover the activities of the secondary and tertiary phases of the fishing industry: processing, marketing and distribution. The national fishery statistical system may have some responsibility to advise on appropriate and adequate coverage, but its main responsibility will be for statistics of the primary phase. The fisheries department, although not responsible for the collection of general industrial and social statistics, should be aware of their extent and of their shortcomings. For example in preparing national statistics of labour utilization and in come levels it is common for fisheries to be included with agriculture and forestry in the final publication. The value of such genera) statistics may be very low in a detailed economic study of the fishing industry, and the fisheries department should have access to any more detailed, intermediate statistics which are collected in preparing the overall figures, and should ensure that they are not destroyed once the overall statistic is tabulated., Cooperation between different users is essential to avoid duplication or wastage. Another common example 9 this is that statistics of numbers of vessels and characteristics will often be kept, for registration purposes, by the ministry or bureau responsible for all shipping.

2.3.1 Statistics of the structure and operation of the primary phase

Many of the statistics for economic and industrial studies are covered by the collect ion of data for stock assessment purposes. The differences lie in the amount of detail and importance of different statistics. For example, for many economic studies it is unnecessary to know the value of the landings of each different species, and a classification into “high value” and “low value" species may be sufficient. It is difficult to specify the amount of detail and the level of priority which should be given to different statistics without knowing the objectives for which they are needed. A few comments on the relative importance of different statistics within a category are given below but the choice of what to collect must be made in the light of each situation. It is probably a good idea to aim for some coverage in each category in order to follow general long-term trends.

The statistics included under the heading "Structure" are more or less unvarying and can therefore be collected once and updated as changes occur or on a regular basis. For example the number of vessels at a port or site could be counted once and checked annually, or it could be the duty of the harbour master, if one exists, to report any changes. The operational statistics need continuous monitoring arid will therefore be more expensive to collect. Opportunities for combining the collection of operational statistics needed by different users should not be overlooked. (e.g., effort statistics for biologists and cost of labour for economists can often be collected. at the same time).

2.3.1.1 Structure

It should be fairly obvious that some of the structural statistics listed here are needed before any others can be collected at all, because they provide the frame within which the others are collected:

1. The location and number of fishing Bites or ports; their size (number and frequency of landing which they can handle) and facilities (ice, processing plants, repair facilities, transport).
2. The number and characteristics of fishing vessels at each port or site. The characteristics may be adequately described, by giving the names of different classes of vessel, e.g., four different kinds of traditional canoe, or a complete breakdown of characteristics may be needed (see Table 4 for example). The number of vessels at each port or site must sum to give the total number of vessels engaged in fishing, i.e., it must take movements into account and not count the same vessel twice.
3. The value (purchase price and current value) end year of manufacture or purchase of all equipment used.
4. The number of fishermen. They can be classified by age and status. Three kinds of statue classification may be used. to show (a) time spent fishing, e.g., full time, part time, occasional, unemployed; (b) employment status, e.g., skipper, mate, deck hand, learner; (c) ownership status, e.g., owner, skipper/owner, shareholder fisherman, employee.

There are also other workers within the primary phase of the industry, who land the fish and do some of the grading and processing before it is sold. They can be grouped generally as "land based" or classified in ways similar to those used above.

Sport fishermen are excluded from international compilations of manpower s but their numbers are often recorded at the national level in order to measure the amenity value of particular resources. The classifications used in completing FAO forms on statistics of fishermen are given by FAO (1966).

2.3.1.2 Operations

(a) Input

The fishing inputs (e.g.; hours worked, supplies, vessel time) discussed in Section 2.2.2 are of interest from two points of view in studies of the industry:

1. measured in terms of their cost, they can be used to assess economic performance
2. the physical and engineering aspects of the fishing operation are measured for assessment of technical performance.

The two approaches may be integrated in order, for example, to evaluate the size and type of fishing vessel which will be most profitable in a given fishery situation (an example is given by Engvall and Engstrom, 1974).

Operational costs include:

(a) repair and maintenance

(b) supplies of fuel, ice, bait, lubricants and food at cost to the vessel

(c) labour costs and hours worked, which can be broken down according to any or all of the classifications previously given.

The frequency with which these statistics need to be collected varies. Repair and maintenance figures may be given annually, supplies and labour more often, in order, for example, to show seasonal variations in employment. The largest cost items are usually fuel and labour.

From both the economic and the technical points of view we need to know not only the cost or the amount of energy used, but the time over which it was used, e.g., the daily cost or rate of work. Since both cost and rate of work depend greatly on what the vessel is doing one needs statistics of time spent fishing, searching, steaming, unloading, in dock, being repaired and waiting for bad weather. Much of this information will also be needed

Table 4 : Characteristics of fishing vessels (FAO, Department of Fisheries, 1973)

1.0 VESSEL CHARACTERISTICS

The list of vessel characteristics to be retained in the register is given as follows:

1.1 <u>Identification</u>

(a) Country
(b) Registration number
(c) Base port
(d) Name of vessel
(e) Name of owner
(f) Type of vessel

1.2 <u>Vessel characteristics</u>

(a) Overall length (m)
(b) Overall breadth (m)
(c) Depth (m)
(d) Gross registered tonnage
(e) Year built
(f) Country in which built
(g) Hull conversion - year (with explanation on type of conversion)
(h) Building material for hull
(i) Propulsive engine (steam-piston, steam-turbine, motor (combustion), electric coupling (diesel electric), others)
(j) Fuel (coal, oil, petrol/gasoline, others)
(k) Capacity fuel bankers (m^3)
(l) H.P. (total all engines)

(m) HP. for population
(n) Type of propeller(s)
(o) Propeller, revolutions per minute (free running)
(p) speed on trials (knots)
(q) Changes in propulsive engine

2.0 OPERATIONAL CHARACTERISTICS

2.1 Types of fishing gear

The fishing gears are recorded according to the classification shown in Part B of this Fisheries Circular.

The aim is to indicate the gear or gears for which the boat was built and not all gear. , could be used by the boat with or without transformations. The statistical record of fishing vessels cannot replace the operational reports on the catches taken by the vessels.

The actual gear utilised should be mentioned in the operational statistics; the fishing vessel statistics should only deal with the permanent characteristics of the vessel.

Table 4 (Contd.)

2.2 Personnel: (crew number)
2.3 Salting facilities :(yes or no)
2.4 Hold capacity (in cu.m.):

(a) Fish hold capacity
  1. without insulation
  2. insulated only
  3. mechanically refrigerated.
  4. frozen (only for frozen fish)
  5. frozen (equipped to hold. also wet fish)

(b) Fish tanks
  1. used dry or as water tank
  2. water tank (refrigerated sea water or tanks for live fish, shellfish or bait)

(c) Other hold capacity
  1. liver oil
  2. fish oil
  3. fish meal
  4. others

3.0 SPECIAL EQUIPMENT

3.1 Processing facilities

(a) Freezing (t. per 24 hours)
(b) Filleting, machine (number of machines)
(c) Filleting, hand (using specialized installation)
(d) Canning (t. of raw material per 24 hours)
(e) Meal (t. of raw material per 24 hours)
(f) Oil (t. of raw material per 24 hours)
(g) Others (t. of raw material per 24 hours)

3.2 Electronic equipment

(a) Radio
(b) Radio V.H.F.
(c) Radar (number of instruments)
(d) Echo-sounder, vertical (number of instruments)
(e) Echo-sounder, horizontal or ranging (number of instruments)
(f) Decca navigator
(g) Loran
(h) Auto-pilot
(i) Direction finder
(j) Facsimile receiver
(k) Netzsonde
(l) Warp tension indicator
(m) Others

3.3 Other equipment

(a) Powered block
(b) Side thrust propeller(s)
(c) Fish pump
(d) Powered net drum
(e) Fishing with lights
(f) Electric fishing gear
(g) Others

in biological studies of fishing effort and unless there is a special requirement for a particular technical or economic study the biological requirement should be sufficient on a routine basis. The more detailed time statistics which may be needed for economic or technical studies can usually be collected ad hoc rather than routinely.

(b) Output

The output from the primary phase is fish and landed fish products of various kinds which are converted to figures of “nominal catch”. They generate revenues to the fisherman, i.e., value at first sale, price. In order to measure technical or economic efficiency by means of input/output ratios these outputs must be classified into the same groups as the inputs (e.g., by vessel/gear type, port and time period), but in addition the total catch is usually classified first by species. The data on output available from collection programmes for biological work will usually be sufficiently detailed for economic studies, with the addition of price or value statistics, but three further cross-classifications may be needed:

1. Type of commodity landed
2. Disposition channel (see Table 5)
3. Quality-for marketing studies and price control

2.3.2 Statistics of the secondary and tertiary phases

Input/output analysis of the later phases is aimed principally at establishing the value added at each stage and at charting connections with other industries and measuring capacities and flows. The inputs again are:

1. Capital - original cost, age, number, type and capacity of equipment and plant, and whether, for example, trucks can be used elsewhere in off-seasons.

2. Labour - hours worked and wages per month for different worker groups
3. Supplies -fuel, power, packing material, purchase of fish.

The purchase price in the secondary phase should equal the landing value, since this is the same transact ion, and the volume and value of sales from each phase should equal the volume and value of purchases later on. Any discrepancies should, be explained. The out put from the secondary and tertiary phases is measured by the quantity and value of the product. The stock holding capacity in each phase should be recorded.

3. COLLECTING THE DATA

Having established what the basic data requirement is, with some indication of priorities, we now turn to the problems of collection. In designing collection methods the advice of a competent and experienced statistician is absolutely essential, as the procedure to follow is by no means simple. The statistician is concerned with the method and design of measurement and will try to establish:

1. What is to be measured?
2. What questions should be asked?
3. What precision is needed?
4. How can the survey beet be carried, out to provide the information desired with the desired precision and no more?
5. What will the survey or sampling system coat?
6. What do the results mean?
7. How can objective measures of the sampling errors and biases be obtained, so that the reliability and meaning of the results can be assessed and methods improved?

Table 5: Disposition channels and commodity types (FAO, 1966)

Disposition channel	Type of commodity produced
(a) For marketing fresh	Fresh products: live, fresh, chilled or iced, round or dressed., fish fillets, cutlets, etc
(b) For freezing	Frozen products: frozen, round or dressed fish cutlets, fillets, etc.
(c) For curing	Cured products: dried, salted (wet-salted, brine-packed, etc.), smoked, spiced, seasoned marinated, vinegar- or sugar-cured, fermentedproducts (sauces, Juices, pastes), etc
(d) For canning	Canned products: packed in airtight containers.
(e) For reduction	(i) Oils: edible and inedible body oils, liver oils containing vitamins, etc.
	(ii) Meals and fertilizers: including various kinds of meals and solubles.
(f) For miscellaneous purposes	Miscellaneous products bait, pearl essence, glues, etc.
(g) Offal for reduction	

Once again we must return to consider the overall objectives and the objectives of collecting data in order to specify what reliability is to be aimed at and what cost we are prepared to pay in order to obtain it. These are questions which a statistician cannot answer, but which he should help us to pose clearly. He may, for instance, design alternative surveys or sampling systems to show the relationship between cost and precision, taking account of the personnel and facilities available and the restrictions likely to be en countered. Finally he should, appraise the precision actually attained and evaluate the results generally, with a view to improving the design. The three steps of specifying, designing and appraising are clearly interrelated, so that a change in specification may alter the design and the result of an appraisal may be a change in specification.

The precision of a sampling procedure can only be estimated if the sample is drawn - randomly from the population being sampled. Precision can be represented as the scatter of points about the mean of a large number of such samples (see for example Bazigos, 1974). The accuracy of this mean is measured by the difference between it and the true mean value in the population. In practice this “true mean value” is not known and often may not even be established by complete census, but some idea of accuracy may be gained by the use of different estimation procedures for the same statistic and by a careful appraisal of possible sources of bias. Apart from clearly defined objectives and a defined level of precision or cost to work to, the statistician requires some information on the structure of the population being studied and on the way in which the sampling may be organized.

In this chapter the problems of collecting from industrialized fisheries based at a few large ports are considered separately from the problems of collecting from scattered, small scale or artisanal fisheries, because, although the objectives are very similar in both, the methods which can be used are rather different. As will no doubt become obvious from later comments, we are using the terms “small scale” and “large scale or industrialized.” in a rather general way to indicate difference in size of vessels, landing sites and markets; degree of technological advance and general level of development. There are of course intermediate fisheries of many kinds, snob as lobster fisheries - scattered fisheries using small boats with advanced technical aide and with international markets.

3.1 Organization and costs

It is worth mentioning again that many of the methods of collection can be carried out only when the personnel and institutional framework of the collecting system have bad tints to develop their capacities. In the initial stages the emphasis should be on training of staff, pilot and feasibility studies and continuing reappraisal of the objectives and methods employed to attain them. Although the statistical collection system finally adopted should be capable of adapting to changing circumstances and objectives, institutional inertia often prevents such change. In any case the value of most statistical series lies largely in their continuity and it may not be advisable to make minor improvements which disrupt this continuity. It is important to get the thing right from the start.

Against this must often be set the need for quick answers to a particular problem. There is little that a general discussion can do to help resolve such conflicts. Speed in producing a set of data does not preclude a subsequent reappraisal of the reliability of the data. Unwillingness to re-examine old methods and fear of admitting that data may be unreliable should play no part in the collection of statistics,

The costs of collecting different kinds of routine statistics varies greatly and depends very much on the existing facilities within a country. Where the industry is sufficiently organized and advanced to have centralised marketing facilities or an auction it will often be possible to obtain some records of total catch and value without the need for sampling arid recording directly, except for checking occasionally for greater detail. It is usually worth spending quite a lot on checking and improving existing records if the only alter native is to set up an independent collecting system. Where no records exist the collecting system must start with a survey to obtain the most basic information about ports, landing sites, numbers and types of vessels, species landed and so on. This is known as a frame survey and part of the cost is non-recurring. The further cost of collecting regular statistics of catch, effort etc., can only be assessed once the basic information from the frame survey is available. Some of the techniques for this type of survey will be introduced in Section 3.3.

The collection of data on fishing effort is usually more expensive than catch data because it is seldom available from existing records in a form which can be used, On the other hand we have seen that detailed statistics on effort may only be required for a part of the fleet. Once arrangements have been made to collect, some statistics in detail, the cost of collecting others in detail is often no greater. For example, if the skipper or mate is being interviewed or asked to complete log books to find out the exact fishing grounds used, it takes very little extra time to record details of the gear, time spent fishing etc., on the form. Even if not required for the immediate objective, the possibility of its future use justifies the negligible cost of collection. This factor should always be borne in mind when planning a questionnaire or collection system.

The cost of collecting data on the size and, where the biological characteristics of the fish allow, age structure of various specie is high compared with the cost of collecting catch and effort data because it involves special sampling of the landings, usually in two stages, and the training of skilled, age readers. The statistics are however essential for the more powerful modelling techniques used in assessment and it is possible to justify the cost in terms of improved management advice in both the short and long term. In the short term detailed size and age statistics make possible yearly forecasts of catch rates and these will help fishing companies to plan their fleet deployment and processing plants to adjust their capacity. An example of the costs and potential benefits of a yearly forecasting system for sockeye salmon runs is given by Mattheus (1971). In the long term the size and age compositions of the population are needed for detailed studies of growth, migration and reproductive patterns. Where the age composition cannot be obtained directly by determining the age of individual fish, indirect techniques may be used.

3.2. Collecting from large scale industrialized fisheries

Although the category “industrialized fishery” includes a wide variety of different kinds of fishing operations and landing patterns, which give rise to differences in sampling methods, there are a number of common factors. There is little difficulty in identifying the number and types of vessels and their ports. Because there are relatively few ports it is possible to set up port based sampling systems. The skippers will generally be literate and able to fill in log books or questionnaires. There will usually be records of catch weights, sales and crew payments.

Because of all these factors it is possible to obtain statistical records of catch weights, sales, vessel characteristics, numbers of tripe etc. simply by arranging to get copies of sales sheets and crew settlement forms. Well informed, collecting staff in the ports are still needed to check on the completeness and reliability of the statistics provided and to collect other data which cannot be found in existing records. Of these data the moat important is fishing effort (fishing input). Whether the aim is to record the fishing effort of every boat landing or to sample part of the fleet, the skipper or mate should be interviewed as soon as possible after the boat returns, in order to obtain inform- at ion on exact grounds fished, number of hauls and hours fishing.

In some cases a great deal of work can be saved by introducing a log book which is kept by the skipper and returned at the end of each trip, or perhaps once a week if the trips are short. With goodwill and cooperation on the part of the skipper this can give very detailed. and accurate information, but if it is simply another chore to be fitted into an already exhausting job then the quality of the data will be poor, Paying to have log books kept or making them a condition of licensing may improve the situation, but if there is some way of giving back the information, which does not destroy the necessary degree of confidentiality but is of interest to the fishermen, this will be a stronger incentive.

Methods of collecting catch and effort data from a demersal fishery landing at a major port and from a purse seine fishery are described by Holden and Raitt (1974). The actual methods of collection will have to be adapted to the particular port and type of fishery, but it is important that the type of form used and the method of completing it should be standardised as far as possible at a national or regional level. This can be done by running central training and refresher courses for port staff, during which they can compare notes with colleagues in other parts of the country, and by producing manuals on how the various forms should be filled in (e.g., Shultz, in preparation). The fisheries scientists or statisticians who run training courses for port staff will also learn the details of the fishing industry which are lost in statistical aeries.

The design of good sampling forms of all kinds, which are straightforward to fill in and easy to check and process is worth spending a great deal of care on. The aim should always be to reduce the number of transcriptions of -the data to a minimum since these are costly and introduce errors. If ADP (automatic data processing) is being used then the aim should be to punch the data straight from the original record.

We have assumed that in industrialised ports the aim will be to record the catch from every landing and to record effort for all or part of the fleet. The aim in collecting length and age data is to estimate, for the more important species at least, the actual numbers landed in each age or length group with the greatest level of precision, given the limits to available funds and manpower. In order to do this a series of small samples is taken and then multiplied up to give the estimate of numbers of that species in the total catch. Establishing the best way in which to carry out this sampling can be very difficult, but since the cost of collecting the length and age data is usually rather high it is worth spending the time and money -to get it right. At present far too little is spent on ensuring that such sampling systems are efficient and the wastage is enormous.

If the fleet landing at a port consists of similar boats using one type of gear and fishing for the same species in a uniform area then the problem of sampling will be fairly simple. If the fish have been sorted into size or quality categories before sampling then randomly chosen samples within each category can be taken and raised to the total weight for the category. If the boats are fishing different areas with different gears then a number of divisions or “strata” will have to be taken into account and the problem is to strike a balance between the degree of subdivision and the number and size of samples which it is possible to take (e.g., Gulland, 1955; Deming, 1950.)

The location at which sampling for size and age are carried out and the time at which the samples are taken may be very important. In order to reduce the problems of transportation and to be sure that a sample does indeed come from a particular vessel it is preferable to sample on the quayside during landing. If this is very inconvenient, uncomfortable or impossible then it may be necessary to buy sample through a merchant for sampling later or to sample the fish at a later stage, e.g., processing. In these cases very great care should be taken to ensure that samples are not biased (e.g., the merchant may always buy from the same boats).

3.3 Collecting from small scale artisanal fisheries

Many of the comments made about standardisation of forms and design of sampling scheme apply to small scale as well as industrialised fisheries but the major problems of collection are quite different. It is simply not possible to attempt to obtain records of the catch from each landing because there are usually no existing records at any level and the number of landings is so large and scattered that total coverage cannot be undertaken. Carefully planned, executed and monitored survey techniques can provide the necessary information by sampling methods and the cost need not be very great. Bazigos (1974) deals with the design of such surveys and refers to several practical applications. Recent examples of the application of these techniques to marine fisheries come from West Africa (Banerji, 1974).

Like a census of human population, a fishery survey will have a number of aims each of which may beat, be achieved by slightly different means, but an estimate of the total catch taken by all vessels will generally be the first concern. The vessels or fishing units, which may be of different sizes, use different gears etc., are grouped according to landing site and there may be further regional groupings to take account of different types of fishery or simply different administrative regions. The first requirement will be to produce a list of all these landing sites with enough information about numbers of vessels and type of fishery to enable um to set up at least a preliminary “sampling frame” for use in estimating total catch. The criteria for deciding what to use as our sampling unit and how to group these units are exactly the same as those briefly discussed when considering how to choose a sample for measurement and age determination in the previous section. A balance must be struck between the degree of subdivision and the number and size of samples which it is possible to take.

For most purposes the landing site is chosen as the sampling unit and -they may be grouped according to their size and location in order to take account of known differences in the kind of area which their fleets fish. Other factors may be shown to be important by a preliminary survey. For example in Sierra Leone fishing vessels were classified into five types, but a preliminary survey showed that a major source of variation in catch arose from landing sites operating the largest class of vessel since these land a far greater amount than the other four types. As a result the landing centres were divided into those with the largest class of vessel and those without.

Once the sampling units (landing sites) have been selected and divided into categories or strata (e.g., by area, number of vessels, type of vessel) and a complete list of sites exists, one can begin to decide how many sampling units within each stratum to sample and which sampling unite to select. In the absence of any information about the variability of catch among the sampling units within each stratum it is best to keep the fraction of units sampled constant for each stratum (e.g., if it is proposed to sample at ten landing sites within a country and there are three strata with 20, 30, and 50 landing sites respectively, then one would allocate 2, 3 and 5 samples). The process of selecting which landing sites to sample must be carried out randomly in order to be able to use statistical techniques in analysing the results. The method used for randomisation can have a great effect on the level of precision attained and it needs careful investigation. One simple method is to use patterned or systematic sampling in which one sample from a stratum is selected by a random start and the others are taken at a constant interval. For the example given previously in which 5 landing sites are to be sampled from a stratum containing 50 such sites, the 50 sites could be listed in geographical order along the coastline; one site is chosen by random number and the others are taken at intervals of 10.

So far we have talked only about estimating the total catch since this is usually the first objective. Many other statistics such as fishing effort, costs and earnings etc., can be collected in the course of frame surveys and catch assessment surveys either by integrating them into the survey questionnaire or by selecting a smaller subsample, within the existing sample design for more intensive investigation.

Two factors of the utmost importance in the subsequent use of information obtained by means of survey techniques are:

(a) the completeness of frames, validity of sampling design and methods, reliability of the collectors, accuracy of copying and processing must be thoroughly checked at all times;

(b) the fullest possible records must be kept of methods of work, techniques for randomisation, suspected or known biases in collection and breakdowns in the sampling scheme.

These factors are obviously also important for statistics collected by routine census-type systems, but are additionally important for surveys in order to compensate for any lack of continuity in personnel and difficulties in subsequent checking. The results should be presented clearly, with indications of the level of precision achieved and with no attempts to conceal possible shortcomings. It is essential that those using them in future should have confidence in them and should be able to learn from any mistakes made.

3.4 Collecting statistics at the regional and international level

Because most of the major marine fish stocks are the subject of exploitation by more than one country, their management must be carried out internationally by regional fisheries commissions or through multilateral agreements. Just as it is difficult or impossible to manage a fishery unless all the participants cooperate, so it is difficult to assess a fishery and give advice on management unless all the participants collect data and provide it in time. The assessment will be as good as the poorest data used in producing it.

With very few exceptions (e.g., Inter-American Tropical Tuna Commission) the international regulatory bodies rely on national agencies to provide the statistics and their function is one of compiling rather than collecting. For example, the annual Bulletin Statistique of ICES provides records of the total catch of each species, by each country in each of the ICES areas since 1906. More detailed stock information, giving length and age compositions and the

catch and effort by statistical square (1° latitude by 1/2° latitude) is published, in the Statistical Newsletter. A number of standardised reporting forms have been developed for international compilations such as these and examples are given in Fig 10a and 10b.

The regional commissions do not as a rule collect and publish information on disposition of catches, production of fishery commodities and employment. Very few economic analyses are carried out for the commissions although they can usually be handled by the same machinery as is used for biological studies. Detailed economic studies are generally conducted at the national or lower level. International trade and commodity data are compiled annually from data, provided by national statistical agencies and published by FAO in the Yearbook of Fishery Statistics.

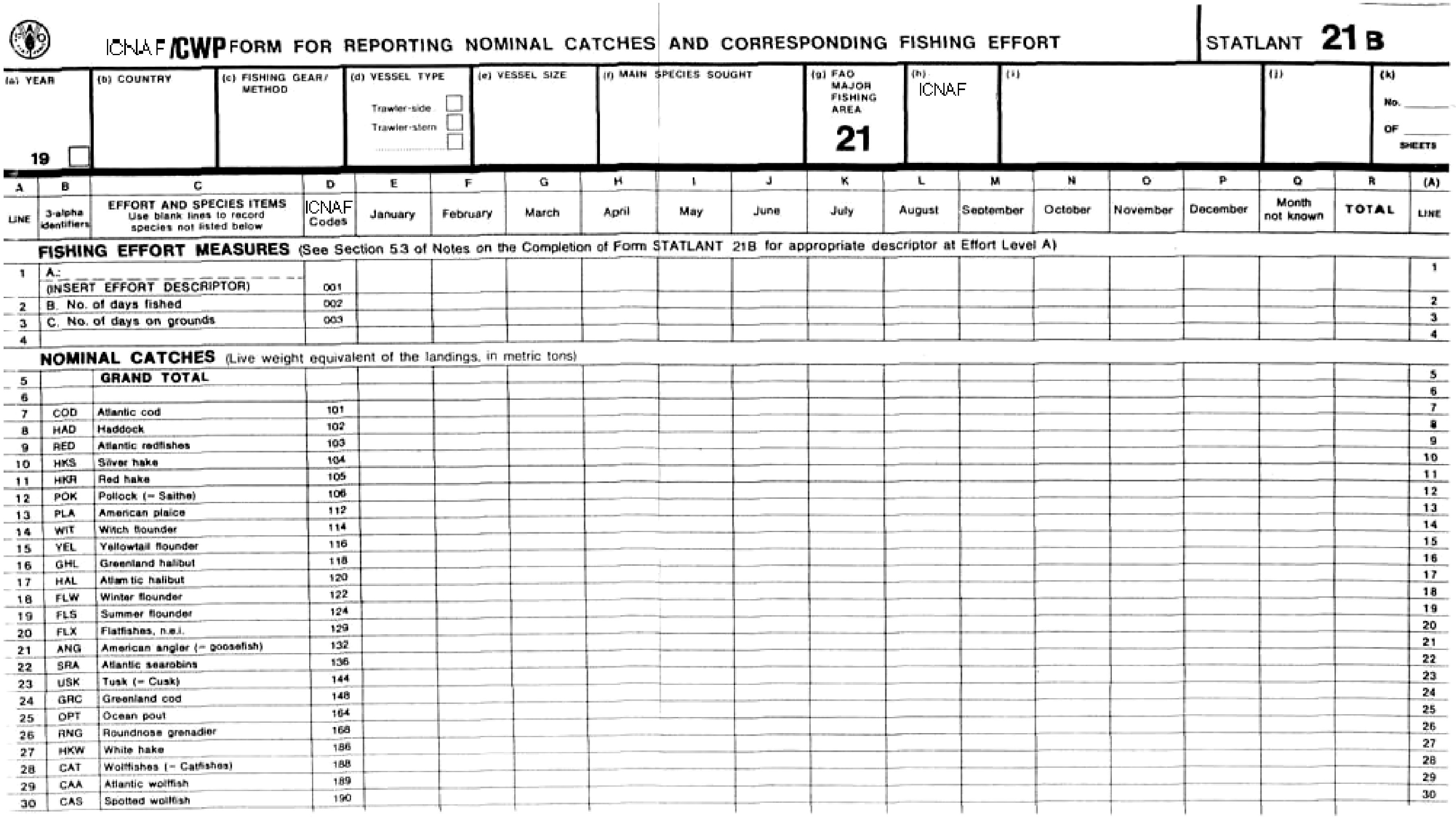
4. PROCESSING AND PUBLISHING THE STATISTICS

4.1 The qualities of the statistics produced related to their use

If the purpose of collecting the data and the users for whom the statistics are intended have been kept in mind throughout the collecting process then the actual details of presentation and publication should raise few problem.. This is not to say that it is unimportant to spend time in ensuring clear and informative presentation - on the contrary - but the audience and level of detail required should be sufficiently well specified by now to make the construction of tables and figures a straightforward design problem. Published tables will not be the only product required of the data collecting system and it is in the field of processing, tabulation and storage of statistics in varying degrees of elaboration that the major advances due to computer have taken place recently. The methods of applying these to the collection of fishery statistics have yet to be developed fully. It should soon be possible to publish only the most widely used tabulations and to produce the more detailed, statistics used for example by scientific working groups when they are required..

The processing and analysis of the data collected in all stages of the fishery, statistical system is not a simple matter of adding together all the results. The methods of processing and analysis depend directly on the methods of sampling and recording used and there must therefore be the closest possible integration between the two. It is quite useless collect data which cannot be processed because the facilities do not exist or because they are too complicated or incomprehensible to the processor. The importance of timeliness in producing statistics has already been stressed on several occasions, but it is worth mentioning again here because timely processing makes for easier checking of the data back to its source. Also the cooperation given by fishing companies and fishermen may be greatly in. creased by processing quickly and giving back the information in a form which they find useful (see Figure 4).

There are many ways in which fisheries statistics can be published, ranging from the weekly records of fish prices and landings at different ports and markets, which are published in the fishing industry newspapers, to the annual summaries of world trade and catches in each country, published by FAO. Once a format for a statistical publication has been decided on it should be kept to as closely as possible from year to year so that people can get used to it and know where to find things. The units and categories should be clearly specified every time, with details of the methods of processing and raising, if these could make an important difference. Any changes from year to year in the units used, e.g., from “landed weight” to “nominal catch” or in the categories or methods of processing should be clearly indicated.



ICNAF /CWP FORM FOR REPORTING NOMINAL CATCHES AND CORRESPONDING FISHING EFFORT

STATLANT 21 B

(a) YEAR 19 ☐

(b) COUNTRY

(c) FISHING GEAR/ METHOD

(d) VESSEL TYPE
Trawler-side ☐
Trawler-stern ☐
.... ☐

(e) VESSEL SIZE

(f) MAIN SPECIES SOUGHT

(g) FAO MAJOR FISHING AREA 21

(h) ICNAF

(i)

(j)

(k) No. ______ OF ______ SHEETS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	(A)
LINE	3-alpha identifiers	EFFORT AND SPECIES ITEMS Use blank lines to record species not listed below	ICNAF Codes	January	February	March	April	May	June	July	August	September	October	November	December	Month not known	TOTAL	LINE
	FISHING EFFORT MEASURES (See Section 53 of Notes on the Completion of Form STATLANT 21B for appropriate descriptor at Effort Level A)																	
1		A.: _ _ _ _ _ _ _ _ _ _ _ _ (INSERT EFFORT DESCRIPTOR)	001															1
2		B. No. of days fished	002															2
3		C. No. of days on grounds	003															3
4																		4
	NOMINAL CATCHES (Live weight equivalent of the landings, in metric tons)																	
5		GRAND TOTAL																5
6																		6
7	COD	Atlantic cod	101															7
8	HAD	Haddock	102															8
9	RED	Atlantic redfishes	103															9
10	HKS	Silver hake	104															10
11	HKR	Red hake	105															11
12	POK	Pollock (= Saithe)	106															12
13	PLA	American plaice	112															13
14	WIT	Witch flounder	114															14
15	YEL	Yellowtail flounder	116															15
16	GHL	Greenland halibut	118															16
17	HAL	Atlantic halibut	120															17
18	FLW	Winter flounder	122															18
19	FLS	Summer flounder	124															19
20	FLX	Flatfishes, n.e.i.	129															20
21	ANG	American angler (= goosefish)	132															21
22	SRA	Atlantic searobins	136															22
23	USK	Tusk (= Cusk)	144															23
24	GRC	Greenland cod	148															24
25	OPT	Ocean pout	164															25
26	RNG	Roundnose grenadier	168															26
27	HKW	White hake	186															27
28	CAT	Wolffishes (= Catfishes)	188															28
29	CAA	Atlantic wolffish	189															29
30	CAS	Spotted wolffish	190															30

Figure 10a: Catch and effort reporting form used in the northwest Atlantic

ICES/CWP FORM FOR REPORTING NOMINAL CATCHES AND CORRESPONDING FISHING EFFORT

STATLANT 27 B

27

FISHING EFFORT MEASURES (See Section 2.7 of Notes on the Compilation of Form STATLANT 27B for appropriate descriptor at category level A)

NOMINAL CATCHES (Live weight equivalent of the landings, in metric tons, to the first decimal place, i.e., 73.4 tons)

Figure 10b: Catch and effort reporting form used in the northeast Atlantic

4.2 Processing

Data processing, whether manual or automatic, may be divided into five steps:

1. Editing
2. Coding
3. Raising and estimation
4. Tabulation
5. Presentation

The completed forms, log books or questionnaires mast be edited before they can be processed further. Editing consists of (a) checking that they are complete and that no essential information is missing and (b) trying as far as possible to verify the accuracy of the contents. This may involve simply checking that the data given lie within certain specified limits or it may require a considerable background of knowledge of the data being reported.

Source documents should be designed for the minimum of coding, particularly if they are used directly for punching and automatic processing. Any coding which is needed after they have been filled in should be done at the time of editing. The reason for punching directly from the source document and for reducing the amount of coding or transcription to a minimum is that each extra procedure takes time and introduces further possibilities of mistakes.

Once the editing is complete the data can be used to estimate population characteristics. For example it may be necessary to determine what proportion of the catch was measured and to calculate factors for raising the sample to the total catch. If this type of procedure is followed as a routine, carried out max ally, then worksheets should be used which break the calculation down into easily handled parts. The worksheets should have checking procedures tilt into them so that any errors are detected at an early stags. The estimates obtained from the worksheets are next transferred to detailed tabulations which may he further summarised for the final presentation.

The introduction of ADP should reduce the actual handling of data to a minimum. This will free staff from much of the drudgery involved in processing, but good background knowledge is still required for editing the data before it is punched. In the initial stages of implementation of an ADP system it is often necessary to introduce more checks than usual on the output, because the intermediate checks will be carried out by the programme itself.

The scope for improvement in fisheries statistics by the use of ADP, particularly if it incorporates data storage and retrieval, is undoubtedly very great but progress is at present slow. Several national and regional bodies use ADP for compiling and publishing their routine statistical tables and there are plans for data storage systems to be used by scientists carrying out regional assessments. There is in fisheries a large gap between what is technologically feasible in terms of data storage, handling and manipulation by means of computers and what has so far been achieved. A great deal of time at international working groups is spent in processing and summarising the available data, before the actual assessment work can even be started. The main problems in setting up a fully automated data processing, storage and retrieval system are:

1. The quality of data received at present from national statistical offices varies a great deal and needs careful checking before it is used.

2. The coding arid classification systems used must be standardised between the national agencies and the regional body and also between regional bodies, since a country may be reporting to several regional bodies.

These are not particularly complex problems, but they do require a high degree of international cooperation and a far higher level of priority and expenditure than they receive at present. Since it is likely that ADP systems will be set up in many countries within the next decade, the need to resolve these problems is urgent if the national systems are to be made compatible.

At the national level the decision about what method of processing to adopt will depend on the volume and complexity of fisheries data to be processed and on the availability of computers and programming skill. The quality and degree of sophistication of the products will be increased arid personnel can be freed for less mechanical jobs, but automation is not a substitute for a reliable data collection system.

5. SHORTCOMINGS IN THE APPROACH AND A FORWARD LOOK

In order to provide a framework for listing and discussing fisheries statistics we have imposed various divisions and categories. The objectives have been divided into resource objectives, national objectives and local objectives; the primary users have been characterised as biologists, economists, technologists and development planners; we have distinguished between structural and operational statistics, between input and output and between short-term and long-term statistics. The emphasis throughout ham been on long-term statistics used for studying the resource and the primary phase of the industry. This chapter will attempt to show the limits of this fragmented approach and to look at some of the difficulties which are encountered in trying to overcome it.

It has been argued that statistics are needed in order to make management possible and that the benefits of good management justify the costs of collection. This does not mean that better management inevitably results from better statistics, but with good statistics the objectives can be more clearly defined, and the means of approaching the objectives can be better evaluated.

One may judge the benefits of good management from a general, long-term point of view or by reference to the specific objectives at the national or local level. The general viewpoint is that many stocks are currently over-exploited and those which are not over-exploited will tend to become so in the absence of management. The loss of potential yield and of potential revenue to the fishing industry is enormous, perhaps 10-20% of current total world yield. This loss could be avoided., and the first step would be to collect and analyse the statistics of catch and, fishing effort in order to make it clear to all those participating in the fisheries in question, that they would benefit from cooperative resource management.

The specific national or local viewpoint will depend on the objectives being pursued. A recent study (Lawson, 1974) found that the commonest stated objectives of a group of countries fishing in the Indo-Pacific were:

(a) to produce enough fish for domestic requirements

(b) to develop exports

(c) to improve the socio-economic conditions of fishermen

(d) to promote general all round expansion of fisheries

(e) to develop fish farming, aquaculture, etc.

The first four of these aims would. obviously be furthered by collecting biological data and making assessments of the stocks in order to see what increase in production could be expected from them and how they could be harvested most efficiently, but to concentrate exclusively on this biological aspect would be wrong. The economic factors, landing and transportation facilities and social factors must obviously also be considered.. One may set up a number of proximate objectives to cover these but the problem is how to assign priorities to all those aspects, particularly the fisheries statistics with which we are concerned here, and how much money to spend on each. A cost/benefit approach covering all aspects of data collection and analysis is hardly possible, but more limited forms of economic evaluation can be useful. For example Matthews (1971) has produced a model which looks at the cost and reliability of annual salmon run forecasting as a means of managing for optimum escapement of salmon and of providing canning plants with advance notification of the capacities they should plan for the following season. The author concludes that a moderately precise forecast provides benefits almost as great as a highly precise forecast, The present forecast costing $100 000 - $250 000 yearly may increase the operating margin of the canning plants by $500 000 - $2 500 000, but he points out that with free entry to the fishery there may be no net economic gain from forecasting. Instead the price of raw fish will rise as the profits of the canning industry increase; this will attract more fishing effort, which is superfluous and the increase in efficiency in canning will be offset by a decrease in catching efficiency.

The situation being modelled is a very simple, short term one, but three conclusions may perhaps be drawn:

1. In an economic evaluation of this kind the biological, economic and management aspects must be integrated.
2. The level of precision in forecasting and the cost of obtaining it must be balanced against increased benefits. Very precise forecasts may not be worth the extra cost.
3. A form of management which looks at only part of the fishing industry may be self-defeating. For a particular management measure to be effective one must try to evaluate not only the immediate impact but also the repercussions in related sectors.

The role of fisheries management at the regional, national and local level is expanding very quickly at the moment as the need to develop the fishing industry and to resolve the conflicts over the ownership and use of fish resources continues. In many parts of the world the basic statistics of catch and effort, needed to monitor the state of exploitation of the stocks, are inadequate. The present task is therefore to bring them up to an adequate level and to ensure that they keep up with the expanding needs of management. It is difficult to see how this can be achieved without a high degree of regional cooperation, particularly for resource management. Cooperation is needed because this is the only way in which common property resources can be managed. Common facilities for data compilation, processing storage would provide a focus for many kinds of fishery statistics and reduce the costs to each country. They would also help to establish standards of coverage and quality for member countries to aim at and provide a means of measuring data collecting performance.

Within countries as well, the lack of communication and exchange of information between the different establishments concerned with fisheries administration, research, statistics and running of the industry may be a serious impediment to management. These groups, too, may recognise that their interests will be served in the long term by setting up a common system of collection for the basic catch and effort statistics at least and possibly also economic data on the industry. The way in which the interests of fishermen, fish merchants and, fisheries biologists end economists may be mat by an automated processing system for commercial fishing operations and fish markets is given in C.N.R. Laboratorio di Tecnologia della Pesca

1974, dagli incontri tecnici VIII. If the value of collecting statistics on the fish resources and the fishing industry is recognised at all levels then the best means of collection can soon be found.

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