A GUIDE FOR THE SMALL-SCALE FISHERY ADMINISTRATOR: Information From The Harvest Sector

DAVID STEVENSON
RICHARD POLLNAC
PHILIP LOGAN

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International Center for Marine Resource Development
University of Rhode Island, Kingston, Rhode Island

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PREFACE

This guide was prepared as a general resource document for individuals in developing countries who either require or are responsible for providing information which is used for making policy decisions which affect small-scale fisheries. Its purpose is a practical one: to assist in identifying important data and in designing and executing data collection programs which will generate information concerning the resource and harvesting sector of any small-scale fishery.

The first objective of this guide is to describe a minimum set of biological, economic and sociocultural information from the small-scale fishery resource and harvesting sector which should be available so that intelligent policy decisions can be made. The first three chapters are directed at this objective. The first chapter describes the interrelationships between the fishery and the economy and stresses the importance of adequate information for decision making. The importance of sociocultural information is emphasized in Chapter II. The third chapter outlines information needed for effective policy decisions in the resource and harvesting sector of the fishery.

The second major objective of the guide is to describe appropriate data collection methods which will generate the needed information. The final three chapters of the guide are directed at this goal as well as towards developing recommendations for multidisciplinary data collection strategies in order to reduce costs. These chapters were intended primarily to assist fishery officers who are responsible for designing and directing the data collection process. Data needs are outlined in Chapter IV, collection methods in Chapter V and the organization and integration of data collection methods in Chapter VI. Finally, the guide includes lists of background information and selected data acquisition forms in four appendices.

A few words should be said about the different emphases placed on the biological, sociocultural and economic sections of the various chapters. The extent to which each of these three disciplines is discussed and the nature of the discussions themselves reflect: 1) the nature of the discipline, i.e., what it seeks to examine, 2) the probable staffing of a fisheries office, 3) the professional training required for tasks such as analyzing data, indentifying which data to collect, actually collecting the data, and recognizing what constitutes data, and 4) the level of specificity in identifying data which will be valid from one fishery to another.

In the authors' experience, fishery office personnel are more likely to be trained as biologists rather than economists; anthropologists and sociologists with experience in fisheries are extremely rare. A fair amount of professional training is required to convert data into useful information in each field. The analyses used in economics and sociology/anthropology, while they are evolving, are fairly standard and are applicable to studies made in countries in different stages of development. This is less so in the case of resource assessment analyses; thus, some attention is devoted to describing the models used in these assessments. On the other hand, it is easier to specify the primary biological and economic data needed for analyses. Sociocultural data needs are much more specific to given sites, communities and cultures.*

As we proceed to actual data collection, it is only in the field of economics that a basic set of questions can be formulated (at this distance) and applied with some modifications, by the non-professional staff member. Specific measurements and observations can be described by the fisheries biologist, but, when species identification is required, that expertise must be present during data collection.

Finally, although the guide gives the impression that a seemingly endless amount of data and information is required, this is not the case. It is true that much more information is required than has historically been appreciated. The justification for a holistic approach, however, is presented in Chapters I, II, and III and the economies which can be derived from a coordinated approach to data collection are outlined in Chapter VI. Although a considerable amount of information is required, a rationale has been provided for its collection.** The increasing use of hand calculators and mini-computers means that the storage, retrieval and manipulation of large quantities of data can soon be accomplished in even the poorest countries. Improvements in data processing facilities and a growing awareness of the importance of small-scale fisheries in many developing countries make it more important now than ever before to acquire this urgently needed information and to use it to promote rational development and management programs.

* This holds in spite of some popular misconceptions concerning the role of economic data and analyses with regard to MEY, MSY, and especially OSY (Optimal Sustainable Yield). More will be said about this at the end of Chapter IV.

** The fact that this information is rational and interrelated will make it attractive research and dissertation material for university faculty and students from both the involved and other countries; hence, it is much less likely to go unanalysed.

CONTENTS

Chapter I

THE FISHERY AND THE ECONOMY: INFORMATION FOR DECISIONS

1.1 THE FISHERY SYSTEM

A fishery is a system or network of interrelated activities which includes the harvesting, processing, marketing and consumer demand for fish (Figure 1). A fishery operates within certain socioeconomic and political contexts and interacts with other sectors of the economy. It functions because the participants, striving to satisfy their basic needs and to achieve such goals as economic gain, self-respect and peer esteem, cooperate and compete with each other. Some aspects of the system can be controlled by individuals (a fisherman's decision to fish, for example). Other aspects of the system (such as the size of the fleet, the weather, and natural fluctuations in resource abundance) are beyond the control of individuals and sometimes beyond the control of all the participants working together. Collective action is required when individual actions fail to produce desirable results. Fishermen's organizations, for example, can buy supplies in bulk to reduce costs while governments have a well-established role in providing public goods. Governments also invest in facilities such as wharves, roads and bridges which reduce the cost of operating the fishery. Finally, governments often act for society in managing common property fishery resources which have no owners.

1.2 THE SMALL-SCALE FISHERY

1.2.1 Resources and Harvesting

This manual focuses on small-scale fisheries conducted in coastal marine waters of developing countries. Most of these fisheries exist in tropical latitudes. Small-scale fishing is conducted in three types of tropical marine environment: 1) the coastal shelf platforms of continents and islands, 2) estuaries, and 3) coral reefs. Reefs and estuaries are usually the exclusive domains of the small-scale fishermen; competition with large-scale industrial fisheries is more common in shallow coastal waters.

In general, tropical ecosystems are composed of a large number of species. In addition, the average size of the fish[1] which are harvested by tropical small-scale fisheries is often quite small. Coral reef ecosystems are characterized by a complex network of inter-species relationships and a high rate of biological production, most of which is consumed within the ecosystem. Tropical estuaries are characterized by highly seasonal river flow, seasonal changes in salinity distributions and much more constant temperatures than are found in temperate zone estuaries; they also serve as important nursery areas for many coastal species. Considerable organic matter is derived from bordering vegetation, especially mangroves. All of these ecosystems are susceptible to environmental perturbations such as those caused by contamination, high temperatures brought about by deforestation, dams, industrial and domestic uses of water, the physical alteration of coastal habitats and fishing.

Small-scale fisheries are characterized by a variety of gear and vessel types. Fishing techniques are generally labor intensive; the types of gear used are diverse and relatively inexpensive to operate. The small-scale fisherman and his family are usually

[1] The term "fish" includes any type of animal which is harvested, such as sharks, bony fishes, crustaceans or mollusks. Many small-scale fisheries depend primarily on invertebrates such as clams, shrimp and lobster and do not harvest many bony fish at all.

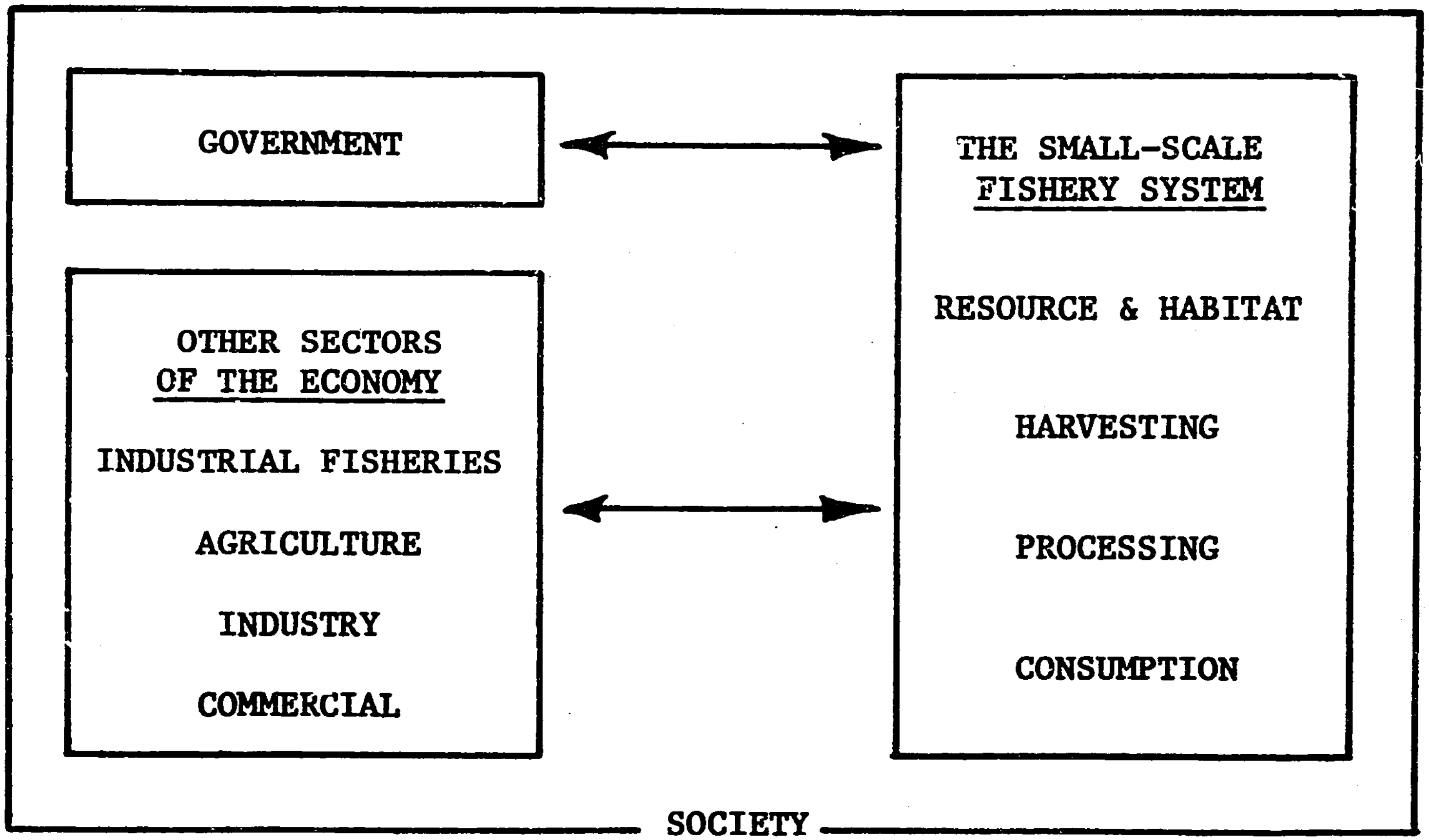

Figure 1. Diagram showing elements of the small-scale fishery system and its relationship with government and other sectors of the economy.

among the poorest of the poor. Their income from fishing is extremely variable and, in general, they have little control over prices which they are paid for fish.

Regardless of how efficiently the fishery functions, its potential contribution to society is ultimately limited by the size and productivity of the resources which are harvested. Fishery resources are renewable and produce surplus biomass which can be harvested (Figure 2). If harvest is excessive, birth and growth processes may not replace the quantity of biomass lost to natural mortality and harvesting. A common objective of fishery management is to maintain a population size which produces the maximum rate of population growth and therefore the maximum sustainable yield to the fishery (MSY in Figure 2).

Most small-scale fishery resources are free to be harvested by anyone who desires to do so. This open access nature of the fishery frequently leads to biological overfishing (beyond MSY) and more frequently to economic overfishing (beyond MEY, Figure 2) to a point where the total cost of fishing is equal to the total revenue gained from fishing. While MEY (maximum economic yield) may in rare instances be to the right of MSY, the maximum economic benefit to the nation from the fishery is usually achieved to the left of MSY.[2] This matter is discussed in greater detail in Chapter III.

1.2.2 Processing and Marketing

Small-scale fisheries are characterized by a variety of marketing systems, ranging from individuals who purchase fish as soon as it is landed and sell it in the streets of the village to fairly sophisticated marketing networks involving a number of middlemen, some kind of processing, and the transportation of fish to distant markets. Fish is purchased and sold at each stage in the process, thus adding to the eventual price paid by the consumer. Each participant in the process assumes certain financial risks in order to earn an income.

Small-scale fisheries are usually characterized by considerable variations in supply, a factor which results in fluctuations in income. Thus, in order to obtain a more reliable supply of fish, dealers often provide loans and other financial incentives to discourage fishermen from selling to competitors. These arrangements are important for small-scale fishermen who have few or no alternative sources of credit. The relationships between buyer and seller are frequently based on extended family ties or other sociocultural groupings within the community; they also affect the efficiency of the procedures which are used to market fish.

Processing maintains and can increase the value of fish: it allows fish to be shipped farther, stored longer and converted into a more desirable form. The types of processing used in small-scale fisheries are relatively simple (drying, salting, smoking and icing, for example).

Government intervention in marketing and processing is stimulated by the desire to improve the efficiency with which the system operates, thereby increasing the quantity and quality of fish which is available. It also provides credit and protects public health by setting minimum standards for fish as it moves through the system. Credit may also be provided by private lending institutions or by fishermen's organizations.

1.2.3 Consumption

In many countries fish products provide an important source of animal protein. The price paid for fish products in relation to other meats varies widely from country to country. Most frequently fish is relied upon more by the poor as a protein source than it is by the more wealthy. Fish, like many other foods, may be rejected by the consumer because cultural taboos prevent people from eating it or because it doesn't "look good." Consumer rejection can result in significant waste.

Governments have frequently been involved in stimulating consumer demand for fish products in an attempt to increase per capita consumption of protein. As we will see later, increased consumer demand for fish does not necessarily improve the fishermen's welfare.

1.3 OTHER SECTORS OF THE ECONOMY

The relationship of other productive sectors of the economy to the small-scale fishery

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[2] A point on the curve which relates yield to the size of the resource and to the amount of fishing effort which lies to the right of MSY (Figure 2) denotes more fishing effort and a smaller population size; a point to the left of MSY denotes less effort and a larger population size.

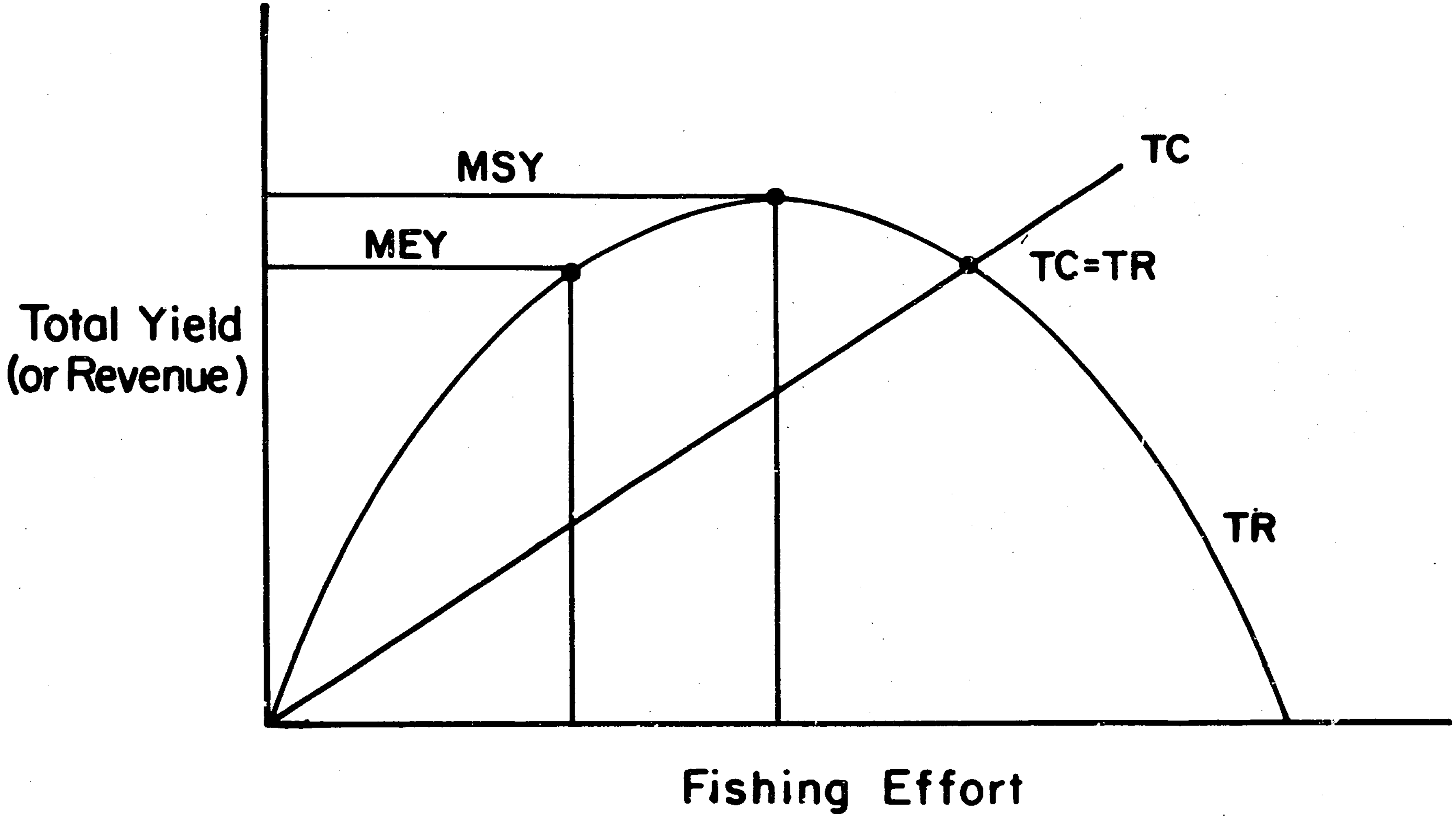

Figure 2. Yield-effort curve for an exploited fishery resource showing how equilibrium yield changes as fishing effort increases (and population size decreases).

This model is based on the premise that equilibrium yield is equivalent to the rate of increase in population size and that maximum sustainable yield (MSY) is reached at one-half the maximum amount of effort (and half the maximum population size). If yield is multiplied times price, the curve becomes a total revenue (TR) curve. Furthermore, if total costs (TC) of effort increase proportionately with effort, a point is reached where TC = TR. Maximum economic yield (MEY) is achieved when total revenue exceeds total cost by the maximum amount.

must also be considered. This relationship is defined by how other sectors affect 1) inputs to the fishery system, 2) the operation of the system, and 3) outputs from the system. The existence of an industrial fishery, for example, can have a dramatic effect on a small-scale fishery. On the positive side, the industrial fishery may provide the impetus for the development of wharves, roads and marketing systems. It may also provide an export outlet for small-scale fishery production. On the negative side, there will be conflict between the industrial fishery and the small-scale fishery if they both harvest the same resources, fish in the same areas, or if the industrial fishery increases the mortality rate of species which are exploited by small-scale fishermen.[3] Frequently the small percentage of by-catch which is sold by industrial fleets is sufficient to depress prices paid to the small-scale fisherman.

Activities in the agricultural sector may affect the small-scale fishery for many reasons: many, if not most, fishing families also raise crops and livestock; the agricultural sector may dominate the regional distribution and marketing network and thereby define the means available for expanding the distribution and marketing of fish; the use of agricultural pesticides and herbicides can threaten the survival of fish and make them unsafe for human consumption. On the other hand, fishing and agriculture can complement each other. For example, by-products of fish processing can be used for fertilizers and animal feed. One of the most important relationships has to do with the supply of labor. The number of people who fish and the amount of fishing they do is closely related to the returns they can expect in fishing relative to their returns in agriculture. The multiple relationships which exist between these two sectors clearly indicate that changes in one sector cannot be considered without taking into account the potential effects on the other.

The operation of the fishery is also related to the credit and marketing services provided by the commercial sector. If fishing is viewed as a risky investment as compared to other investment opportunities, financing may require government subsidy. If the industrial sector cannot provide the technologies required by the fishery, they will probably have to be imported, thus influencing in a small way the country's balance of payments.

1.4 CONTEXTS

The small-scale fishery system operates within economic, physical, sociocultural, legal, institutional and political contexts. In general, the contexts determine how the system and its participants operate. They define what is allowable, acceptable and desirable. The contexts set limits on how the system and its participants will respond to changes - expected changes such as price fluctuations and the gradual introduction of new fishing practices which take place at their own pace and accelerated changes (such as the introduction of new fishing gear or decisions to increase or reduce effort) which result from deliberate interventions.

Attempts to intervene at some point in the system without adequate consideration of the possible effects on the entire system and its various contexts incur considerable risk of failure. Changes which are unacceptable in the economic, sociocultural, institutional or political contexts can result in failures as certain as changes which are, for example, technical failures. These determinants of failure are the lessons of development least learned.

In the broad political context the extent of the government's intervention in the fishery is clearly related to the fishery's significance in national planning. If fishery development is perceived as being of minor significance or in conflict with other policies concerning the use of the ocean and its shoreline, important support structures such as government fisheries offices, extension services, and regulatory agencies may be overlooked. On the other hand, it is clear that the fishery administrator is responsible for generating information which will ensure that the fishery is properly evaluated in the process of establishing national priorities.

1.5 INFORMATION AND DECISIONS

The last section of this chapter describes how a hypothetical decision process aimed at increasing per capita consumption of

[3] Increased mortality is caused, for example, when a shrimp trawler discards fish which are too small to have any market value. These fish are dead when they are discarded and will never be available for capture by the small-scale fleet.

fresh fish might be carried out.[4] The fishery in question is a very simplified one - devoid of most real world complications. The decision process is examined solely to demonstrate its multi-disciplinary nature and the wide variety of information which is required. This exercise is not intended to represent a plan for action.

In Figures 3 and 4 it is assumed that adequate analyses have concluded: 1) there is a need to increase the supply of animal protein; 2) the fishery appears to present a reasonable alternative for increasing this supply; and 3) sufficient fresh fish is not available at current prices to meet projected demand. It is at this point interventions aimed at increasing the supply of fresh fish should be evaluated.[5]

1.5.1 Post-Harvest Losses and Underutilized Resources

One of the most cost effective ways of increasing the supply of fish is to utilize fish which is already caught but never reaches the consumer. Post-harvest losses are caused by the failure to use ice or the improper use of ice during harvesting, and by poor handling and insufficient storage or distribution facilities once the fish is landed. In addition to reducing these losses, another effective method for increasing supply would be to reduce the quantity of fish that is discarded at sea during commercial fishing operations. Decisions to utilize by-catch require economic evaluations of processing and marketing possibilities. Fish which have no value in the fresh fish market might require some form of processing and market promotion.

Other important sources of additional fish protein are resources which are not presently being harvested or which are harvested, but are not directly utilized for human consumption. Significant increases in fresh fish production can be realized by making changes which improve the capture and/or marketing of underutilized resources. These changes may be obvious ones such as the use of more effective fishing gear or a type of processing which makes the product more acceptable to the consumer, or they may be more subtle changes such as the recruiting of crew members who are willing to spend longer periods of time at sea.

1.5.2 Resource Assessment

If production is low and post-harvest losses are minimal, it becomes important to determine whether or not there are sufficient fish resources available to support increased exploitation. At this stage in the decision-making process, a simple preliminary evaluation of the resources can be based on interviews with individuals who are familiar with the changes which have taken place in the fishery (species, quantities and sizes of fish; types and number of vessels, gear or fishermen) and on historical records of catch and effort, if they are available. A preliminary evaluation only permits qualitative judgments of the degree of over- or underexploitation. A more thorough assessment should define more exactly the degree of over- or underexploitation and predict the expected effects of certain management strategies on resource abundance and yield.

If a preliminary evaluation suggests that resources have been overexploited, then some intervention may be necessary to reduce catch and/or effort. At the same time, a more thorough assessment should be initiated in order to estimate how much increased production can be expected as a result of certain management strategies, and a mechanism for collecting the necessary data should be established as soon as possible. Also, a search for new, unexploited resources should be considered.

If currently harvested resources appear to be underexploited or if new resources which are not being utilized can be identified, attempts to increase production can proceed, but should proceed slowly while data for a more detailed stock evaluation are collected. Development of new resources which have not been assessed should proceed in well-defined stages so that changes in biological and economic parameters can be evaluated as production increases. A simple monitoring of changes in catch per unit

[4] As will be discussed further in Chapter III, this goal is frequently in conflict with the goal of assisting fishermen and their families.

[5] There are, of course, other paths that could lead to a decision to stimulate increased production. For example, foreign exchange can be generated from a resource that commands high international prices. Some small-scale fishery resources (snapper or spiny lobster, for example) command high international prices; increased production and export of these resources generates foreign exchange.

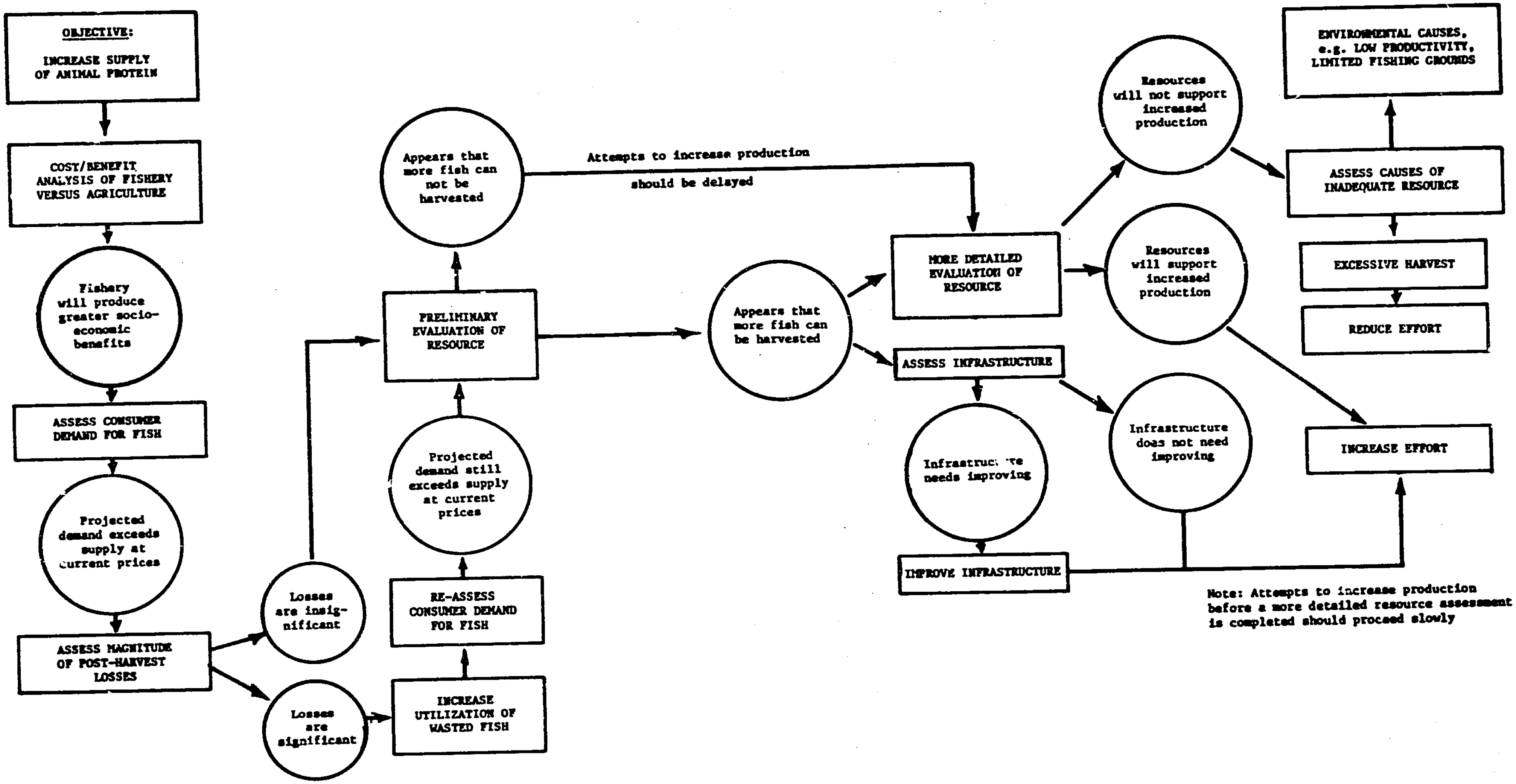

Figure 3. A hypothetical series of actions and decisions which must be considered when attempting to expand the fishery's role in increasing protein supply.

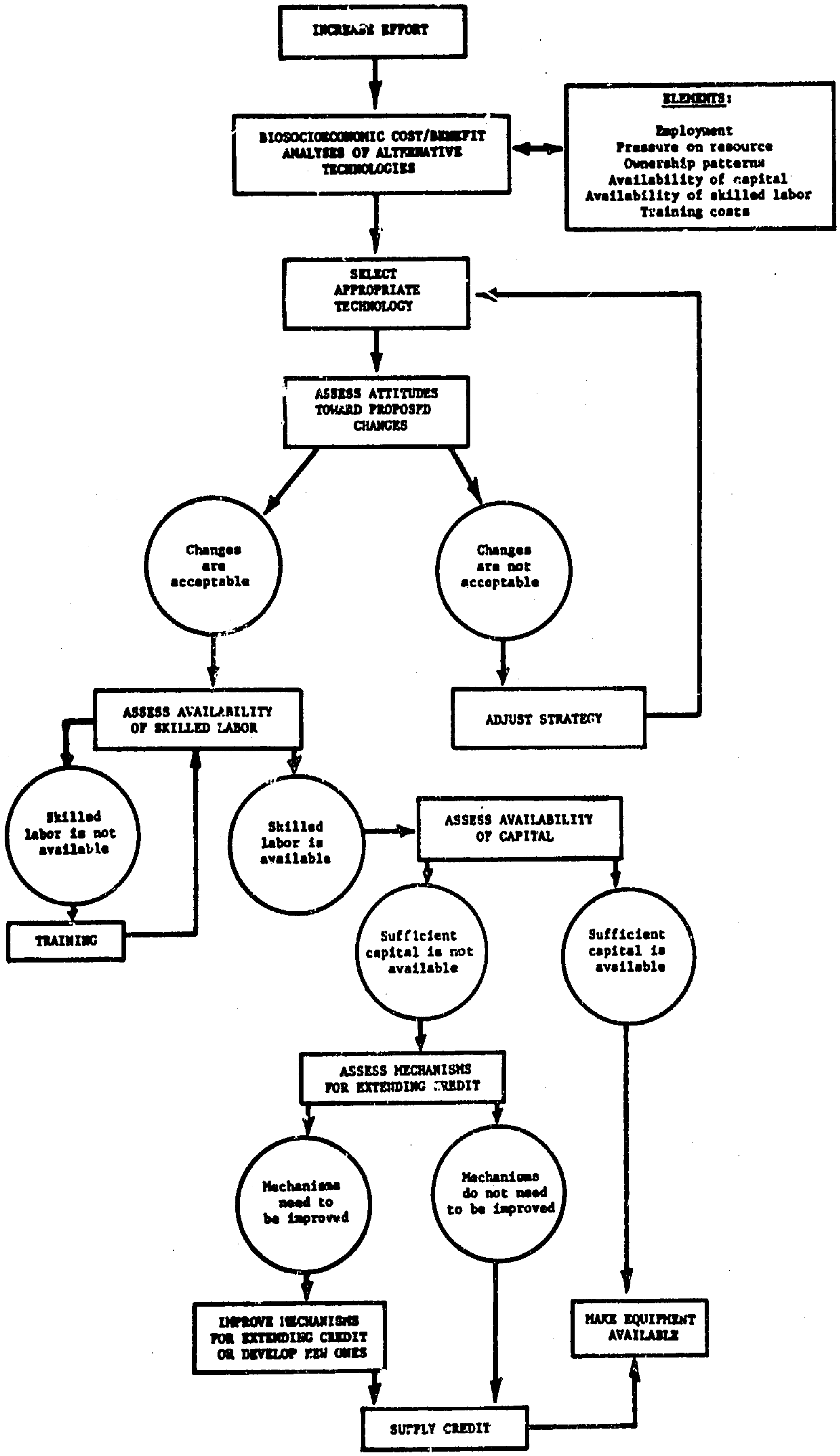

Figure 4. A hypothetical series of actions and decisions generated by an attempt to increase production from the fishery by increasing fishing effort.

effort, for example, and in the economic profitability of different technologies over time can provide useful information for making development and management decisions when thorough stock assessments are not feasible.

Decisions to proceed with more detailed resource assessments cannot be made lightly. Detailed analyses can require considerable expenditures of time and money. However, even in regions where there is little fishing and existing fishermen seem to have no trouble catching as much fish as they want, detailed stock assessments should be considered in cases where increased fishing pressure is anticipated.

1.5.3 Infrastructure

If a preliminary resource assessment suggests that stocks will support increased exploitation - or that post-harvest losses can be reduced - then the potential for expanding marketing, transport, processing and distribution services should be evaluated before attempts to increase production are made. This means examining the delivery system for obvious bottlenecks in storage, transport or marketing services. If sufficient infrastructure for providing these services exists, then development can proceed while data are being collected for a more thorough stock assessment. However, if the infrastructure needs improvement and an analysis of the anticipated benefits and costs of the improvement is positive (indicating that the benefits exceed the costs), development plans which include infrastructure improvement can be made while additional resource assessment data are collected.[6] If the analysis is negative, then attempts to increase small-scale fishery production should probably be abandoned or reformulated in terms of overall rural development objectives.

1.5.4 Reductions in Effort (or Catch)

If resource assessments indicate that stock sizes are small and will not support increased harvesting, the possible explanations should be examined. Is resource abundance limited by environmental factors such as poor primary productivity, unfavorable climatic conditions or limited fishing grounds or has it been reduced by excessive harvesting? If stocks were previously more abundant, but have been recently depleted by intensive fishing effort, a reduction in effort or catch would eventually lead to stock recovery and increased production.[7]

In cases where stocks are small, but were never very large, the gains in production which would follow any regulation of effort would probably not pay the social and economic costs of management. The societal costs of any regulatory scheme include those which are immediately obvious, for example, those associated with designing, negotiating, managing and enforcing regulations and those which are less obvious such as the costs of developing alternative employment opportunities and retraining fishermen, or the costs of unemployment and urban migration.

Regulations are usually intended to limit the size at which fish are first captured and/or to limit effort.[8] Regulations which are related to size protect the reproductive capacity of the stocks by ensuring that enough sexually mature adults remain in the population to replace fish which die naturally or are harvested. Examples of this type of regulation include minimum size limits, gear restrictions which affect the size of fish captured and closures in particular locations or times of year when small fish are more abundant. Effort regulations are intended to limit the catch to a certain level. Some of the more common ones are closed seasons or areas, gear restrictions, catch quotas and limits on the number of boats or fishermen.

However, none of the management strategies mentioned above are successful in preventing the over-investment of labor and

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[6] It is unlikely that small-scale fisheries alone would justify major infrastructure improvement unless extensive underutilized stocks of fish are found. Infrastructure improvement need not be on a large scale, however, to improve the way in which the fishery functions.

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[7] The immediate result of a reduction in effort on an overexploited stock is a decline in production until the fish which escape capture, grow larger and produce a greater number of offspring.

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[8] These two management strategies are not independent of each other. In practice, regulations aimed at reducing effort result in a greater average size since more fish escape capture and eventually grow to reach a larger size.

capital in the fishery. Effort restrictions, for example, which are directed at limiting only certain components of effort (time, location or the efficiency of capture) - but not total effort - may reduce catch, but will result in the waste of society's human and financial resources. Only in the case where someone acts as the owner of the resources and charges for their use is there proper economic exploitation. Examples of regulations which simulate this type of ownership are taxes on effort or catch, or marketable individual boat quotas or licenses. A combination of a size-related restriction with one on total effort is often ideal.[9]

1.5.5 Increases in Effort (or Catch)

If it is determined that the stocks can support increased fishing effort because, for example, 1) the area they inhabit is larger than previously believed, 2) human population pressures have not as yet led to their overexploitation, or 3) new stocks can be exploited if the range of the boats can be increased, then the next step is to determine by what means to increase effort.

It must be realized that there can be a tradeoff between seeking the least costly method of extracting additional quantities of fish and other goals such as increasing employment and promoting rural development. For example, many small-scale fishing techniques are extremely efficient in their use of both labor and capital despite the fact that fishing trips are of short duration (a day or less) and the limited range of the vessels limits most fishing to nearshore grounds. Economies of scale can often be realized with larger vessels but increased efficiency must be weighed against the possible risks of favoring certain individuals (wealthy versus poor fishermen, for example), as well as the ability of the participants to obtain financing and the existence of credit sources - to name just a few of the important economic and social considerations. The potential impact of the proposed changes in harvesting strategy on the resources must also be examined. Figure 4 outlines some of these considerations.

Caution is warranted here; there is a long history of failure associated with technological innovations. A technological change as simple as replacing multifilament nylon gill nets with monofilament nets permits day-light fishing and can dramatically increase catches, thereby depleting resources, overloading the marketing network and perhaps reducing prices paid to the fishermen. Short term gains such as increased production may very well be followed by long term losses in resource abundance, damaged personal relationships between fishermen and a less desirable income distribution.

1.6 SUMMARY

In sum, a hypothetical decision process aimed at increasing per capita consumption of fresh fish was examined to demonstrate its multi-disciplinary nature and the wide variety of information required. Following a brief discussion of the importance of socio-cultural information in the next chapter, the remainder of the guide will identify specific information needs, the data from which the information is derived, and appropriate data collection methods.

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[9] The plight of the remaining fishermen is not necessarily any better after a reduction in total effort. This is discussed in Chapter III.

Chapter II

THE IMPORTANCE OF SOCIOCULTURAL INFORMATION

2.1 INTRODUCTION

Although numerous studies have indicated that the success or failure of fishery development projects depends largely on sociocultural factors, they are often overlooked when development projects are being planned. The rationale for biological and economic information is relatively well developed and widely accepted. This is not the case, however, with respect to sociocultural information. Sociocultural information has two important functions in fishery development. In addition to addressing development and management issues, it facilitates economic and biological data collection. Identification of social groupings of fishermen, their informal and formal leadership patterns and their systems of communication provide information which can be used to structure effective data gathering systems while increasing the likelihood of obtaining the cooperation of the fishermen.

2.2 RELATIONSHIP BETWEEN TECHNOLOGY AND SOCIAL ORGANIZATION

Several aspects of small-scale fishery technology result in social relationships that differ somewhat from those found in agrarian social groups. It is therefore important to examine the relationship between small-scale fishing technology and certain aspects of the ownership of equipment, as well as work-group and non-work-group structure and the degree of social stratification. An understanding of these relationships allows one to predict potential costs accompanying alternative processes of technological change, and thus enables the planner to weigh these costs against the benefits of introducing the technology.

In earlier papers, Pollnac (1982; 1979), drawing on available literature and research experience, developed a model which indicated that vessel size and complexity affect both crew size and the recruitment of crew on the basis of skill. It should be noted, however, that more efficient equipment which reduces necessary crew size may result in unemployment and increased social stratification. The model also indicates that crews are often selected on the basis of social criteria such as kin group membership. Small-scale fishermen work-groups, however, tend to be egalitarian in structure due to the fact that many shipboard tasks require close cooperation between fishermen. These close interdependent ties between crew members often result in the formation of male groups ashore based on the work-group which prevails at sea.

Furthermore, the model notes that the generally low cost of small-scale fishing technology, the impermanent nature of the equipment (due to the destructive nature of the sea) and the close on board cooperation which is required usually result in little social distinction between owner and laborer within small-scale fishing groups. Nevertheless, as equipment costs increase due to increased size or complexity, the likelihood of ownership by individual fishermen decreases, thus promoting the development of social stratification and inequality. Additionally, increased costs of capital equipment often lead to the development of financing specialists. Finally, as production increases, there is an increasing need for distribution and processing specialists.

The relationships between these various aspects of small-scale fishing technology and social organization are illustrated in Figure 5. Data are needed at all points in the decision-making process in order to predict changes that will result from a given technological change. To predict changes, it is

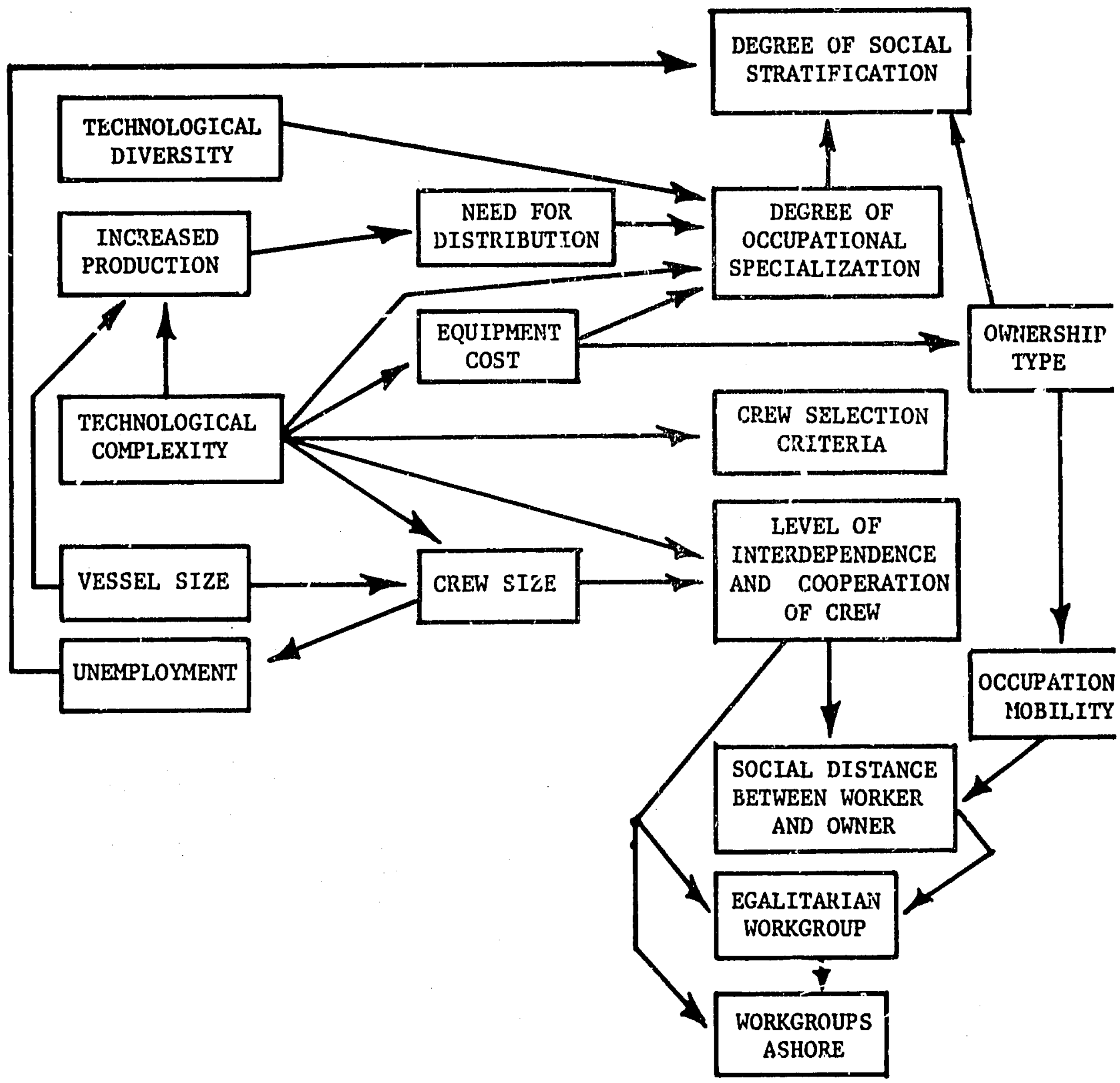

Figure 5. Relationships between technology and social organization (adapted from Pollnac, 1981).

necessary to evaluate the technology in terms of its complexity, labor requirements, cost, and productivity - variables which play key roles in the relationship between technology and social organization.

At this stage of the discussion it is perhaps appropriate to introduce several examples which will demonstrate the interrelationships between technological and institutional changes and aspects of social organization contained within the model. A study conducted by Fraser (1966) among Malay fishermen of South Thailand provides a good example of the impact technological change can have on work groups and community social structure.

Traditionally, the Malay fishermen of Rusembilan relied on oars and sail to take them to their fishing grounds. In 1956, groups of boat owners and steerers (traditionally a high status position in the boat crew) dominated deliberations concerning the best way to motorize the fleet. They decided to introduce tow boats to take fishing vessels to fishing areas and bring them back. Groups of boats formed tow groups associated with a particular tow boat. This new technology immediately placed considerable strain on the traditional social system.

First, membership in tow groups meant that individual boat crews and steerers lost their previous independence with regard to locating fish and timing the return to market. Second, after a period of poor fishing, wives of members of the more skillful boat crews realized that they were subsidizing less successful crews since shares were based on the tow group's total catch. Fraser (1966) notes that this situation had broad repercussions in other areas of community life. It resulted in overt hostility between women, and relations between men became strained. The coffee shops, which were the focus for community decision-making groups and associated with boat crews, manifested a marked drop in attendance, reflecting the social strains. Attendance at coffee shops never fully recovered. Further, traditional village authority figures, the orang baik (morally good man), were involved in ownership of tow boats and their operation. Thus, the chief source of authority and means of maintaining village control were undermined. Finally, because the religious leaders of the village remained aloof from the changes, their status increased. Before long the strains became too great and the tow boats were eliminated.

The return to individual fishing did much to restore good relations, but the degree of community organization which was originally based on boat crew membership and the traditional authority of the orang baik (whose traditional status depended on boat group affiliation) was never regained. Further, the introduction of nylon nets and individual motorized vessels reduced the need for a large crew; nevertheless, the crews were kept larger than necessary in keeping with traditional crew structure. Fraser (1966) argues that the maintenance of large crews plus decreasing catches undermined the sense of pride that traditionally characterized crews. This decrease in group solidarity reduced the relatively high status of the steerer and, hence, his status in the community at large. Thus, a change in technology that was poorly adapted to the traditional social structure of work was rejected, and the negative impact on the social structure of the community was never totally corrected. Furthermore, labor saving technological innovations were ineffective because the fishermen were unwilling to use fewer than the traditional number of crew members.

A similar reluctance to change work-group structure was recently reported for small-scale fishermen in Malaysia. Sabri (1977) notes that although winches were installed, thus reducing the number of fishermen needed on a vessel, traditional crew size was maintained to provide employment for members of the extended family. In another area of Malaysia, however, Yap (1977) reports that improved technology resulted in a reduction in crew size and significant unemployment among fishermen with no alternative occupations. This impoverished class of unemployed fishermen, of course, increased the degree of social stratification within the fishing community as the model would predict.

2.3 ACCEPTANCE OF CHANGE AND THE SUCCESS OF DEVELOPMENT PROJECTS

In order for production to increase as the result of introducing new technologies or new fishermen into the fishery, the participants in the fishery system must be willing to accept change (see Figure 4). It is obvious, but often overlooked, that if the participants refuse to cooperate, development projects will not succeed. Often this reluctance to cooperate is based on rational considerations which can be accounted for when designing the project if they are known beforehand. It is therefore necessary to assess the attitudes, beliefs, and values of the participants towards the proposed changes. Consideration of these factors in the early planning stages is an important ingredient in project success.

If attitudes toward change are negative, then it is essential to determine why and attempt to adjust the changes in order to satisfy the perceived needs of the people. If attitudes are positive, then success in the use of a new technology or the addition of more fishermen depends on the availability of skilled personnel - another decision point where detailed information is needed (see Figure 4). If there are not enough skilled personnel, some sort of training program should be considered to either retrain existing fishermen in the use of the new technology or teach unemployed people how to fish.

2.4 TECHNOLOGICAL CHANGE, PURCHASING POWER AND SOCIAL STRATIFICATION

Once sufficient skilled personnel are available, the only remaining obstacle which could still prevent fishermen from utilizing a new capture technology is their ability to purchase the equipment. If sufficient funds are not available, methods for extending credit must be considered. If the distribution of capital is very unequal, the introduction of new technologies could result in increased social stratification, a process which is often accompanied by other social problems (Pollnac, 1976). In many cases the only individuals who can effectively take advantage of new opportunities are those who are already wealthy and the new technology only enhances their situation in relation to others. The model presented in Figure 5 outlines the relationship between technological change, equipment cost, equipment ownership patterns, and social stratification.

Once again, some examples from fishery development projects are in order. Epple (1977) provides a good example of how mechanization, because of the increased price of capital equipment, altered patterns of fishing boat ownership on Grenada. Prior to mechanization, 90 percent of the fishermen owned their own boats. Following mechanization this figure dropped to 25 percent. Sabella (1974) also noted that as Peruvian small-scale fishermen began to depend on expensive, highly specialized equipment, their formally egalitarian community began to manifest signs of social stratification. Finally, among Malay fishermen increased costs of productive equipment associated with modernization has produced a class of equipment owners.

Firth (1966) has noted that although equipment modernization has resulted in greater economic returns to the entire fishery, increasing capital costs have led to a marked drop in the percentage of earnings going to the labor force. Despite the fact that the fishermen have become, in effect, employed laborers in the new system, they are treated as participants in a common enterprise and thus not put on a regular wage basis. Their income is still based on a share of the catch. Specifically, Firth (1966) has noted that among the Malay fishermen, costs are removed from the catch before shares are calculated; thus, given the periodic nature of production in the marine environment, fishermen often receive next to nothing. He therefore reports that in 1963, the fishermen were in a less advantageous position than when he first studied them in 1939-1940, and that the entrepreneurs were much more economically powerful than their predecessors of a generation earlier.

Even when governments are aware that the high initial costs of new technologies can increase social stratification, problems often persist and increased disparity in wealth results. For example, Alexander (1975) reports that in Sri Lanka the government was aware of financing problems associated with costly new fishing technology, so they introduced a hire/purchase scheme. Individuals who took part were selected by ballot from qualified applicants. The individual fisherman had to provide a deposit and received a government loan, repayable over five years, to purchase a boat hull with an engine. Unforeseen problems developed, however.

First, the deposit, in combination with the fact that the loan covered vessel and engine but not gear, meant that the fishermen had to borrow money from private money lenders. Second, the new equipment deteriorated faster than the old, and there was no provision for maintenance funds. Third, loan repayment was not related to the value of the catch - it was a fixed monthly payment; thus, during periods of low production the payment could exceed income. Nevertheless, production increased, so the government viewed the project as a success and invested more funds in it. The total income to the fishing village increased, but problems began to appear.

Since the number of fishermen increased little during the years after the new loan scheme was first introduced, increased population size resulted in greater unemployment. New boats were introduced, but they rightfully were made available only to experienced fishermen. Important for our discussion, however, is the fact that inexperienced new fishermen were recruited only from the pool of relatives; therefore, few opportunities existed for those not related to the boat owning elite to acquire the experience necessary to qualify for operating a boat. The number of elite in the community increased substantially with the bulk of the population being reduced to the poverty level. Alexander (1975) suggested that since the elite have political power and control recruitment to the most favorable occupations, the degree of social stratification in Sri Lanka will become even more marked in the future. Increases in social stratification have been attributed to similar factors in other communities where costly innovations were introduced (Norr, 1972).

Clearly, the introduction of new, relatively costly technologies can result in income disparties and associated increases in social stratification. If such a situation is deemed undesirable, then techniques to extend credit to poor fishermen should be investigated. If local organizations (such as development banks and fishermen's cooperatives) for credit extension exist, then they should be used. If not, locally appropriate solutions should be developed, ideally using traditional organizations if they exist (Siebel & Massing, 1974).

The distribution of wealth is closely related to the distribution of power in a community. In addition, the process by which reciprocal obligations form the basis of business and social transactions may be affected. Unless these aspects of the social structure are investigated in advance, the credit systems which are designed may be inadequate and it may not be possible to anticipate potential problems. In some communities, attempts by development agencies to introduce costly fishing technology in a manner which would possibly reduce the potential for increased social stratification by avoiding traditional equipment owners and money lenders have failed due to the fact that fishermen viewed the traditional patron-client relationship as legitimate and the government's planned intervention as illegitimate. For example, Emmerson (1975) describes a development program in Indonesia where a more complex, expensive technology was to be introduced to indigenous fishermen using a plan wherein crewmen would collectively own the equipment. Traditionally, crewmen were bound to a boat by an interest-free permanent "loan" provided by the boat owner. The boat owner was bound to a money lender by a similar arrangement. According to Emmerson, the participants did not perceive the relationship as exploitative - it was one of reciprocal obligations, freely engaged in, and viewed as being fair. When this traditional system was threatened by the introduction of the new equipment, the fishermen destroyed the equipment and assaulted a project administrator.

Other problems with the extension of credit can be related to the fishermen's perception of the immediate source of the loan. For example, in one fishery development project in Malaysia, the source of credit for the fishermen was a government sponsored institution (a cooperative). Many of the fishermen in the region reasoned that since the function of the government was to help them, the loans were like charity and did not have to be repaid (Narkswasdi, 1967). As a result, the loans and the equipment that was provided were considered as gifts and the project encountered serious difficulties. It should be clear that the determination of locally appropriate structures for extending credit to fishermen is crucial for project success.

2.5.SUMMARY

In sum, the arguments presented in this chapter along with examples drawn from actual fishery development projects should make it obvious that sociocultural information can play a critical role in developing a fishery. Techniques for obtaining this information are discussed elsewhere in this guide.

Chapter III

INFORMATION REQUIREMENTS

3.1 INTRODUCTION

The analysis and interpretation of data provide information. Data are collected and compiled in a series of steps and in the process become more and more refined until they form the elements of an analysis. For example, estimates of the quantity of fish captured by an individual vessel using a particular gear type, when combined with similar data from trips made by all vessels which use the same gear type during a given time interval, are transformed into annual catch statistics. A time series of annual catch data is combined with fishing effort data for corresponding years and is analyzed to provide an estimate of the maximum quantity (weight) of fish which can be harvested every year which will not endanger the ability of the resource to replace losses caused by fishing and natural mortality (predation, disease, etc.). The kinds of information which are required depend on the types of analysis which are performed, the nature and quantity of the available data and the management and/or development objectives which are being pursued.

Decisions concerning what types of information should be obtained ultimately depend on the resources which are available for collecting, compiling and analyzing data and the anticipated costs and benefits of different data collection procedures. Predicting the usefulness of different types of information, however, can be difficult. Thus, a good strategy is not to rely on a single type of information, but rather to compile several different types of information at the same time, taking advantage of alternative data sources and collection procedures. Later, less useful or reliable information can be eliminated and data collection efforts can be reduced. Another good strategy is to compile information which has multiple uses in the decision-making process.

The purpose of this chapter is to describe a minimum set of biological, economic and sociocultural information which should be available in any developing country where small-scale fisheries are practiced. This description is not intended to include all the possible types of information which might be important in any particular situation: such a task would be impossible. Nor is it intended to recommend certain types of information as being more important than others since the selection of necessary information depends on management or development priorities and objectives which apply in any particular situation.

This minimum set of information can be defined on the basis of its usefulness in evaluating the feasibility of intervening in the fishery and predicting the impact of management and development efforts. Interventions may be made at any point in the fishery system, but we are concerned only with interventions which affect the resource and harvesting activities and the information which is needed to evaluate them. The emphasis is on evaluating the impact of various proposed changes before they occur, not after. It is also important to point out that most of the information which is described in this chapter is generated from data which are collected from the resource and harvesting sector of the fishery. The nature and usefulness of economic information from other sectors of the fishery are discussed in section 3.4.

Data which are needed to satisfy this minimum set of information needs are described in Chapter IV and relevant data collection methods in Chapter V. A strategy for effective multidisciplinary data collection is presented in Chapter VI. Analytical procedures are not described in detail at any point in this guide although particular analyses which produce useful information are mentioned. As has been pointed out already in Chapter I, much of the information which is required is multidisciplinary in nature. Nevertheless, the discussions of information and data needs and data collection methods which follow in this chapter and in Chapters IV and V are organized according to biological, sociocultural and economic issues.

Some of the terminology which is used in the following discussions is fairly technical and may be unfamiliar to many readers. Nevertheless, in order to describe the information and data which are needed to formulate solutions to small-scale fishery development and management problems, we feel this kind of language is necessary. Whenever possible, specific terms have been defined and references to additional information have been included.

3.2 BIOLOGICAL/ECOLOGICAL INFORMATION

3.2.1 Fishery Resources

The structure and operation of any fishery is dependent on the resources which are harvested. Fishery resources are defined according to the species and sizes of fish which are captured, the gear which is used and the processing and marketing practices which are followed in making fish available to the consumer. A pelagic purse-seine fishery, for example, harvests small schooling fish at or near the surface which may be canned for human consumption or reduced to fish meal or oil, while a bottom longline fishery harvests demersal (bottom) fish which are usually marketed as fresh or frozen whole fish or fillets. Small-scale fisheries generally produce a great variety of fish in relatively small quantities which are usually marketed as fresh fish. A resource may be defined to include a number of species which are harvested by the same gear, or the term may be applied to a single species. Ultimately, however, the biologist is concerned with single species populations or with populations made up of several species which share certain common biological and/or ecological characteristics which make them equally vulnerable to exploitation by the same type of gear.

3.2.2 Unit Stocks

The ideal management unit is the unit stock, a term applied to a resource which is exploited in a particular geographic location and whose individual members respond similarly to fishing pressure. Thus, a group of fish with similar natural mortality, birth and growth rates will not be depleted at the same rate as another stock with different characteristics which is exposed to the same amount of exploitation. A single species distributed over a fairly wide geographic area may therefore be made up of several unit stocks. By the same token, a unit stock may include more than one species. In practice, unit stocks are difficult to identify on purely biological grounds, and managers are forced to define them on the basis of available information. As more information is obtained, unit stock definitions may be revised. Unit stock identification is particularly impractical in tropical small-scale fisheries since so many species are frequently exploited in the same areas with the same gears and since so little is known about their biology. In addition, some species (coral reef fish, for example) are characterized by extremely patchy spatial distributions.

3.2.3 Background Information

General biological information which is needed in order to determine what resources are exploited includes a knowledge of the species, sizes and relative quantities of fish which are harvested by each fishery. Ecological information should include some basic understanding of the physical habitat and the ecosystem which supports the resource (i.e. the environment in which it exists and other organisms upon which it depends for food, which act as predators or which compete for the same prey), and an evaluation of the sources and extent of primary production which provide the organic matter necessary to sustain population growth. The potential maximum yield which can be expected from any resource and its vulnerability to fishing pressure are largely functions of its role in the ecosystem and its life history characteristics.[1]

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[1] Energy is dissipated at each successive stage in the ecosystem so that smaller herbivorous fish which feed directly on plant material, for example, produce larger populations than larger carnivorous fish which do not have as much food available to them. Furthermore, species which invest more energy in growth than reproduction tend to produce populations with large numbers of small, short lived individuals which should be harvested in bulk at relatively young ages. Species which invest more energy in reproduction than growth tend to produce populations with a fewer number of large, long lived individuals which should be harvested selectively at relatively older ages. Species which are adapted for slow growth, large individual size, late maturity and greater longevity are generally more sensitive to fishing pressure.

3.2.4 Resource Assessment

Once this background information is available, some kind of resource assessment can be performed. Assessments should reveal whether or not the resource(s) is (are) overexploited, i.e. has fishing caused the mortality rate of the exploited population to exceed the natural rates of growth and recruitment so that the maximum rate of population growth (and therefore the maximum sustainable yield or MSY) is no longer being achieved, or has the size of the spawning population been reduced so much by fishing that the recruitment of young fish to the exploitable population has been severely reduced?[2] Resources are usually reduced below the size which produces MSY when heavy fishing pressure is combined with poor recruitment. Maximum sustainable yield is theoretically attained at half the unexploited population size (see Figure 2).

Recruitment is a function of the number and age of spawning adults in the population and environmental conditions which affect the survival of eggs, larvae and juveniles. Given the extreme variability in the environmental factors which affect recruitment, a stock which has been heavily exploited may suddenly "collapse" when a period of poor egg production corresponds with a period of unfavorable environmental conditions which reduce the survival of eggs, larvae and juvenile fish.

If the resource is overexploited, a reduction in effort or regulations which impose limits on the quantity or sizes of fish captured can result in increased production. If the resource is underexploited, development of the fishery (i.e. an increase in effort) is a more feasible alternative. Any management strategy should ensure that the population is maintained at a large enough size to protect against sudden "recruitment failure," i.e. at more than one half the unexploited population size.

Resource assessment may take the form of a qualitative preliminary assessment which simply indicates whether or not overfishing is a problem or a more sophisticated quantitative assessment which requires a great deal more information. Regardless of how it is defined, resource assessment is actually a continuous process since the information which is required for a preliminary assessment may also be useful in the initial stages of a more detailed assessment.

Quantitative assessments — if successful — indicate the degree to which resources are or are not overexploited and can be used to predict gains in production which can be expected as a result of certain management strategies. Quantitative assessments are expensive and time consuming. The data required for analysis are often not available and even when they are, the results may be inconclusive. In many cases, therefore, less rigorous preliminary assessments must be relied upon for determining whether or not the resources are sufficiently large to support an expanded fishery.

Ideally, resources should be evaluated before they are overexploited. In practice, concern over the effects of increased exploitation is seldom expressed until catches begin to decline. In these cases, sufficient information necessary for an assessment may not be collected in time to prevent overexploitation. Even in situations where assessment data such as catch and effort statistics are available for a number of years, the analysis and interpretation of trends in the data is much easier when the early years of the fishery — when population size was large — are equally represented with the later years after the resource was depleted.

Increases in fishing effort frequently take place in the absence of any resource assessment, either as a result of the natural development of the fishery or following a deliberate introduction of more efficient fishing gear by a development agency. The failure to evaluate exploited resources — even qualitatively — before major development projects are implemented can have serious consequences: major increases in fishing effort over a short period of time can lead to the collapse of stocks which are already under extreme fishing pressure.

3.2.4.1 Preliminary Assessments

Preliminary assessments are very simple exercises which are designed to answer the questions "is the resource more heavily exploited now than it has been in the past" and "will additional fishing pressure most

[2] These two types of overfishing are referred to as growth and recruitment overfishing, respectively. Recruitment is defined as the number of young fish which survive to reach a size where they can be harvested by the gear in use. In recruitment overfishing, excessive harvesting results in the capture of so many immature fish (fish which never have an opportunity to reproduce) that the rate of population increase is reduced to below the size which produces the maximum sustainable yield.

likely lead to reduced or increased production?" Answers to these questions must come from an examination of historical changes in landings (and effort, if such data are available) and information concerning the species and sizes of fish which are harvested by particular gear types. Often, such information must be based on the recollections of fishermen or other people who are knowledgeable with the fishery. Sometimes, historical catch and effort statistics are available.

In situations where resource depletion is clearly not serious, attempts to increase production can proceed without the immediate necessity to conduct a more thorough assessment. Positive indications that the resource is not in danger of overexploitation include: 1) no overall downward trend in landings for particular species or groups of species with time, 2) a tendency for increased effort (number of fishermen or boats) to produce increased catches, 3) a tendency for increased effort to produce either the same or increasing catch per unit effort, 4) no dramatic changes over time in the relative abundance of different species caught by a particular gear, and 5) no dramatic reduction in the average size of individual species captured by a particular gear over time.

A decision that a more detailed assessment was not urgent could be based simply on the observation that fishermen who have traditionally fished for particular species in a particular area have no trouble catching all the fish they want. It is important to bear in mind, however, that just because resources seem to be abundant and there is no urgent need for a more detailed resource assessment does not mean that a new assessment will not be necessary sometime in the future as fishing pressure increases. Any decision to increase production from exploited or underutilized resources should be accompanied by a commitment to collect the necessary quantitative data for a later more complete resource assessment.

Other important elements of a preliminary assessment could be 1) an estimate of the productivity of the ecosystem and the yield that can be expected of important commercial species according to their role in the ecosystem and their life history strategy, and 2) the extent and location of accessible fishing grounds. Again, quantitative data are not required. It may suffice to know that the current yield of a pelagic species which feeds on phytoplankton is only half (or double) what is to be expected on the basis of known primary production rates and assumed rates of energy transfer from primary producers to herbivores or that the catch of demersal fish from a known area of bottom is much more or much less than can be expected based on catch per unit area estimates from other similar fisheries in similar habitats.

Indications of extreme resource depletion are much easier to detect. There is usually an obvious increase in the number of fishermen, boats or gear which are active in the fishery over a period of five or ten years. Increased effort is accompanied by reduced total catch or by very noticeable changes in the species composition of the catches and/or the mean size of individual species which are captured. If total catch has not yet begun to decline, it will have remained more or less stable despite increases in effort; thus, catch per unit effort (CPUE) will be declining in response to effort increases. Fishermen complain that they can't catch as much as they used to; the fish are smaller and the higher quality species are less abundant. In this situation, it would be a mistake to encourage additional fishing effort until a more thorough resource assessment has been completed.

3.2.4.2 Quantitative Resource Assessment

More detailed resource assessments require more specific quantitative information and more sophisticated analytical procedures. In this mode, resource assessment follows a well established series of analytical steps, each of which requires estimates of certain parameters which are defined by a conceptual model. Two general types of models which are frequently used for stock assessment purposes are: 1) the surplus production model and 2) the dynamic pool model. Both of these models are equilibrium models in the sense that the size of the exploited stock (which is a function of its rates of growth, natural mortality and recruitment) and the yield which that stock will support are assumed to reach an equilibrium with any given level of fishing effort or mortality.

3.2.4.2(a) Surplus Production Models

Surplus production models require at least four or five successive years of catch and effort data for a given unit fishery (defined in terms of the species captured and the gear used) which ideally represent a range from low to high effort. These models have been applied on a "total biomass" basis (all exploited species combined) and to individual species populations. Surplus yield is considered conceptually as a function of population size (see Figure 2) and analytically as a function of effort. Model parameters are estimated from plots of CPUE versus effort.[3] A common resource management objective is to maintain MSY — a point defined by the peak of the yield curve shown in Figure 2. Management is aimed at adjusting effort in order to maintain a stock size which produces MSY. Surplus production models are particularly amenable to either biological or economic analysis since total revenue rather than total catch may be examined as a function of effort and because costs can easily be factored into the model (see section 3.4).

3.2.4.2(b) Dynamic Pool Models

Dynamic pool models are of various types. The original model (Beverton and Holt, 1957) considers surplus yield as a function of the rates of growth, recruitment and mortality for individual unit stocks. Using estimates of these biological rates of change plus other parameter estimates derived from age or size composition information, the model predicts yield as a function of the age or size when fish are first captured and fishing mortality. Maximum yield results from the proper combination of age or size at first capture and fishing mortality. Management is aimed at adjusting the sizes of fish captured (by changing mesh size in a trawl or a gill net, for example) or the amount of fishing mortality. In practice, changes in fishing mortality must be related to changes in fishing effort since there is no direct way to regulate fishing mortality.[4] Yield is evaluated as the weight which can be harvested from each individual recruit when reliable estimates of the number of recruits entering the population are not available. This version of the Beverton and Holt dynamic pool model is called the yield per recruit model.

Besides modifications in the original Beverton and Holt model which permit the use of size instead of age-specific parameters (Holt, 1962), other modifications make it possible to use estimates of mortality to growth ratios (Kutty, 1970), thus making the model more adaptable to situations in which separate estimates of natural mortality (M) and growth (K) are not feasible. Furthermore, the compilation of size information and M and K estimates for individual species and unit stocks (Pauly, 1978; 1979) has led to the derivation of empirical equations which relate growth rates to maximum size and natural mortality rates to growth, size and mean environmental temperatures for individual species or stocks (Pauly, 1979; 1980a and b). Earlier work by Beverton and Holt (1959) demonstrated that individual taxonomic groups (families, genera) were characterized by a more or less constant M/K ratio, thus making it possible to estimate M or K for an individual species belonging to a given taxonomic group when an estimate of only one parameter is available. These procedures represent "shortcuts" for estimating population parameters which can be considered when available data are limited.

3.2.4.3 Selection of an Appropriate Yield Model

Each of the yield models mentioned so far has certain advantages and disadvantages associated with it which should be considered when selecting an appropriate model for a particular resource evaluation. Simplifying assumptions which apply in each case should be examined carefully and results interpreted accordingly. The use of a particular analytical approach also depends on the biological characteristics of the organism(s) which is (are) exploited and the kind of data which are available or which can easily be obtained.

A major advantage of the surplus production model is that it does not require detailed biological data; a major disadvantage is that in order to make reliable yield estimates, catch and effort data must be available for several years and include a range from low to high effort. Also, the importance of defining the fishing power of different fishing gears and standardizing for changes in capture efficiency over time should not be underestimated. The yield per recruit (Y/R) model requires a number of parameter estimates, but analysis can be

[3] There are two forms of surplus production model which consider CPUE as a linear or an exponential function of effort. The linear model was developed by Schaefer (1954) and the exponential model by Garrod (1969) and Fox (1970). In addition, Pella and Tomlinson (1969) proposed a general version of the surplus production model which permits the fitting of multiple functions to CPUE versus effort data.

[4] Fishing mortality is defined in terms of the probability that any individual fish will die as a result of exploitation during a particular time period.

based on estimates collected during a single year. Two major disadvantages of the yield per recruit model are 1) that direct regulations of fishing effort are not possible, and 2) recruitment is usually unknown. On the other hand, if reliable estimates of all the necessary biological parameters are available, the Y/R model is a much more powerful management tool since it allows for the separate regulation of size selective fishing gear (i.e. gear which captures fish in a certain size range) and fishing mortality.

3.2.4.4 Resource Surveys

Exploratory fishing surveys conducted aboard commercial fishing vessels or research vessels equipped with standard commercial fishing gear can produce estimates of resource abundance, distribution and seasonal availability. Other types of survey such as egg and larval surveys or hydroacoustic surveys may be applicable in some situations for some species, but are not as frequently applied as exploratory fishing surveys, particularly in the assessment of small-scale fishery resources. Egg and larval surveys (see Smith and Richardson, 1977) require a large number of samples to overcome problems of extreme statistical variability and also require knowledge of the fecundity (i.e. the average number of eggs produced per female of a given size) of the species which are being studied, the identification of eggs and larvae (preferably by species), the exact timing of spawning and the rates of egg and larval mortality between the time of spawning and sampling. Hydroacoustic surveys (See Burczynski, 1979) are more applicable to schooling species whose identity can be deduced from the nature of the acoustical signal which is produced: verification is usually necessary and requires the use of a vessel equipped with some kind of appropriate capture gear. The use of data gathered by remote sensing gear placed aboard aircraft or even satellites can be useful for purposes of mapping sea surface temperatures or chlorophyll concentrations, but direct applications for resource assessment are not feasible at this point. Finally, it should be remembered that any kind of resource survey, including exploratory fishing, is expensive. Further discussion of resource surveys in this guide is limited to exploratory fishing surveys.

There are two types of exploratory fishing survey: 1) surveys which simulate commercial fishing operations and 2) surveys which estimate stock size or biomass. Simulated commercial fishing surveys are carried out on new fishing grounds (or using new harvest techniques) and are intended to demonstrate whether or not commercial fishing on these previously unexplored grounds (or using new techniques) is feasible. The objective is to maximize catch rates by locating the most productive fishing grounds (or by using the most efficient harvest technology); no attempt is made to obtain a reliable estimate of the mean catch rate for the entire area inhabited by the stock. Catch rates obtained from simulated commercial fishing surveys therefore provide an overestimate of total resource abundance. Surveys which are intended to produce reliable estimates of stock size must be designed so that individual catches are made at randomly selected stations over the entire survey area during all seasons of the year since resource abundance can be expected to change both as a result of location and time of year.[5] In addition, it is critical that a standard gear type is used and a standard fishing procedure is followed on each sampling occasion.

Estimates of stock biomass can only be inferred from catch rates (weight/unit time) if one knows: 1) the proportion of the total stock biomass in a given area sampled during a given period of time, and 2) the total area which the stock inhabits. Procedures for estimating capture efficiency and for converting catch per unit time data to catch per unit area data have been developed to some extent for trawls which sweep a known area of the bottom per unit time at a given speed and which may or may not capture all the fish in their path. Trawl performance depends on a number of factors such as the size and design of the net and doors, mesh size, towing speed, etc. Since trawl surveys can only be relied upon to assess demersal fish populations which inhabit bottom areas where trawls can be towed, they are not applicable for most small-scale fishery assessment purposes. Wider application of survey techniques to tropical small-scale fisheries will require the use of other gear types and the development of suitable methodologies. Further discussion of exploratory fishing methods will therefore not be included in this guide; the reader

[5] Ideally, the survey area should include the entire area inhabited by the stock, or that proportion of the total area which is routinely fished by the commercial fleet. In practice, biomass can only be estimated for the area which was in fact surveyed, i.e. the area within which sampling stations were randomly selected.

is referred to Mackett (1973) or Saville (1977) for more information.

Even in situations where trawls can be used to estimate biomass, estimates of maximum sustainable yield are very approximate since they are based on extremely variable estimates of mean biomass and single estimates of natural or total mortality rates which are frequently applied to all species caught in the trawl, thus ignoring differences which may exist between species.[6]

3.2.4.5 Empirical Yield Models

Another group of predictive yield models may be classified as empirical models. These are models which simply establish statistical correlations between variables. They can be used to forecast catch based on 1) historical trends in catch and effort data and an estimate of effort in the up-coming year and 2) historical relationship between catch (or recruitment) and some set of environmental variables. These empirical models make no attempt to explain the mechanisms which produce changes in yield or to establish causality. Computer simulations can be used to evaluate the sensitivity of yield predictions to changes in individual variables and combinations of variables. These variables can include economic and sociocultural factors as well as biological ones. Because these models require so much data and data processing capability, they are usually not practical for the evaluation of resources exploited by small-scale fisheries in developing countries.

3.2.4.6 Multispecies Fisheries

Considerable attention has been focused in recent years on multispecies fisheries and multispecies stock assessment. Conventional models such as the Beverton-Holt model and surplus production model were developed originally for application to single species populations. Since no species exists in isolation from other species in the fishery or in the ecosystem, and since many fishing gears exploit more than one — and often many — species at once, attempts have therefore been made to modify the conventional models to include the effects of species interactions such as competition for food and space, predator/prey relations and the exploitation of several — or many — species by the same gear. At the same time, more attention is being paid to models which do not assume constant survival rates throughout the life cycle and models which allow for random variations in recruitment, growth and mortality rates. Although these represent important advances in assessment, the models are diverse, complicated, and require a great deal of data, more than is generally available even in developed countries, not to mention developing ones. Even though this guide describes data requirements and collection methods which relate to unit stock (single species) assessments, it should be emphasized that these data can also be used for multispecies assessments.

3.3 SOCIOCULTURAL INFORMATION

3.3.1 Introduction

As mentioned in Chapter II, sociocultural information performs two functions: it facilitates the collection of biological and economic data and is a key element in making development and management decisions. In this chapter, the types of information needed are identified and divided into three general categories. Individual data needs in each category are listed separately and referenced according to the section in Chapter IV where they are described in detail.

3.3.2 General Background Information

General sociocultural information is required in order to understand the structure and function of a small-scale fishery system (see Figures 3 and 4). If interventions in the fishery are to succeed, this information is crucial. Perhaps the most basic sociocultural information which is needed concerns the identification of groups (4.2.2.1). If fishermen appear to belong to distinctive groups (linguistic, religious, or ethnic groups, for example) it is necessary to determine where they are located and the

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[6] Gulland (1971) proposed the following equation for estimating MSY for an unexploited population from estimates of biomass and natural mortality:

$MSY = 0.5\, M\, B_0$

where M = instantaneous rate of natural mortality
and B = the maximum (unexploited) population biomass as estimated from surveys.

This equation has been modified for use with exploited populations, i.e.

$MSY = 0.5\, Z\, B_0$

where Z = instantaneous rate of total mortality
B = the exploited population biomass.

degrees of intergroup tension which exist between them (4.2.2.2). Often, the design of development projects will be influenced by intergroup differences; if groups are identified during early stages of planning, it will be possible to more realistically estimate project costs (Cochrane, 1979).

After groups have been identified, the numbers and locations of potential project participants within these groups must be determined (4.2.2.3). At this time it is also possible to obtain information concerning traditional communication channels (4.2.2.4) which will facilitate other data collection programs as well as enhance communication of proposed changes (Pollnac and Sutinen, 1980). Information needs at this point include 1) level of development of target communities (4.2.2.5), 2) occupational structure of the target region (4.2.2.6), 3) numbers of small-scale fishermen, both employed and unemployed (4.2.2.7), 4) availability of alternative occupations for fishermen (4.2.2.8), 5) temporal distribution of fishing effort (4.2.2.9), and 6) local knowledge about fishing and fish (4.2.2.10).

3.3.3 Social Structure of the Occupation

If a decision is made to increase production by improving technological efficiency rather than increasing the number of fishermen, then information needs indicated by Figure 4 become essential. Basically, what is required is an analysis of the social structure of the occupation of fishing and its place in the social structure of the community. The required data include 1) fishing gear types and ownership patterns (4.2.3.1), 2) crew size and social composition (4.2.3.2), 3) criteria for crew selection (4.2.3.3), 4) degree of occupational mobility (4.2.3.4), 5) types of interaction between crew members and between owner and crew (4.2.3.5), 6) degree of on-and-off vessel occupational specialization (4.2.3.6), 7) relationship of fishing groups with other social groups in the society, (4.2.3.7), and 8) the local distribution of wealth[7] and power (4.2.3.8). This information is also valuable if the number of fishermen in the community increases, but technology remains relatively unchanged.

3.3.4 Innovation, Occupational Preference and Training

Information concerning previous attempts to introduce innovations, their type, and their acceptance should also be gathered at this time (4.2.4.1) as a means of evaluating the potential for change as well as the most effective means for accomplishing it. Attitudes toward risk, change, and investment (4.2.4.2) can also be evaluated at this stage of the project. These will be important variables to be considered in the cost/benefit analysis of the various technological alternatives.

After the most appropriate technology is selected, it is important to assess how the expected changes which will follow are perceived by individuals and groups which will be affected. Often the new technology is only one of many changes which are considered. For example, if the costs of the technology require that credit be provided, then the expected methods for extending credit also need to be evaluated prior to introduction (Pollnac, 1981).

If new fishermen are recruited to the occupation, attitudes of non-fishermen toward fishing should be assessed (4.2.5.1). If potential new fishermen require training and if there is a pool of individuals who wish to become fishermen, then social and economic costs and benefits of alternative training techniques should be compared. This analysis should recognize the importance of using locally acceptable training techniques for adults. It has been reported that training efforts have failed for reasons as trivial as inappropriate setting (Foster, 1973). Both the recruitment and training of new fishermen should be treated as innovations requiring information of the types listed below.

In the situation where resources need to be managed, information referred to above (such as alternative occupations for fishermen and skill levels) will make the selection of appropriate management procedures easier. It will, however, be necessary to obtain information concerning fishermen's attitudes toward fishing as contrasted with possible alternative occupations (4.2.5.2) as well as attitudes towards changes in income (4.2.5.3). Proposed management strategies

[7] Wealth refers to different things in different societies (Cochrane, 1979; Foster, 1973). In some, a wealthy man is one with many children, in another, wealth is equated with the leisure time to fulfill social obligations, while in others it is equated with the possession of certain material things (e.g., gold, religious statues, yams, cattle, etc.).

(such as gear restrictions, closed seasons, or size limits) must also be treated as innovations requiring the specific information listed below.

As changes are introduced, it is important to evaluate the ways in which the following attributes of the changes are perceived by the fishermen: 1) complexity (4.2.5.4); 2) compatibility (4.2.5.5); 3) relative advantage (4.2.5.6); 4) trialability (4.2.5.7); and 5) observability (4.2.5.8), (Rogers and Shoemaker, 1971; Pollnac, 1976). Individual attributes associated with innovativeness (4.2.5.9) should be assessed at this time as a means of identifying individuals who will serve as appropriate subjects for demonstration purposes.

3.4 ECONOMIC INFORMATION

3.4.1 Introduction

Some of the more important reasons for acquiring economic information about the fishery system can be stated in general terms. They include the need:

1) to understand how the system functions;

2) to evaluate the potential of the fishery to provide protein and employment;

3) to be better able to suggest and to evaluate the potential impact of interventions, i.e. of regulations and/or investment projects;

4) to determine the impact on the fishery of development in other areas - especially in the development of the industrial fishery.

In Chapter I we examined a series of decisions that would have to be faced in attempting to expand the fishery's role in supplying protein. A significant amount of information would have been required to determine if that goal were realizable, if the interventions proposed would have the desired result, and if the entire process were worthwhile. Any particular intervention would require information from many sources and the coordination of many ministries or departments. We concern ourselves here with information (this chapter), data (Chapter IV) and collection procedures (Chapters V and VI) particular to the fishery department's ongoing responsibility for small-scale fisheries. This information forms a core for project design and evaluation. For detailed information on fishery investment projects see Campleman (1976) and Engstrom (1974).

In this section of Chapter III we shall look more closely at economic forces at work and see why information about them is important. The qualitative results of using simple bioeconomic relations will point out information needs. We shall see that attempts to help fishermen and consumers, to conserve the resource and to rationalize the harvest sector are often at odds with each other.

While the economic operation of the entire system connects suppliers of inputs to fishing at one extreme and the consumers of fish at the other, the primary focus of what follows will be on the economic operation of the harvest sector itself. For the purposes of this guide we define this to be limited to the purchase of inputs by fishermen, the fishing or harvesting process and the sale of output to middlemen or consumers (see 4.3.1). It is not our purpose to explain the analyses which are commonly used to obtain this information. Detailed explanations exist in several sources and they will be referenced.

3.4.2 The Bioeconomic State Of Harvesting

3.4.2.1 Open Access

An open access fishery is one in which there is freedom to enter and exit — freedom for an individual to take up fishing or leave it depending on the opportunities available to him. Because of the opportunity this freedom offers, there is a tendency for open access fisheries to overexploit the resource in an economic sense. There is a tendency from society's, and not the individual fisherman's, point of view for more labor and capital to be used in catching the fish than is desirable. New investment persists until the total cost of catching the fish is equal to the total revenue the fishermen receive for all the fish during that year. This may occur to the left of, at, or beyond MSY (Figure 2). We will examine how an open access fishery develops around a newly exploited resource and how individual decisions lead to economic and perhaps biological overexploitation.

When a fishery is new, fishing represents an opportunity for people to make better incomes than they would normally. They enter the fishery in anticipation of receiving better returns (or at least as good) for their labor and invested money than they would receive in the next best employment or investment opportunity.[8] If local, regional

[8] We use opportunity here to mean those which can be taken advantage of. There may exist barriers - cultural, educational or social - which prevent opportunities from being pursued. We will assume for now that there are no such barriers to entering the fishery.

or national economic conditions are such that current incomes are low, then the "normal" income may mean subsistence farming, rural or urban unemployment. If we assume that the selling price of our single species of fish remains constant regardless of how much is sold to middlemen and that all fishing operations are the same, then Figure 6 represents a simplified picture of two of the many possible alternate courses of a new open access fishery through time. It shows the annual total revenue (catch multiplied by its price) received for fish and the annual total cost of catching the fish (effort multiplied by the cost per unit effort) at different points in time.[9] We will first discuss situation C, represented by the solid lines.

Initially there is a large quantity of fish to be caught by relatively few fishermen. This quantity is even larger than the quantity of surplus production at MSY because fishermen are reducing the initial total population as well as catching some of the surplus production. As more people realize the opportunity for larger incomes, they enter the fishery. As more and more begin fishing, the catch per unit effort begins to decline. There are still above "normal" returns to be made at, say, C' but less so than there were earlier. At C", for the first time, the total revenue of the entire fishery is just equal to the total cost of catching the fish. At C" the average fisherman is making only a "normal" income. Because of the delay in the apparent response of the stock to fishing and because of the difficulty in selling boats and gear, there are years of disequilibrium in which the total costs exceed what the fishermen receive for the fish (e.g., point C'"). After a while, in our simplified fishery, a somewhat stable equilibrium is reached (at C_1).

The initial rate of response of the entrants depends upon the perceived above normal returns. If their incomes had been above subsistence level, for example, and if the method of fishing used were more costly than in the case just described, the response might have been quite different. An example is given by situation A, represented by the dotted lines in Figure 6. Note that the equilibrium level of total revenue (and therefore catch) reached at point A_1 is above that reached at C_1. Nevertheless, at point A_1 the annual total revenue of the fishery is equal to the annual total cost.

Figure 7 compares the annual revenue and costs of an average lone fisherman at points C' and C_1 respectively. The operating costs are the same under both situations; however, the incomes differ substantially. At C' the average fisherman's income is above "normal." It is composed of two parts: the return which he would be able to earn in other opportunities (his opportunity cost of fishing) plus a share of the industry-wide profits being earned (at C' total revenue exceeds total cost). At equilibrium point C_1, however, these profits are gone. The average fisherman, given our assumption of similar firms, is earning exactly the opportunity cost of his time and the opportunity cost of his equity capital.[10]

The existence of the fishery-wide profits at C', as at all the points before C', drew people into the fishery. The increased effort on the resource gradually diminished catch rates and, consequently, the revenues each fisherman received. People continued to enter the fishery until there was no advantage in doing so.

Points like A_1 and C_1 can be thought of as points on the equilibrium yield (total revenue) curve. Figure 8 shows two bioeconomic equilibrium points and their associated total cost (of effort) lines (cf. Anderson, 1977). Where an equilibrium point will lie relative to MSY depends on the reproductive nature of the resource, the fishing mortality inflicted on the resource by a nominal unit of effort, the price received for the fish and the cost of effort. Recall from Figure 7 that these costs include a "normal" return. In general, if the resource has a low reproductive rate, or the nominal effort has a large impact on fishing mortality, or the price of fish is high and the cost of effort (including the normal return) is low, then the bioeconomic equilibrium point is more likely to lie beyond MSY.

[9] We use "effort" here to mean nominal effort such as total number of days fished so that there is a correlation between nominal effort and the number of people in the fishery. The cost per unit effort is assumed constant but differs between A and C.

[10] Economists refer to this "normal" income available in other occupations as the opportunity cost. The opportunity cost of fishing is the foregone returns available in the next best use of a person's labor and money. Opportunity cost is a useful measure which helps explain why individuals switch occupations and/or investments. As such it can be used to predict, for example, the supply of labor to an industry. The absence of alternate employment and/or investment opportunities is an indication that people will persist in their work/investments perhaps in spite of poverty level incomes. Smith (1979) examines this in relation to small-scale fisheries research issues.

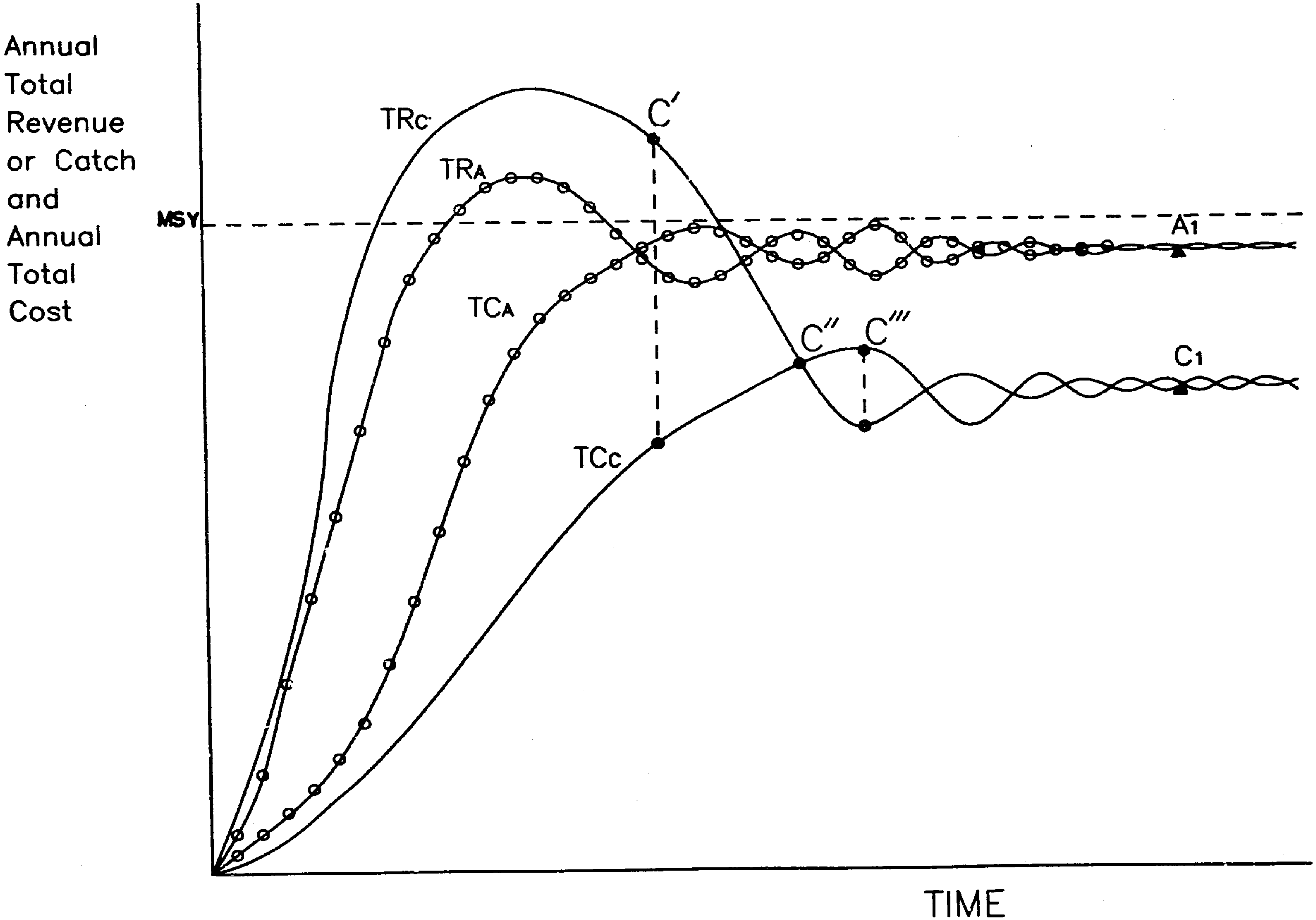


Figure 6. Two possible courses of exploitation of an unregulated fishery. *In situation C the price of fish is higher, the cost per unit of effort is lower and entry ceases later than in situation A. The equilibrium catch in situation A, A_1, is closer to MSY than the equilibrium catch in C, C_1. Neither equilibrium is perfectly stable. At both A_1 and C_1 industry-wide profits are zero.*

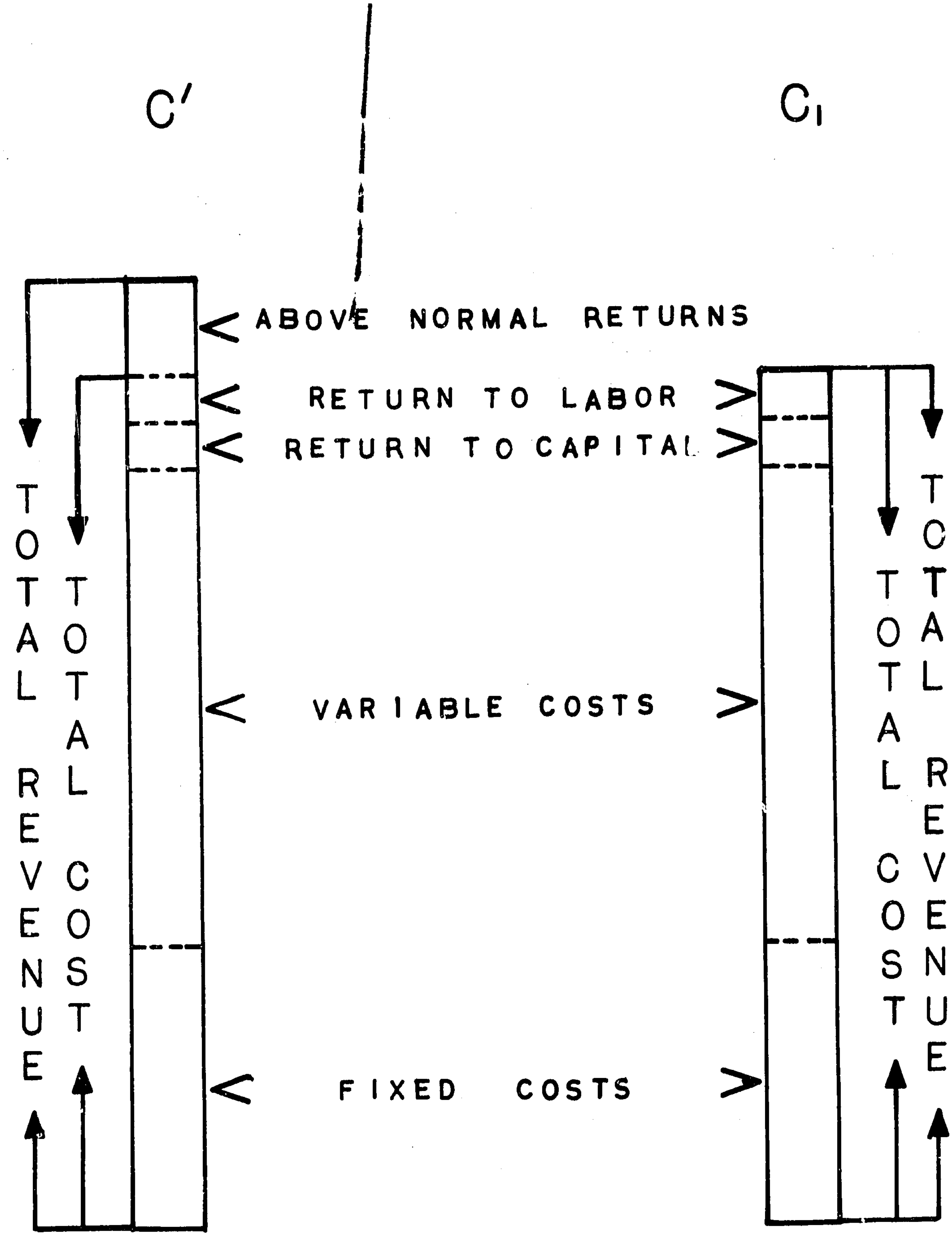


Figure 7. Annual total revenue and annual total costs for an average lone fisherman in situation C. *At C′ the fisherman earns greater than "normal" returns to his invested money and labor. At C_1 his revenue is equal to his costs. His costs include his perception of the opportunity cost of his money and time. All costs are considered in this example to be independent of the value of the catch. Otherwise the costs at C′ would be greater than those at C_1 (see 4.3).*

Let us assume that the fishery is in a state of biological and economic overexploitation (point C_1 in Figure 8). C_1 is undesirable in a biological sense because surplus production is less than it could be. The equilibrium stock size is likewise smaller and therefore more susceptible to the effects of environmental and/or recruitment variations. This is not so at A_1. The economic conditions at C_1 are undesirable, but this holds for those at A_1 as well. In society's view too many productive resources are being used in both cases to produce fish.

Let us examine the reaction of a biologically and economically overexploited fishery to a change in 1) the price of fish; 2) the price of an input (fuel) and 3) a technological change.[11] If, after a campaign promoting fish consumption, the price of fish were to increase, the total revenue curve in Figure 9 would shift up (new price multiplied by catch). A vertical gap would appear between the new curve and the cost at the old equilibrium, C_1. Fishery-wide profits would become available again. To take advantage of this profit, fishermen would fish more and new fishermen would enter the fishery. Catch per unit nominal effort would fall and those profits would gradually disappear. After a period of adjustment a new equilibrium will be reached at C_2. At C_2 the resource is even more overexploited in both senses. The amount of men and money in the fishery is larger than before and the fish population smaller. Figure 9a shows the reduced flow of fish as a result of the price increase. An approximate indication that the catch has been reduced may be obtained by dropping a vertical line from the new equilibrium C_2 down to the old sustainable total revenue curve. The average fisherman at C_2 is no better off than at C_1. In the long run consumers, paying more for less fish, are worse off.

Figures 10 and 10a show the long run response of the entire fishery to an increase in an input cost. If we assume that the input is fuel (though it could as well be ice or bait), then the average cost of a day's fishing would increase. We indicate this in our picture of the harvest sector by rotating the total cost curve up and to the left. A temporary condition is immediately created in which the total cost of fishing exceeds the total revenues. Given that we are using a nominal measure of effort, the figure shows a reduction in the number of days fished or in the number of fishermen. We might argue that some fishermen find that this increased cost reduces their income below their opportunity cost of fishing, i.e. they have alternate opportunities which offer a larger return; hence, they leave the fishery. The actual response is likely to be much more complicated. They might, as a group, fish closer to their home ports or substitute sail power for motor power. It is safe to say, however, that inasmuch as fuel use is correlated with effective effort, less fuel use would mean less pressure on the resource. The long run result of either explanation (shown as C_3) is that the stock size increases and the flow of fish to market increases. As we might expect, the remaining fishermen are no better off than before. The mix of capital and labor may have changed but, as shown in the figure, the total amount invested will have increased.

An increase in the cost of catching a given quantity of fish can also be brought about by the imposition of biological regulations such as those that limit size at first capture. Such regulations cause the temporary adoption of harvesting inefficiencies. They achieve some biological good however. The long run effect of mandatory adoption of larger minimum mesh size nets can be seen in Figures 11 and 11a. The short run effects are more clouded in this example than in most of these long run scenarios. Because the catch per day is initially reduced, people may either leave the fishery immediately or try to fish longer hours. The increased mesh size being used by fewer total fishermen results in significantly less pressure on the resource. Gradually both the numbers and size of the fish caught increase. Ultimately profits reappear and people enter the fishery. Profits exist even at the former level of nominal effort simply because the resource has had an opportunity to rejuvenate itself. The level of nominal effort increases until the profits disappear at the new equilibrium C_4. In a sense this complicated set of dynamics can be compared to an imposed form of savings: current consumption is delayed so that a larger (sustainable) supply is available later. At C_4, however, there is a larger investment by society in the fishery and, perhaps, more people fishing. And while the flow of fish to market has stabilized at a higher level, the individual fishermen, as in all of the situations described above, have not benefited. Industry-wide profit is zero.

[11] Economists will recognize the limitations imposed by the straight line total cost function. For the purposes at hand, responses to the changes in the examples will be shown as straight line changes while the text will discuss differential impacts, suggesting different opportunity costs and inframarginal rents.

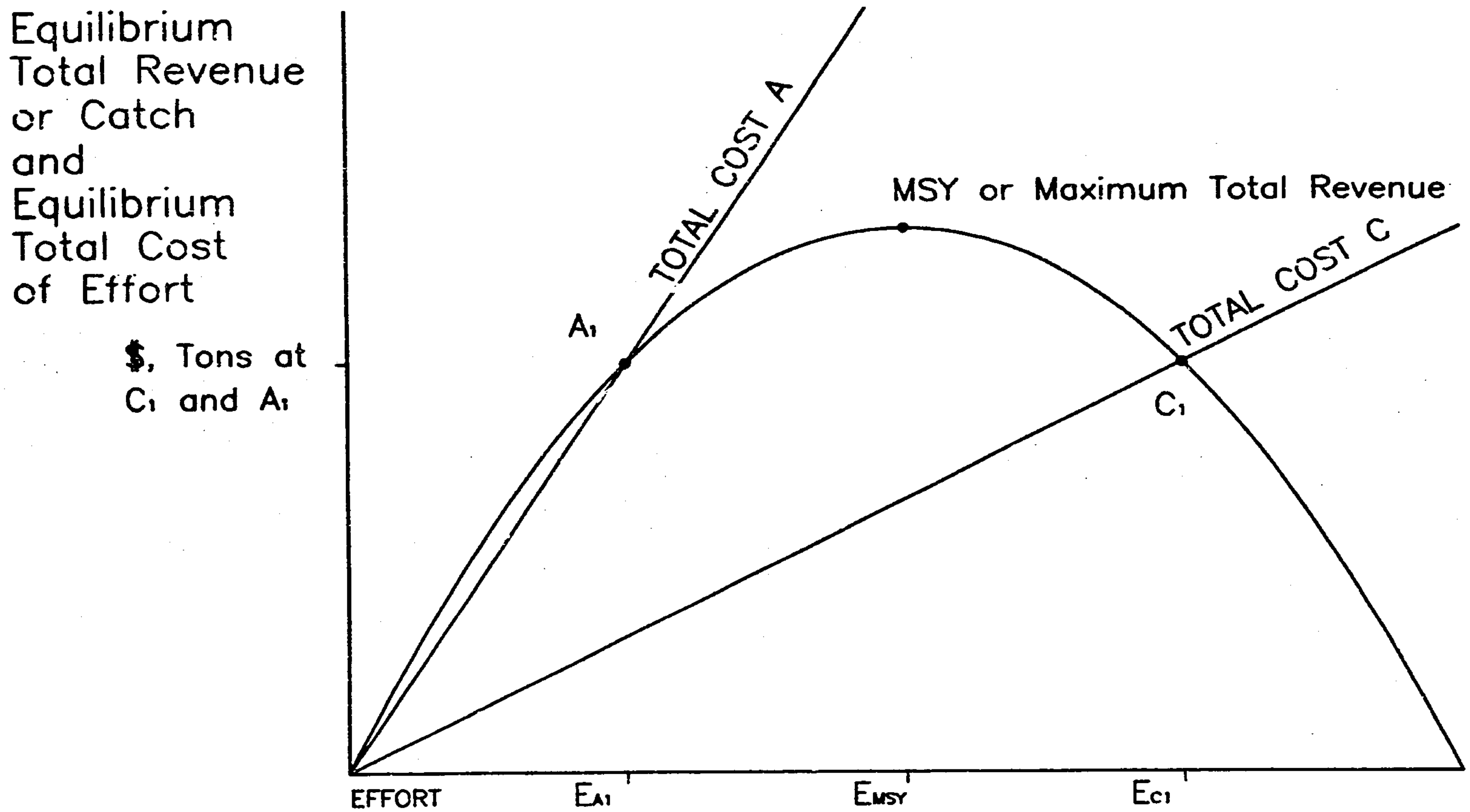
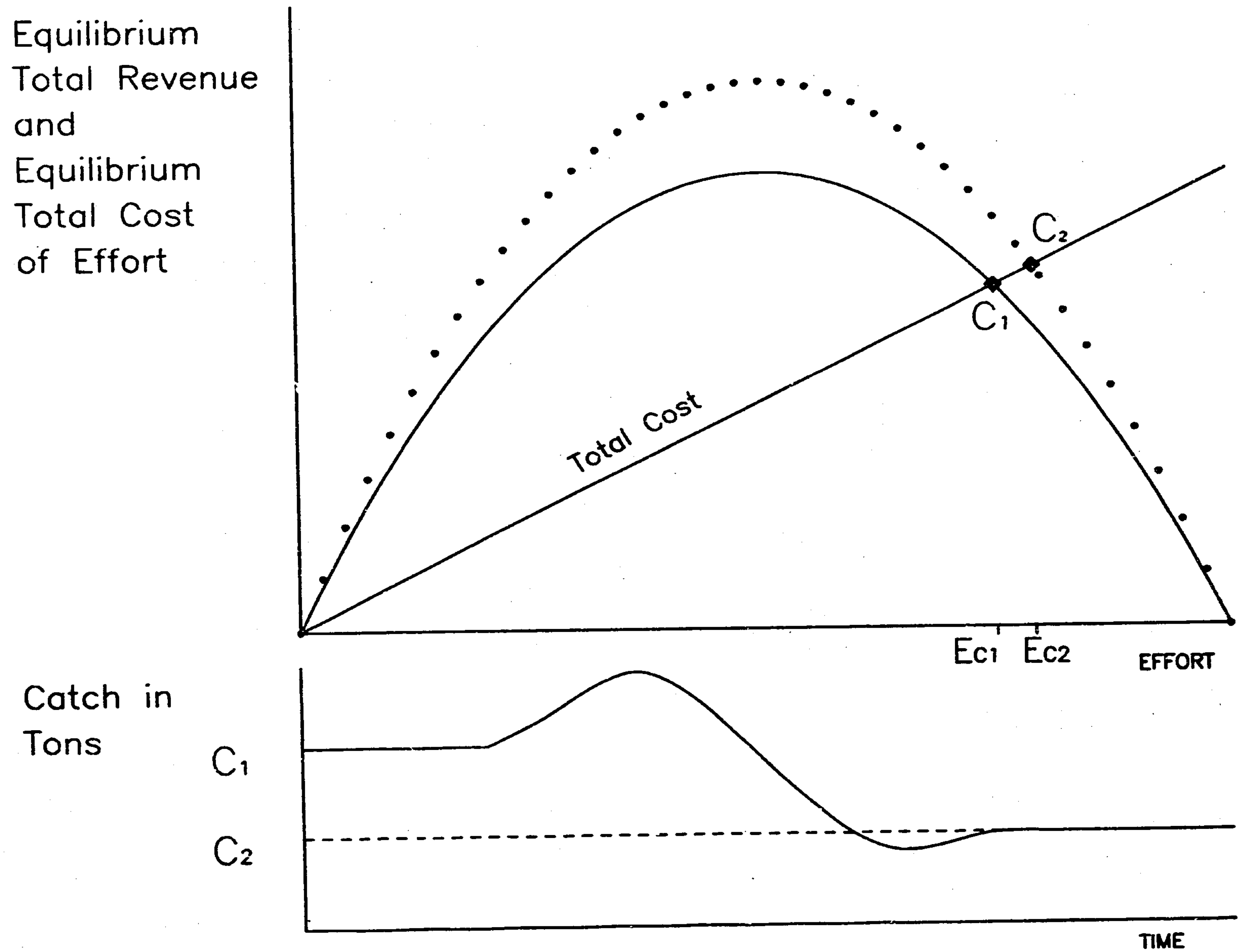
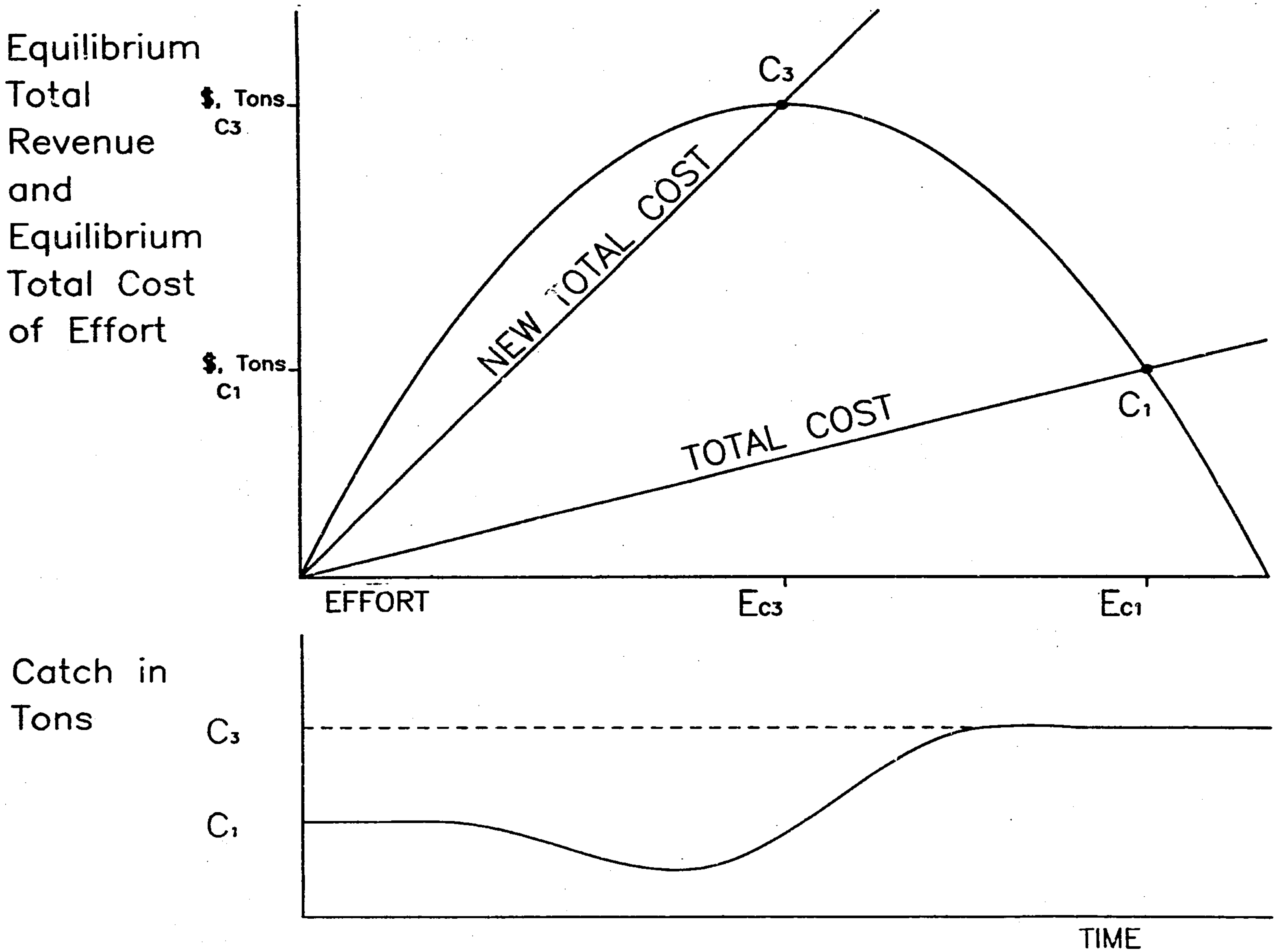


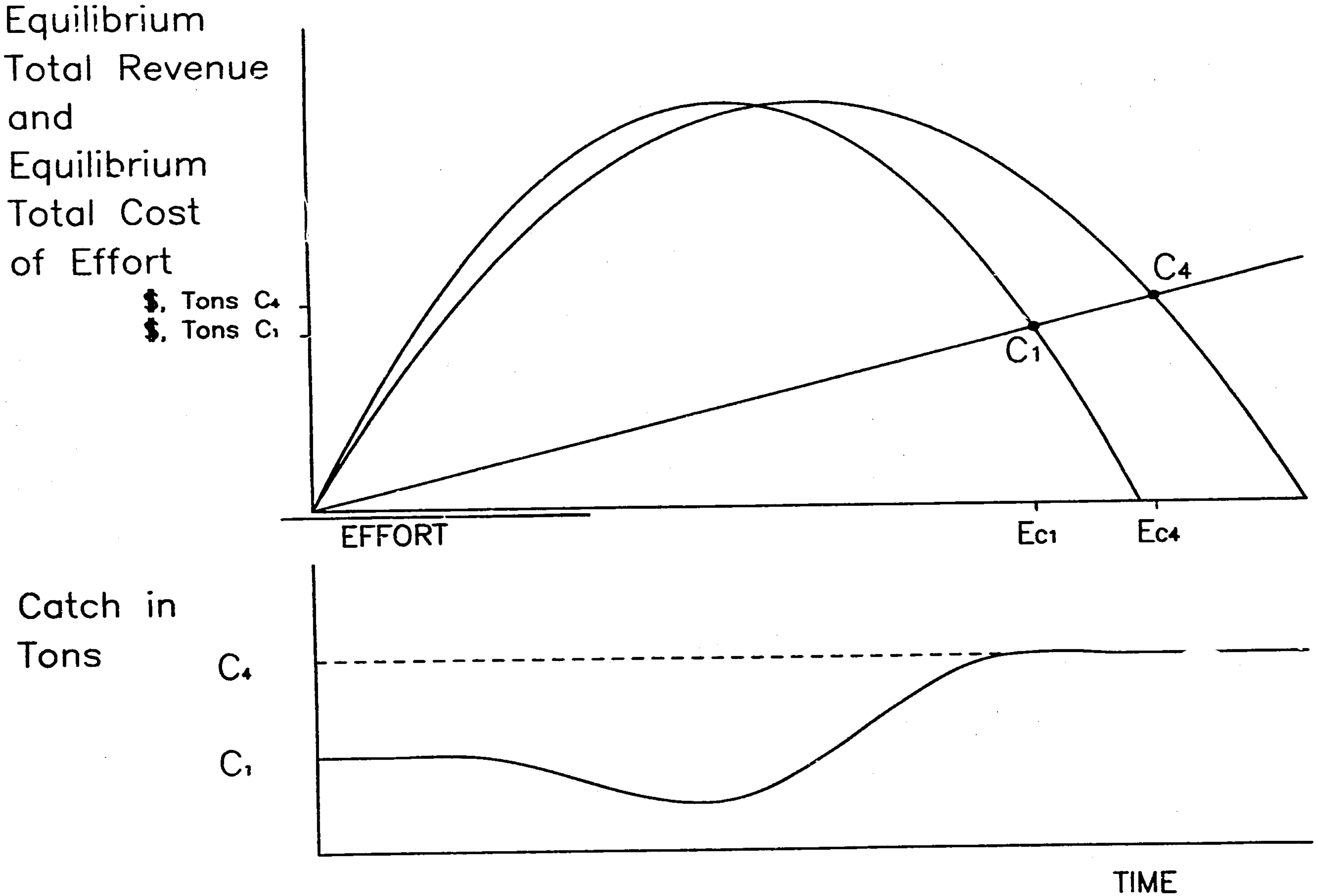
Figure 8. Two cases of economic overexploitation. ***At A_1 there is no biological overexploitation while at C_1 there is. In both cases industry-wide profits are zero. The per-unit cost of nominal fishing effort is much greater along line A than it is along line C. The flow of fish to consumers is the same in each case.***



Figures 9 and 9a. Long run response of an economically and biologically overexploited fishery to an increase in the price of fish. ***In the short run, industry-wide profits would appear directly above C_1 attracting new fishermen and increasing the amount of fishing by those already in the fishery. A new equilibrium will eventually be established at C_2 with greater overfishing and greater overinvestment of people and money in the fishery. In addition, the flow of fish to market will be less at C_2 (Figure 9a).***



Figures 10 and 10a. Long run response of an economically and biologically overexploited fishery to an increase in the price of fuel. ***In the short run there will be less effort expended on the stocks as fishermen either leave the fishery, fish less, fish less far from home, or switch methods of propulsion. The stock will recover to some extent and catch per unit nominal effort will increase. A new equilibrium will be established at C_3 with zero industry-wide profits but a greater flow of fish to market (Figure 10a).***



Figures 11 and 11a. Long run response of an economically and biologically overexploited fishery to a larger minimum mesh regulation. *In the short run the pressure on the stocks will decrease as the less efficient gear catches fewer and on average older fish. As the stock regenerates, industry-wide profits will appear. New fishermen will enter or former fishermen will reenter the fishery. The new equilibrium at C_4 shows a greater amount of nominal effort employed, larger sustained yield (Figure 11a) and larger but equal total revenue and total cost of fishing.*

Without redrawing Figures 9, 10 and 11, we can see the results of the reverse situations - falling prices, decreased costs of nominal effort, and more biologically effective gear - by starting with the new equilibria and working backward. We should keep in mind that all of these equilibria are of a long run nature and are the theoretical end result of the shorter run dynamics of firm and stock adjustments.

3.4.2.2 Resource Rents and Owners

The "industry-wide profit above opportunity cost" is often called the "resource rent." This rent is most easily thought of as the total annual amount that an owner of the resource could charge those using his stocks. In some traditional societies in the Pacific, fish resources are "owned" by certain coastal communities. These communities lease rights to fish to others in exchange for goods and services.

For the purposes of explanation, let us imagine a resource owner and assume that he confronts a situation in which there is both biological and economic overexploitation of his resource. If, starting at a position such as C_1 in Figure 8, he were to charge a small fee per pound of fish caught, some fishermen would be forced to leave the fishery; their costs would have risen while the price they received would have remained the same. After a while the owner would have a somewhat larger stock of fish than existed at C_1 and fewer fishermen seeking to fish. If he were to continue each year to raise the price per pound caught, effort would be reduced further. Consequently his resource would replenish itself to a level where it would be harvestable at MSY. At MSY he might be able to collect a considerable annual rent.[12] There would also be significantly fewer fishermen fishing. The owner could pursue this policy of increasing the catch fee until he maximized his rent at MEY.

The same results would come about if the resource owner taxed or charged for effort, as long as the effort was, in turn, directly related to fishing mortality (i.e. effective effort). Likewise, he could hold an auction and have fishermen bid for the privilege of fishing for and catching a certain amount of fish. In other words, he would have the option of controlling the amount taken each year either directly or indirectly (effective effort).

The owner would incur management costs, of course. There would be research costs, administrative costs, negotiation and legal fees, and substantial enforcement costs. These would differ depending on which method was chosen to collect the rent. After a few, initial, unprofitable years, he might be able to finance these costs from the rents received. These rents would increase as the stock replenished itself from the open access point C_1 through MSY to MEY. The process of reducing effort might take several years and, depending on all the various factors involved, the management costs might exceed the rent at MSY and, possibly, even at MEY. If there were an owner of the resource, then, and if he decided to collect the rent due him, he would have to estimate the magnitude of the rent and compare it to the estimated management costs.

Whether there exists such an owner is a legal, even constitutional, question which has implications for the disposition of the rent and for the magnitude and distribution of management and certain other costs. If society is considered the owner and the government can and does act on its behalf in collecting the rent, then broader efficiency and equity questions are raised. The narrow efficiency goal, from society's point of view, is to produce the biologically and economically proper amount of fish at minimum cost (Anderson, 1977). This minimum cost refers to the opportunity cost of scarce resources used to harvest the fish. Trying to bring about the proper level of harvest has costs of its own. We have already discussed management costs. But perhaps additional costs will be incurred by society, such as payments to fishermen and their families from established social insurance programs. Or, perhaps, some other costs will be assumed by society out of equity considerations. Perhaps some of the rent should be used to buy back (retire) boats and gear gradually. Or perhaps alternate income opportunities should be developed for those who are displaced.

From quite another viewpoint, arguments can be made for recognizing existing fishermen as owners of rights to a certain percentage of the annual catch. This total amount could be adjusted annually. For example, enforcement costs could be reduced by establishing individual rights which would be recognized in the courts. The number of

[12] The amount depends on the factors we are familiar with: the price of the fish, the productivity of the resource and the costs of fishing.

fishermen being granted or being recognized as having these rights could vary from the number currently fishing to some smaller set based on, say, historical participation. Once granted, these rights might be freely sold, traded, or gradually bought back by the government.

There is considerable middle ground where society and fishermen can share rents. It is doubtful that many, if any, management schemes would be able to succeed without incentives to the fishermen. We would expect the enthusiasm of all fishermen to be diminished for any scheme if they were asked to trade the certainty of increased costs today for uncertain future returns.

The issues involved in trying to improve the condition of an economically overexploited open access fishery are many and complicated. Several different management schemes are in use and many more are under discussion.[13] In general these schemes recognize society's interest in seeing that the resource is properly used (narrow goal) regardless of the ownership question. They then examine the broader efficiency and equity aspects of who, among society, consumers and fishermen, benefits and who pays the costs.

We saw earlier that the imposition of biological restrictions which do not properly control total effort can only address some aspects of the problem. While the quantity of fish flowing to the markets will eventually increase as the stock rebounds, management costs are incurred, excessive resources (the money value of vessels, gear and labor) are still diverted from more productive areas of the economy, and those who have not been forced out of the fishery are not better off than before. There is, of course, the option of doing nothing. This option is not costless, however: the economic condition of the fishermen will persist and very possibly grow worse; the resource, which may already be stressed, will be increasingly exploited; the benefits of an increased protein supply from the fishery are foregone; an annual amount of money called the resource rent or industry-wide profit which is equal to the annual value of the overinvestment in the fishery (but which is not costless to collect) is foregone for all uses; and, as we will see below, the price of fish will be higher than it could be.

3.4.2.3 Other Options

Having seen the case of biological and economic overexploitation, let us examine an open access situation in which the resource is not as yet fished beyond MSY. We will assume that the fishery is in equilibrium at some point like point A_1 in Figure 12. The standing stock which can yield A_1 is larger than that which yields C_1, larger, in fact, than that which could produce MSY. The flow of fish to market is the same in either case but less than the flow at MSY. Given our assumptions, there are fewer fishermen at A_1 than at C_1 but there is no industry-wide profit to share in either case; the incomes of those fishing are the same.

Is there economic overinvestment of men and money in this situation as well? Yes. Total revenue equals total cost at A_1 as it does at C_1. In fact, given the way Figure 12 is drawn, the total revenues and total costs are approximately the same (we measure these values by distances on the vertical axis, not by areas). However, the amount of overinvestment in situation A, OI_A, given the technology and its per unit cost of effort, is less than that in situation C, OI_C. This may not be immediately clear, especially since the individual profitability of the fishing units is the same in both situations. However, we can see that the technological change that reduced the costs of fishing (per unit of nominal effort) has benefited the nation and the fishermen only in the short run. In the long run, there is a greater amount of rent foregone at C_1 than there was at A_1.

Depending on our goals, for example to increase utilization of the resource or to better the conditions of fishermen, the creation of rent can be viewed as either a tool or as an end in itself[14]. The rent is, as we have seen, the difference between the total revenue to the industry (to all fishing units) less total costs. Rent can be generated in the short run by increasing total revenues. Programs to stimulate demand or to establish an export market can raise the price received by

[13] Several international conferences have focused on the merits of different management schemes. Some of the contributions to these conferences are referenced at the end of this guide (see Pearse (1979) for example).

[14] In a fishery the amount of rent actually or potentially available is a useful quantitative measure for evaluating the alternate weights to be given to non-efficiency considerations such as levels of employment in the fishery, income levels and income distribution. MEY is simply the yield/effort combination of maximum potential rent.

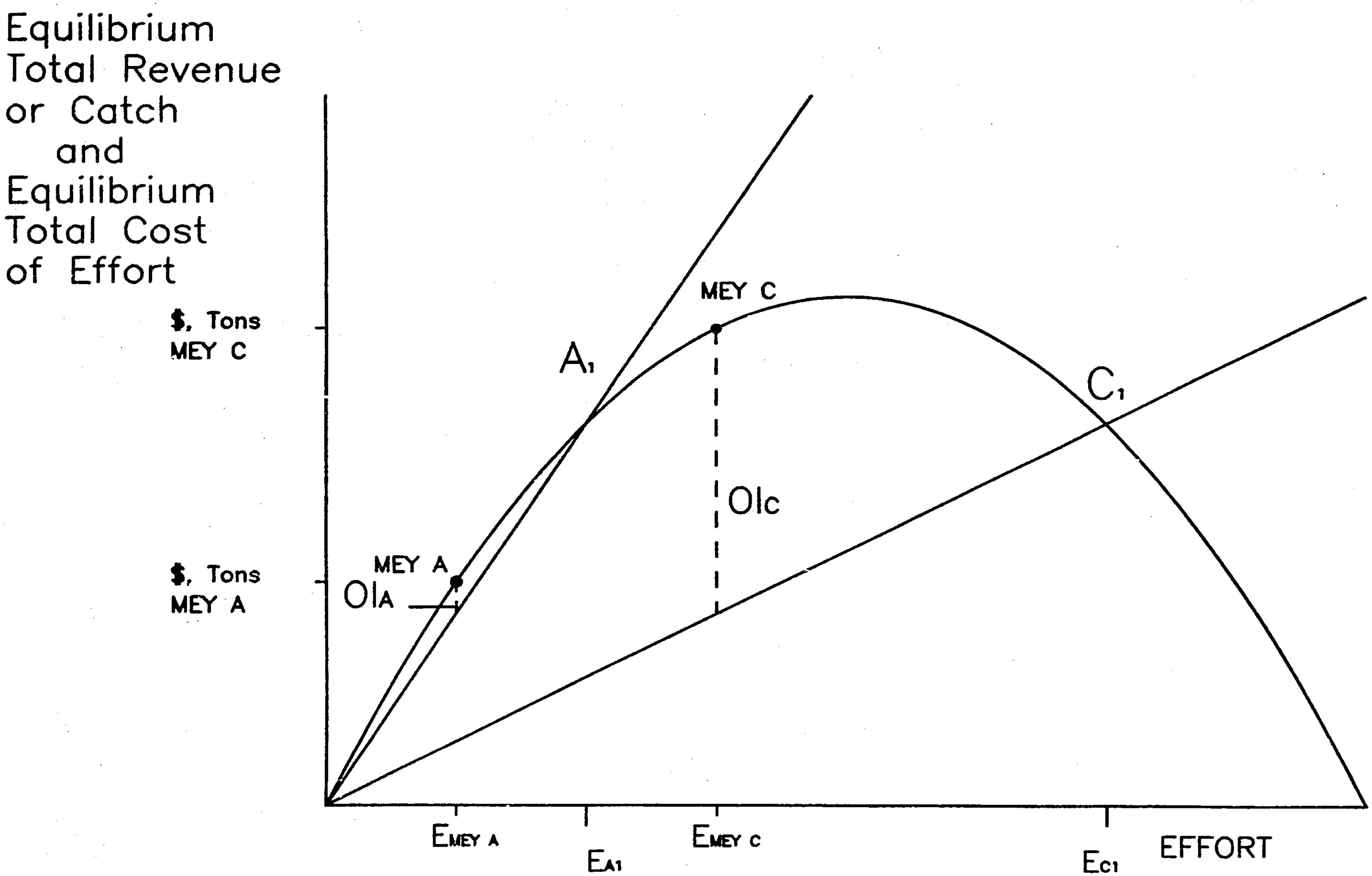


Figure 12. Two cases of overinvestment. *Similar to Figure 8. Case A shows no biological overexploitation which case C does. An investment in more efficient technology reduces the per unit cost of nominal or effective effort from A to C. In the short run the returns to that investment (the benefits) will be positive but ultimately, at C_1 industry-wide profits will be zero. In addition there is, at C_1, biological overfishing, and the loss of a greater amount of potential rent. Viewed another way there is a greater amount of social overinvestment in Case C (OI_A versus OI_C).*

fishermen. Reducing total costs will have the same rent generating effect. Rent can also be made available by allowing access to new, perhaps more distant stocks through new vessel designs, for example. This, in effect, redefines all of our equilibrium yield figures. Once this potential rent is available, effort and the utilization of the resource will begin to increase as shown in Figure 6.

There are many situations in which indigenous barriers may slow the desired increased biological exploitation. On the other hand these barriers can work in our favor by substantially delaying the loss of the newly created rents. Many development projects aimed at increasing incomes to fishermen have been premised on the existence of cultural, educational (skills) or geographic (isolation, access) barriers which will permit improved incomes for those involved for long periods of time. In the long run, however, without some measure of control these industry-wide profits will disappear. The speed at which this will occur depends on the nature of the barriers.

Figure 13 shows various long run, equilibrium states of the harvest sector. The three straight lines represent three different sets of total costs of nominal effort - each representing a different cost per unit of nominal effort. Along line OA this per-unit cost is highest, along OC it is lowest. We have seen and discussed the situation at C_1. At A_1 and B_1 we encounter economic but not biological overexploitation. At MEY_A, MEY_B, and MEY_C we have three different, economically optimal situations. Given our narrow efficiency goal — the biologically and economically proper amount of fish extracted with the smallest total extraction cost — the situation at MEY_B is better than that at MEY_A and is "best" at MEY_C.[15]

The goal of investing in more effective gears, for example, can be characterized as trying to move from line OA, to some point on line OB, even to a point on OC. Without some controls these investments will, slowly or rapidly, lead to a new intersection with the total revenue curve at, for example, B_1 or C_1. While a change from A_1 to B_1 gets more fish to the markets — assuming the rest of the delivery system is operating well — the benefits of increased production must be weighed against 1) the amount of over-investment in the fishery will have grown from R_A to R_B and 2) the economic condition of the greater number of people fishing at B_1.

Control of the quantity of fish captured, by whichever of the economically effective methods discussed above, stops the dissipation of rents along any of the cost lines at a point short of intersection with the total revenue curve. For any of the given situations this rent is largest where the respective solid total cost lines in figure 13 end; it diminishes along the dotted lines as it approaches the total revenue curve. Without real information on the shape and height of the total revenue curve, the cost curve, the mix of capital and labor which make up the effort and on the method of sharing rents, etc., it is impossible to reach anything more than a general, qualitative evaluation of any action. For example, an investment that moves us from open access point A_1 to point B_2 results in less fish to consumers, probably fewer fishermen fishing, and the creation of rent R_B. If all of this rent (less management and other costs) is retained by the government, the remaining fishermen's incomes will not change.

3.4.2.4 Many Species and Mixed Gear

We have used several simplifying assumptions in this static, long run analysis. Two of these implied that a single species of output called "fish" was captured by applying the effort produced by similar fishing units or firms. Tropical small-scale fisheries, of course, exploit a large number of species using a variety of combinations of boat, gear and men.

These different fishing units or firm types differ from each other in their effect on the resources as well as in their economic operation. Each type catches a different but often overlapping subset of all the species available and has varying degrees of control over directing the effort at particular species. The effective effort each exerts on a particular species differs as does the average size of fish each catches.

In fisheries which exploit a very large number of species, prices are often assigned to groups of species or to groups of species of

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[15] There is obviously a different MEY, and, therefore, a different economically proper quantity of catch for each different per unit effort cost. The MEY point is graphically defined where the slope of a tangent to the curve is equal to the slope of the total cost line. It is here that the marginal costs of, say, an additional boat in the fishery is equal to the marginal (or additional) revenue of that boat to the fishery.

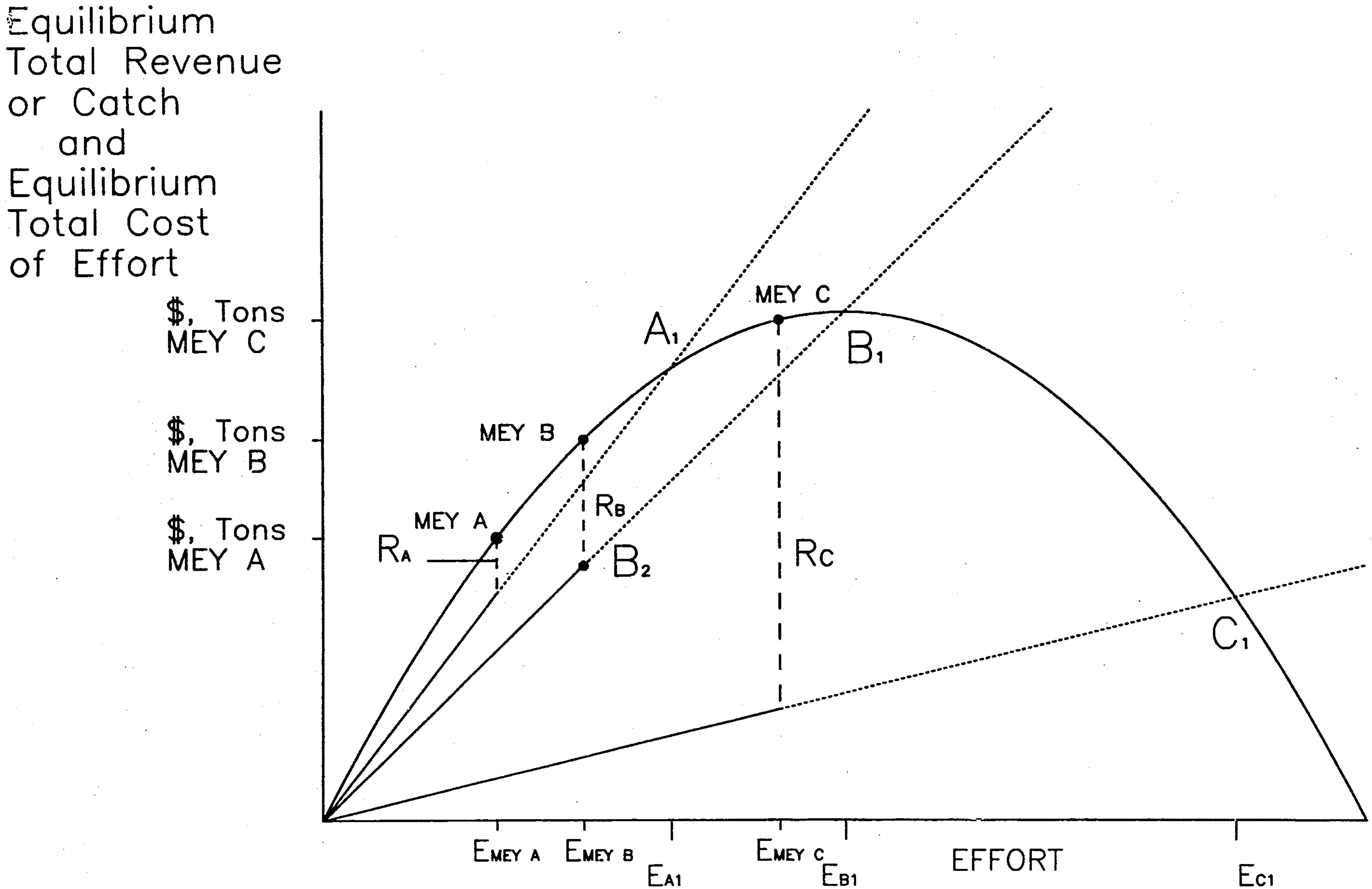

Figure 13. Three different cost-per-unit-effort cases. *Each has its own point of maximum economic yield (MEY) where the potential rent is largest. Beyond each of these points (dotted lines) the potential rent (R_A, R_B, R_C) diminishes until it is zero as the cost line and revenue line intersect at A_1, B_1, or C_1. An investment project or the independent adoption of more efficient technology which brings the fishery from situation A to, say, B_2 on line B will maximize social returns. The revenue will be at the level MEY_B and the cost at the vertical level of B_2.*

a certain size. These groups may or may not have similar biological characteristics. The commercial classes are generally assigned relative prices on the basis of consumer taste preferences. These relative prices are generally stable but may vary during certain seasons as the quantity caught and species mix change or prior to traditional events such as Easter. During these periods the price of all fish can change substantially. Consequently there is a difference in revenues received by each firm type and by all firm types over the course of a given year.

Each type of fishing unit uses different amounts of capital and labor and in differing combinations. This results in different sets of costs and, therefore, in different responses to changes in input prices. Some variable costs are closely related to the amount of nominal effort exerted; others, particularly labor costs, can be more closely tied to the amount of fishing mortality inflicted (effective effort). The fixed costs of the different fishing units reflect, in large measure, the amount of capital invested. They include interest payments, depreciation and some proportion of maintenance and repair costs.

As a result of all of this variation, the composite measure of this biological and economic activity, the firm's profit, differs over firm types.[16] The profitability within a firm type can vary substantially over individual firms, reflecting different skills or experience.

A particular boat type, kind of gear and crew configuration is often used by all of the fishermen of a particular community, section of coast or island. Likewise, the set of alternate opportunities available to fishermen is, to a greater or lesser degree, conditioned by the economic circumstances of their community. Therefore changes in the fishery, whether induced or not, have an impact that is neither geographically nor socioeconomically random. Information about different biological, social and economic characteristics of the fishing units' operation and their setting should be available prior to any attempt to intervene. Furthermore, management of both the total biomass and its value in a multispecies fishery will involve management of and, it is very likely, management by fishing unit types. The point here is that information which is important to, and important because of different concentrations of people and their fishing activity, should not be obscured.

3.4.3 The Delivery System

Another assumption used above, that of a constant demand price for fish regardless of the quantity supplied, rarely holds. There are many more opportunities for the price to vary as both the quantity supplied and the quantity demanded change. Let's examine the flow of fish through the system and see what factors determine the price.

Figure 14 represents an abstracted fish production and delivery system. Three markets are involved. In the first market variable inputs (ice, bait, labor) and fixed inputs (motors, gear) are supplied to the fishermen. These are offered to the fishermen by suppliers who are incurring costs to do so. The suppliers pay rent on buildings, import duties, and the opportunity cost of their time and labor. The fishermen purchase these inputs, combine them with their own labor, risk and opportunity costs, and convert them into fishing effort. They anticipate that this process will result in output (fish). Their demand for inputs like ice and bait is derived from the anticipated sale of fish to middlemen.

In the second market the middlemen purchase, transform and transport fresh fish and incur costs from using ice, trucks, buildings, freezers, from assuming risks, and from foregoing other opportunities for their labor and money. The demand of the middlemen for fresh fish from the small-scale fishery is derived from an anticipation of revenue in the third market, i.e. from the sale of their processed product to consumers.

If we assume away any spoilage, we see that the quantity of fish sold is the same in markets two and three. The prices asked by the middleman are higher per unit so that he can cover his costs.

The quantity of fish that flows from the harvest sector to consumers in a period of

[16] The firm's profit can be thought of as the annual accounting profit, i.e. as the difference between revenues and fixed and variable costs. If we were to add to the fixed costs of the firm an amount equal to the firm's opportunity cost of labor (the owner's) and capital, or subtract this amount from the firm's profits, then the differences across firm types would be much smaller. If, after having added each firm's opportunity costs to its fixed costs, the revenues still exceed all of the costs for many firms, this difference is an indication of the existence of industry-wide profit which attracts new entrants.

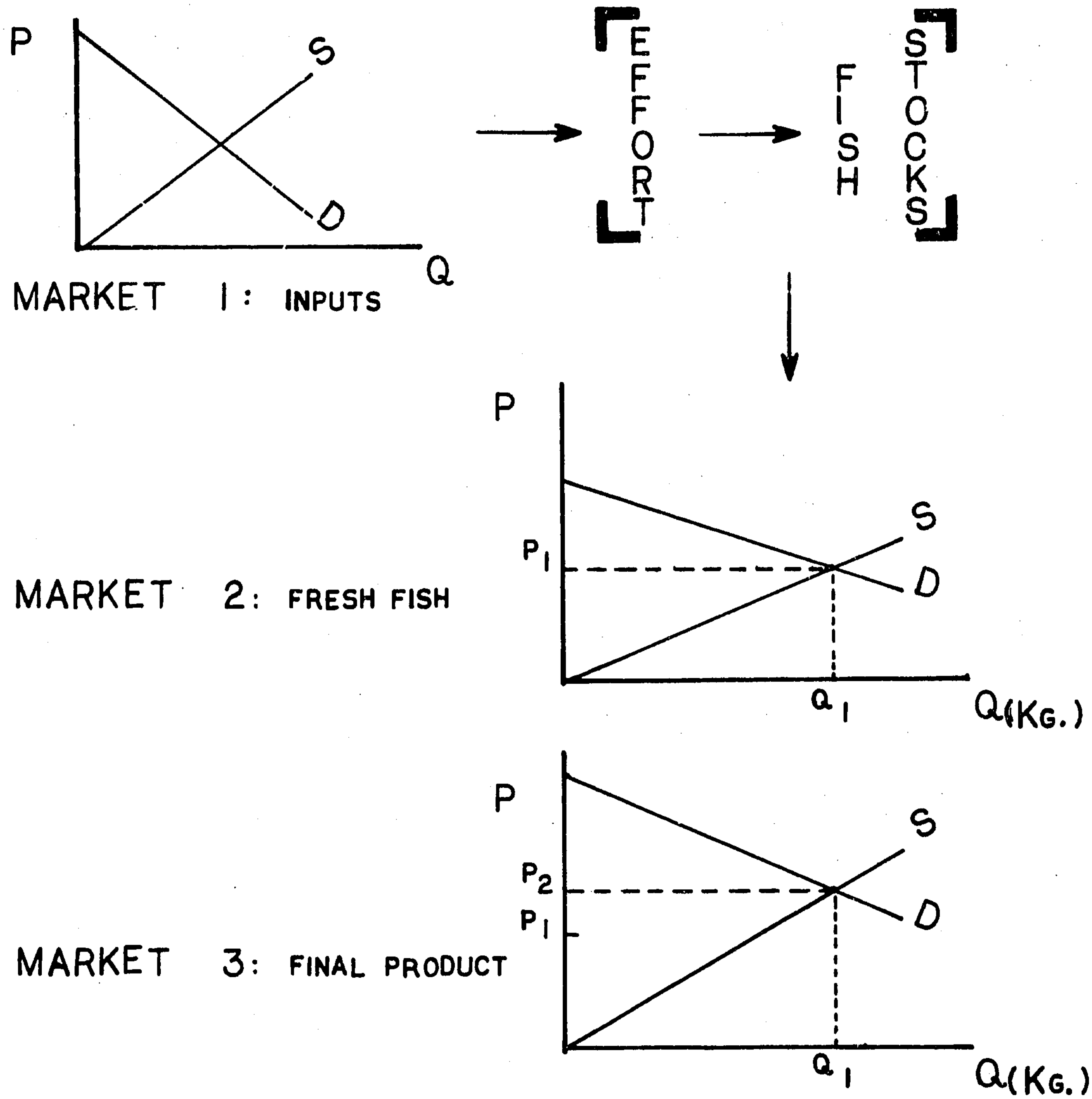

Figure 14. A simplified annual three market delivery system. ***The fishermen purchase inputs and produce nominal effort. This results in quantities of catch depending upon the size of the available stocks of fish. Notice that the quantity of fish purchased by primary buyers in Market 2 and sold them in Market 3 is the same (assuming no losses in handling) but that the price of the exchange in Market 3 is higher. The middleman use this margin to cover their operating, risk and opportunity costs.***

time depends on several things, most notably 1) the state of the fish stocks and the nature of the production process; 2) the quantity of fish supplied (usually to middlemen) from the industrial fleet's catch or by-catch; 3) the amount demanded by consumers; 4) the existence of imperfections in the three markets; 5) the level of infrastructure (landing sites, roads, transport systems); and 6) post-harvest losses.

3.4.3.1 The Industrial Catch

The industrial fishery can affect the small-scale fishery at many points, helping in some instances and hindering it in others. The supply of inputs available to the small-scale fishermen, for example ice and netting, is frequently enhanced by the response of input sellers to the industrial demand. Likewise, roads are constructed, wharves built, and other services provided to accommodate the flow of the industrial catch. The interaction of the two fleets with the fish resource can be very complicated. The actions of either fleet on the same stocks will have an impact on the resource available to the other fleet. Both may be fishing for the same stocks, catching some of the other's target species as by-catch, or directing their effort at different year classes of the same species.

Some of the output of the industrial fleet, frequently the last day's by-catch, finds its way into the flow of fresh catch of the small-scale fishermen. Middlemen often find it more convenient and less costly to fill their trucks with the by-catch of, for example, shrimp vessels rather than visit several scattered landing sites. A proper bioeconomic analysis of the small-scale fishery must account for these effects.

3.4.3.2 Consumer Demand

The quantity of fish demanded by consumers in a period of time is related to its price, the price of substitutes, the income level of the consumers and the numbers of consumers. In general, as the last three factors increase, the quantity demanded does as well. The quantity of fish demanded decreases as the price increases. This inverse relationship is a characteristic of the well known demand curve. Figure 15 shows an idealized short run picture of supply and demand curves for fish. Notice that the axes are labeled "Price" and "Quantity" of fish. A single demand curve can describe only this partial relationship. The other factors affecting demand, i.e. the preference for fish, the numbers of consumers, the income level of consumers, the price of chicken, etc., are behind the scene. If one or more of these increases, for example if the price of all meats increased, the new demand curve (labeled New) would lie to the right of (above) the old one. If one or more of these decreases, the new demand curve would lie to the left of (below) the old.

There are many demand curves, of course. We can speak of the short run demand for all fish, covering a period of, say, a year. Many of the shifting factors would be constant in this case and monthly data would be required. Or we can speak of the long run demand for shark - covering, say, a ten year period. Consumer income changes would be important in this case. The nature of the collected data determines what we can say about demand. When we actually estimate a demand relationship, we employ all of the important factors determining the demand. When we represent a demand curve graphically, we show the most important element of that relationship — that between quantity demanded and price.

One important characteristic of these curves is their steepness or slope. All else equal, if the demand curve drops very rapidly from upper left to lower right, it indicates that consumers are relatively insensitive to the price of fish: the total amount demanded will not change very much unless there is a great reduction in the price. If the demand curve is more flat (horizontal), there is a greater sensitivity among consumers to the price. A measure of this sensitivity is called the price elasticity of demand.[17]

If the demand for fish is inelastic, then a short run increase in the supply of fish can actually result in lower trip revenues to fishermen. For example, if there were only one buyer of fish, and many fishermen with good catches on a given day, the buyer could

[17] The price elasticity of demand (P.E.D.) is the ratio of the percentage change in the quantity demanded, $\Delta Q/Q$; to the percentage change in the price, $\Delta P/P$; therefore, $P.E.D. = \frac{\Delta Q}{Q} / \frac{\Delta P}{P} = \frac{\Delta Q}{\Delta P} \cdot \frac{P}{Q}$.

The P.E.D. has a range of from 0 to ∞ and its value is different at every point on a straight line demand curve. If the P.E.D. is greater than 1, the demand at that point is said to be elastic. If it is less than 1, the demand is said to be inelastic. At 1 it is said to be unitary elastic.

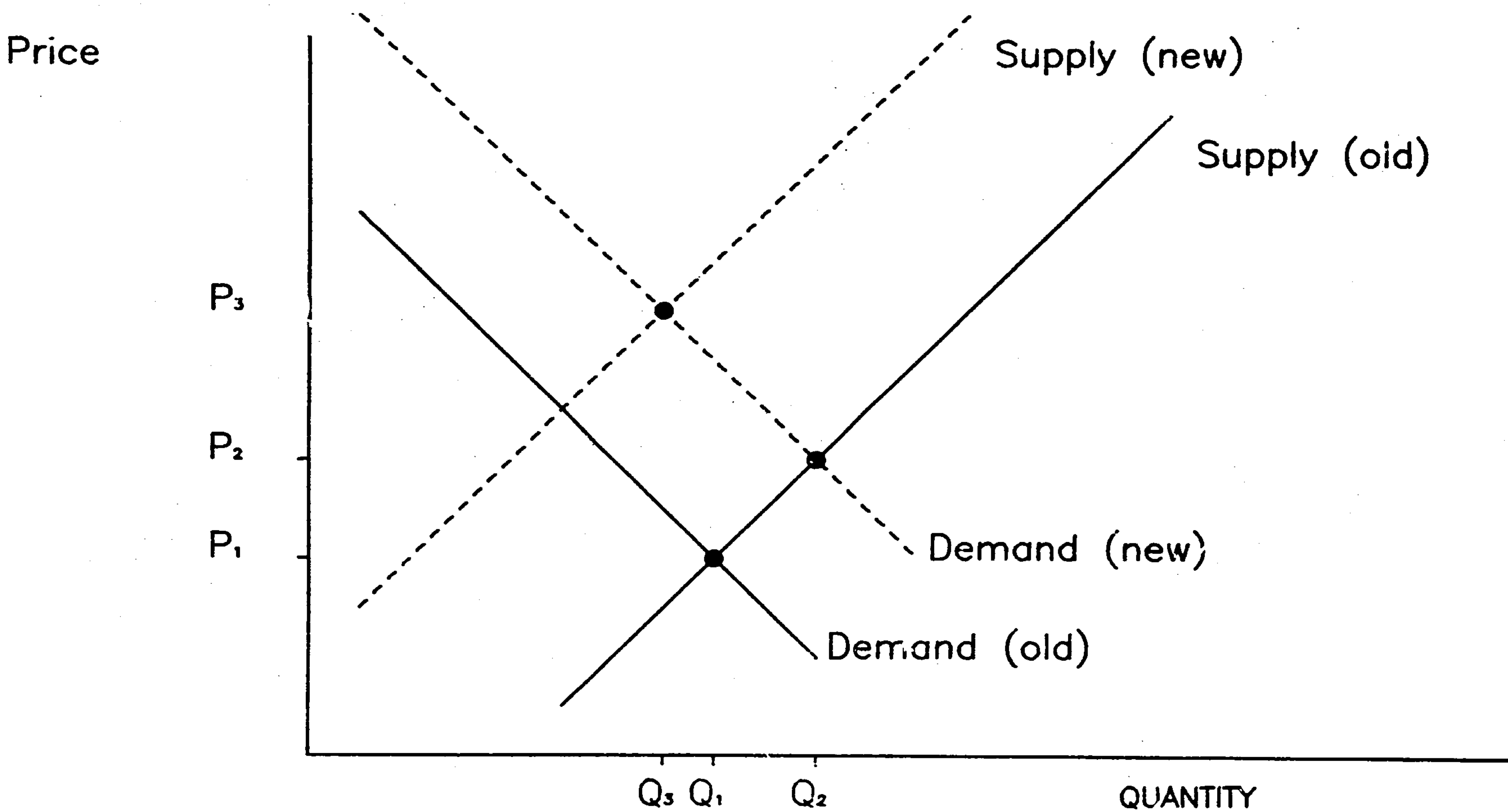

Figure 15. Short run supply and demand curves. ***This figure shows the effect of changes in other (than price and quantity) supply and demand determinants on supply and demand curves. The shift to a new demand curve can come about because of increases in the price substitutes for fish. A new supply curve might be defined for seasons in which fishing is dangerous.***

only be induced to increase his purchases through a considerable drop in the price asked by the fishermen. The price, once agreed upon, would apply to all of the fish sold, not just to the extra catch.

We could likewise draw figures (which are not strictly demand curves) which relate some other factor, for example incomes, to the quantity of fish demanded. These curves too have elasticities. We can speak of the income elasticity of demand (I.E.D.), for example, which relates the percentage change in the quantity of fish demanded to the percentage change in consumer income levels.

Since each species or commercial class has its own demand relationship, it is rewarding to compare the impact of the same demand determinant for different species or classes. For example, the income elasticities of demand for different commercial classes often differ greatly. Research in Central America demonstrated that as the income of consumers changed, their demand for more desirable (and expensive) species increased while the demand for less desirable fish actually decreased. The more desirable fish were caught by fishermen with more capital intensive operations and the less desirable fish by the poorest fishermen (Coslit, Lampe and Sutinen, 1980).

An individual decides how much fish to purchase by considering its cost and the cost of other things he needs or wants. He is usually restricted from buying as much as he wants of everything he wants by his income. The usual approach to estimating demand relations is not to analyze all of these decision processes for all consumers, but to examine the transactions that actually take place in the market together with some of the other important factors in individual decisions. These transactions reflect the results of all individual decision processes grouped together.

3.4.3.3 Supply

Supply relationships indicate the quantity of goods that producers are willing to sell given the price of the goods, the cost of producing the goods and, in the case of the fishery, the state of the resource. As with demand, supply relationships measure a flow of goods in a time period. We can speak of the supply of all fish in a given year, the supply of certain species or classes, the supply by all firms (industry) or by certain types of firms, for example all gill net fishermen.

The short run supply curve for fish is similar to most other supply curves in its appearance. This curve, which reflects a positive as opposed to an inverse relationship between prices and quantities offered, can be shifted to the left (or above) by increased costs or a smaller standing stock. A larger stock and/or reduced costs of effort will shift the curve to the right (or below) indicating that more will be offered for sale at every price (Figure 15). The shape of the long run supply curve of fish, on the other hand, is influenced directly by the reproductive capacity of the resource. A common formulation of this curve incorporates the Schaefer-type equilibrium yield curve (Figure 16).

If we compare the price elasticities of supply (commonly called the price response) for two short run curves we would expect the elasticities to be greater for that situation in which there was a larger standing stock. In both cases fishermen respond to price incentives by fishing more — increasing the supply of effort. We would expect the success of that effort applied to an underexploited stock to be greater than if it were applied to a depleted stock.

In the long run where all inputs to fishing, including capital (vessels) are allowed to vary, the long run price elasticity of supply is constrained by the reproductive capacity of the stock. This measure is greater (more elastic) at equilibrium points before MSY, decreasing as it approaches the maximum yield. At points near MSY it is very inelastic and is negative beyond MSY: as price incentives create profits and induce more effort, the total output of the industry actually decreases.

3.4.3.4 Bottlenecks, Power and Losses

The three remaining conditions mentioned above — the level of infrastructure, the existence of market imperfections and post-harvest losses — can further reduce the quantity of fish reaching the consumer. These three conditions can be mutually reinforcing as well. Conditions such as unreliable transport or a lack of roads to scattered landing sites can cause the waste of landed fish. Such conditions also contribute to the ability to exercise market power — power which can cause the wastage of fish.

Undervalued fish is either discarded at sea or at the landing site. The undervaluation problem is most often a question of preferences related to taste, appearance, boniness, taboos, etc. As such it requires the attention

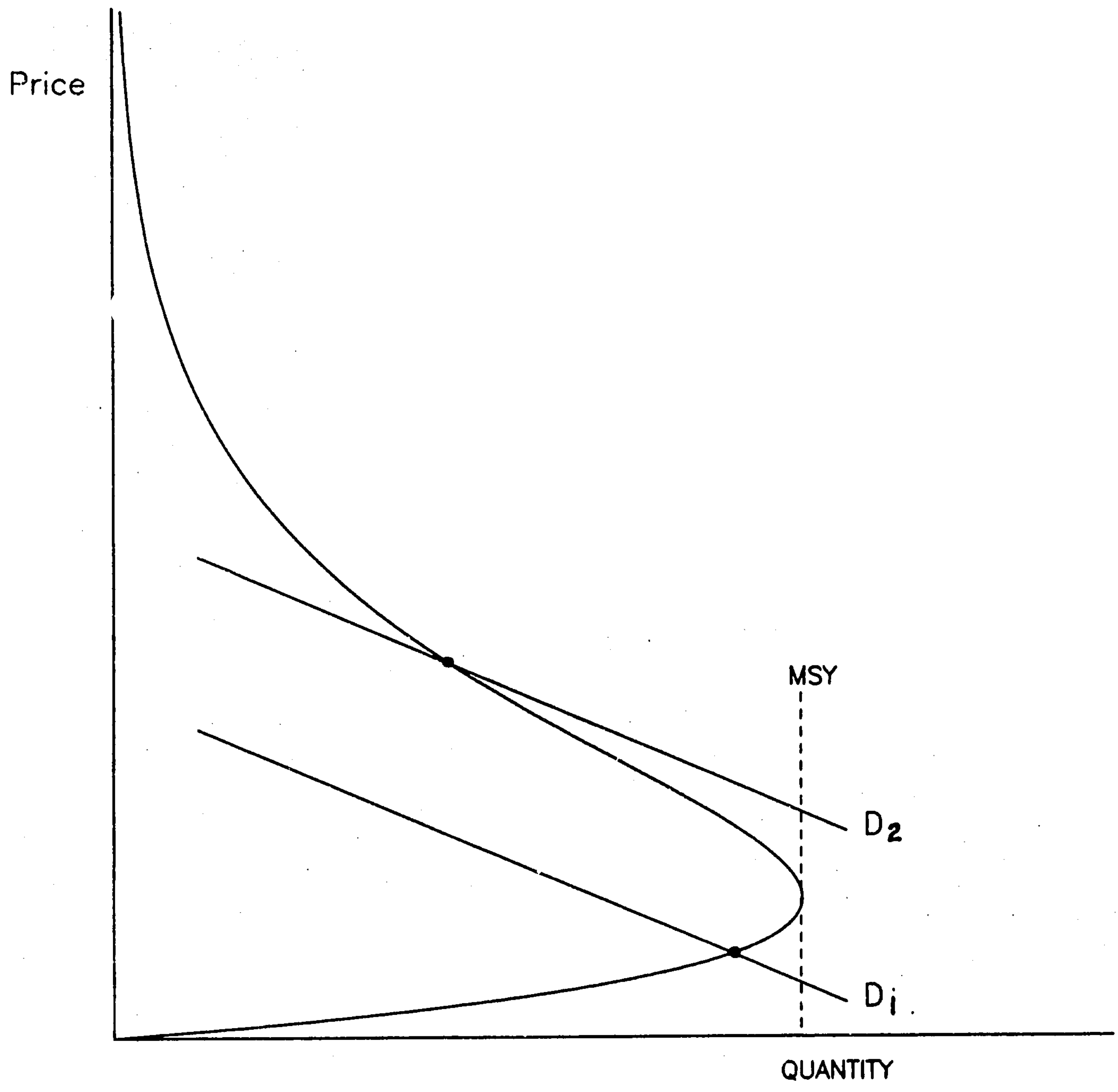

Figure 16. Long run supply and demand. ***The long run supply curve (after Copes, 1972) incorporates the long run response of the stocks to increased fishing effort. The intersection of demand curve D_2 with the supply curve occurs in a situation of biological overfishing.***

of people specializing in food habits, fish processing and marketing — in the sense of advertising and education. Fish which is valued can be wasted, as well, as it deteriorates in a physically and economically inefficient delivery ststem.

The consumer demand for fish is influenced by the quality of the fish supplied and, to some extent, by the consistency of that supply. In an attempt to assure a consistent supply of fish, arrangements are often made back through the system of retailers, wholesalers, middlemen and fishermen. These arrangements can appear as the vertical integration of firms in which, for example, middlemen acquire boats, transport and retailing outlets. The middleman thereby becomes a complete delivery subsystem unto himself. Or these arrangements can appear as mutually beneficial (initially at least) agreements between, for example, a middleman and a set of fishermen. In return for their guaranteed supply (periodic though it may be) the fishermen may receive loans for gear or for personal debts (Smith, 1979). In this regard the middleman can be represented in both the input (to fishing) market and the fresh fish output market.

The three markets we have discussed can operate "perfectly" — maximizing the flow of fish through the system at minimum cost — in spite of these arrangements as long as there is no exercise of market power, i.e. as long as no one exploits either buyers or sellers. The opportunity to exercise market power exists when one or a few individuals can influence prices because they are protected from competition by another set of barriers. These too may be physical barriers due to isolation (infrastructure), information barriers (on prices) or economic barriers (high capital costs, risk, etc.).

Control over the demand for a good by one or a few people is termed respectively monopsony or oligopsony power. Market power in the hands of a single or of a few suppliers of goods is termed, respectively, monopoly or oligopoly power. In our simplified three market system we would expect that there are many fishermen and many consumers. There exists the possibility, then, of three distortions: monopoly power in supplying inputs, monopsony power in buying fresh fish, and monopoly power in selling processed fish.

To the extent that opportunities exist for exercising both monopolistic selling power (inputs) and monopsonistic buying power (fresh fish) in the harvest sector, it is more likely that 1) the quantity flowing through the system will be less than that which would flow through under competitive conditions, 2) the price to the consumers will be higher than that determined by competition, and 3) the total income to fishermen will be smaller. Furthermore, the advantage that the monopolist has over buyers or the monopsonist has over sellers tends to be greater as the respective demand or supply curve is less elastic.

Groups of competing fishermen, facing either or both monopoly sellers of inputs such as ice or monopsonist buyers of their fresh fish, often organize to develop their own market power. They form fishermen's organizations or cooperatives so that they can buy and sell as a unit. These organizations further develop, at times, by integrating marketing, processing, transport and retailing activities.

It is frequently observed that over time the numbers of buyers or sellers in a particular market decreases. Those remaining may have come upon a scale of operation (size of plant) that has a smaller cost per-unit output. For example, larger more capital intensive plants may have this advantage. The flow of fish may be such that one or two plants can adequately handle the supply. However, as the numbers of buyers or sellers in a market decrease, the ability to collude and to set prices increases. This concentration of buyers or sellers, aided by barriers to competition, can easily increase its profits beyond what the same level of investment would make in another industry.

The monopsonist buyer of fish can increase his profits by offering fishermen a price below that which would be offered if competition existed. The exercise of this power may even result in resource conservation. In this instance the fish buyer is in effect collecting the resource rent.

The degree of market power is sometimes equated with the difference between the price paid for inputs and that charged for output. This difference, however, includes all of the costs incurred by, in this example, the middleman. Frequently these costs are underestimated by the casual observer. Another commonly used indicator of the exercise of market power is the percentage of the final retail price that fishermen receive for their fish. While the opportunities for the existence of market power can easily be identified, only careful analysis of specific cases can reveal exploitation (see for example, Epler, et al 1980; Scheid, et al 1980; and Coslit, Lampe and Sutinen, 1980).

3.4.4. Information Requirements

The review of the fishery system above should have demonstrated the need for a variety of economic (bioeconomic) information in understanding the forces at work in the system. We have attempted to show that the interaction of biological, cultural and economic forces complicate intended changes. Furthermore, the goals of assisting fishermen and consumers, of conserving the resource and of rationalizing the harvest sector can be frequently incompatible if not pursued simultaneously. We examined the fishing process and saw that the production of fish was affected by the legal and economic milieu in which it operated; that the potential supply from this sector could be affected by the nature of the intervening markets and by a number of combinations of supply and demand elasticities. We have reviewed the operation of this simplified, yet complete system so that the relationship between the harvest sector and the rest of the system would be clear. The information requirements for economic analyses depend upon what is being examined. On the other hand, all of these analyses draw upon a set of data whose elements are related to each other by the decisions of fishermen. Therefore, rather than repeat even the limited uses of economic data presented in this chapter, information is classified as that necessary to study supply and demand relations and that necessary to examine productive processes.

3.4.4.1 Transactions

The data identified for collection in the next chapter will include that on transactions in the first and second markets: on the purchase of inputs and the sales of output (fresh fish). Transaction information does not represent either demand or supply curves, merely their intersections through time. When combined with additional information on other supply and demand determinants from both inside (the harvest sector) and from sources outside (such as price indexes or per-capita income estimates), these transactions can be made to reveal the supply and demand relations.

The supply and demand relations and many of the important elasticities that can be calculated from them also require what is called time series data. There is no substitute for collecting this through time if anything is to be said about supply or demand curves.

The particular need for other information from outside the harvest sector is dictated by what one wishes to know and what interventions are planned. For example, if background information and observations suggest distortions in the supply of inputs, an analysis of the structure and performance of input markets may be called for. The important time series of transactions can be coupled with, for example, production information to identify the supply and demand relations in that market.

In the primary market for fresh fish the time series of transactions can be coupled with information on other determinants of demand by the middleman (his costs and selling prices) in order to identify this relationship. Furthermore, to the extent that there is competition in the purchase of fresh fish by middlemen — or perhaps a lack of counterindications — the demand by the middlemen may be interpreted to reflect demand by the consumer. A constant per unit margin for the middleman is assumed in this case.

If commercial fleet catch or by-catch is competing in the same markets as small-scale catches, then an equivalent time series of prices and quantities for this industrial output is required (see 4.3).

In sum then, the harvest sector can yield crucial information for the determination of supply and demand in all three markets. Transaction information by itself can yield interesting statistics but must be complemented with information from outside what we have strictly defined as the harvest sector in order to reveal supply or demand relations.

3.4.4.2 Productive Processes

We have identified the incentives to enter or leave the fishery as, respectively, industry-wide profits or rents which offer the opportunity for "above normal" returns, and returns which are less than those which could be earned in the next best use of one's labor and money. In the open access fishery we expect these rents to be zero once the fishery is in equilibrium regardless of the level at which the stocks are exploited. Earning the normal return requires the fisherman to make many decisions concerning the physical process of fishing and its economic consequences.

The physical production relationship requires information on the kinds and quantities of inputs used in a period of time. In the short run the physical process involves combining fixed inputs such as the hull and gear with variable inputs like ice, bait and crew services. Each firm takes these inputs and finds the different levels of output resulting from varying the input combinations. Over the long run even the fixed inputs are changed.

Changes in the physical production process are motivated by the different returns each mix of variable and fixed inputs can bring. The returns are determined by the quantities and prices of inputs and the quantities and prices of the output they produce. Variations in the prices of outputs or inputs bring both short run and long run adjustments in the production process.

If we add to information on the prices of inputs to the physical production relation, we can generate a total cost of production relationship. If we add information on prices of output to the production relation, we can arrive at a total revenue relationship. Combining these cost and revenue relationships yields a profit or net revenue relationship.

In sum, we will see that most of the important fishery-wide economic information we seek (and which can be obtained in the harvest sector) is generated from data which describes the fishing activity of individual firms. Supply and demand information and that on the economic and physical aspects of production is derived from data on the technical and economic decisions made by individual fishermen and on the impact these decisions have on the resource.

Chapter IV

DATA REQUIREMENTS

4.1 BIOLOGICAL/ECOLOGICAL DATA

4.1.1 Habitat/Ecosystem Data

4.1.1.1 Biological/Ecological Inventory

An inventory of the species currently exploited by the fishery (and species which might be exploited in the future) is an essential first step in designing data collection procedures which will provide information necessary for management and development purposes. This inventory should include all that is known about the life histories of the principal exploited species and the ecological factors which affect their distribution, relative abundance and availability. Some of the important items in the inventory should be longevity, size (age) at first maturity, maximum size, fecundity, temperature and salinity tolerances, feeding habits, description of habitat, migrations, spawning seasons and locations, growth rates, and sexual differences in size, morphology and behavior.

Once these data are obtained, it should be possible to group individual species which share common ecological and biological characteristics and which are likely to be harvested together. Examples of such groups are small pelagic schooling fish caught in purse-seines, large non-migratory demersal fish caught with hook and line or several species of spiny lobster which are harvested in traps. Such groupings can form the basis for a crude definition of a unit stock for resource assessment purposes until more specific data are available for individual species.

4.1.1.2 Extent of Fishing Grounds

Once some kind of a resource inventory has been compiled, it is advisable to conduct an inventory of fishing grounds which are presently supporting the fishery or which could support expanded fishing effort. For example, for demersal species known to inhabit coastal waters in depths up to 50 meters, a reasonably accurate estimate of the extent of harvestable fishing grounds could be obtained by calculating the area of offshore continental shelf within the 50 meter contour. Finer distinctions might be made between different types of substrate (mud, rock, sand). This inventory will require some knowledge of the fishing gear used to exploit individual species or groups of species. Rough estimates of expected increases in catch following an expansion of the fishery to new grounds can be obtained by multiplying catch per unit area data for existing small-scale fisheries which use certain gear types and exploit certain species combinations by the area of the new grounds which could be exploited if existing fishing gear or practices changed.

4.1.1.3 Production Rates and Ecosystem Dynamics

It is important to know the sources of primary production which support exploited stocks and whether primary production from these various sources is high, low or moderate.[1] Sources of primary production

[1] Primary production is defined as the photosynthetic production of organic matter by plants, a process which converts sunlight into plant tissue which is available to herbivorous animals and therefore supports the entire ecosystem. The ecosystem is composed of different "trophic groups" at different "levels," i.e. phytoplankton (microscopic plant life) at the primary trophic level, zooplankton (tiny herbivorous animals) at the second trophic level, small plankton-feeding fish at the third level, etc. until ultimately reaching top predators such as man. Secondary production refers to the production of animal tissue through growth and reproduction.

in tropical marine ecosystems are 1) phytoplankton in coastal oceanic or estuarine surface waters, 2) benthic algae, 3) coral reefs, 4) rooted aquatic plants, or 5) detritus derived from mangrove swamps. If average annual rates of primary production are known and a reasonably accurate rate of energy transfer between succeeding trophic levels can be assumed (usually 10%), it should be possible to estimate theoretical rates of secondary production for certain exploitable components of the ecosystem. Some proportion of this production, i.e. the energy which is used for growth and reproduction of offspring which survive to reach a size (age) where they can be exploited by the fishery, is converted into biomass. Surplus biomass (i.e. biomass which remains after natural mortality has been accounted for) can be harvested.

In order to assign individual species to specific trophic levels or ecosystem components, feeding habits data are needed. Furthermore, if predator-prey relationships can be deduced from these data, it might be possible to predict the effect on total stock biomass and yield of selectively removing certain species (by fishing). Other types of competition between species (such as for the same food source or space) can also result in unreliable yield estimates for individual stocks which are treated as separate biological entities.

4.1.1.4 Hydrographic Data

Estimates of the amount of freshwater flow into major estuaries and coastal waters and information on coastal currents, tidal flow and amplitude, and offshore upwellings are important for identifying factors which limit rates of primary and secondary production, principally by limiting the availability of nutrients necessary for photosynthesis and plant growth. Hydrographic data may also contribute to an understanding of the migratory patterns of juvenile and adult fish, the dispersal of eggs and larvae and the spatial distribution of fishing effort.

4.1.1.5 Other Physical/Chemical Data

These data are important since they provide information concerning the environmental limits to production and habitat information for resource inventories. Furthermore, physical/chemical data can be related empirically to catch statistics and thus form the basis for yield predictions. This technique has been successfully applied to freshwater habitats where yields have been empirically related to an index which combines the quantity of total dissolved solids and the depth of lakes (Henderson et al., 1973; Ryder et al., 1974; Ryder, 1978). A similar exercise has been conducted with large river systems by relating yields to the size of drainage systems (Welcomme, 1979). Extensions of this procedure to the coastal marine habitat would require a thorough cataloguing of physical and chemical parameters and a search for possible mathematical relationships with harvest data.

4.1.2 Stock Assessment Data

4.1.2.1 Introduction

Although a number of approaches to resource assessment were discussed in Chapter III, further discussion of resource assessment in this guide will focus on data requirements and collection methods for the surplus production model and the yield per recruit model. When it is appropriate, a distinction will be made between preliminary assessments and more detailed assessements. Other types of resource evaluation are not excluded because they are less important, but because the assessments performed in developing countries should be based on available data and/or data which can be most easily obtained.

The most common types of assessment data which exist in developing countries are catch and effort data. Estimation of growth and mortality rates for use in more sophisticated models can sometimes be accomplished by fairly routine compilation of size frequency data from samples of commercial landings or from research techniques such as tag and recapture studies. One purpose of this guide is to focus on relatively low technology research techniques and data collection methods since the necessary tools (vessels, equipment and computers) and skills (personnel trained in fisheries science, mathematics and statistics) may be lacking.

4.1.2.2 Catch and Effort Data

Catch and effort statistics are extremely useful for resource assessment purposes. As outlined in section 3.2.4, these assessments may be preliminary and involve simply an evaluation of temporal trends in catch, effort and catch per unit effort (CPUE) data. At this level, useful conclusions can be reached from several years of data. Qualitative judgements can be made about the degree of resource depletion and the probable outcome of increased or reduced fishing effort, i.e. "will catch increase or decrease and what will be the impact on the resource?" More thorough quantitative assessments incorporate catch and effort data as parameter estimates in mathematically-derived models and require a longer and a more reliable set of annual catch and effort statistics.

Both preliminary and more detailed assessments may be performed with catch and effort data for a combination of species or stocks which are exploited by the same gear in the same general location or for individual species or unit stocks. Analyses performed with combined data sets, however, may provide more reliable maximum yield estimates since they account for species interactions (for example, predator-prey relations) which are not accounted for in unit stock applications which ignore the biological and ecological relationships between species.

Catch and effort data which are required for surplus production analysis are generated in two stages. Primary data are collected as fish are landed and delivered for sale to primary dealers. In the second stage these data are compiled according to specific time periods (months, years), gear types and general fishing locations. Effort data should account for the capture efficiency of the gear which is used as well as the amount of time spent fishing. Adjustments are required in order to correct landings statistics for fish which is captured, but not landed.

Once sufficient data are available for individual time periods, they are compiled into a time series of annual catch and effort estimates which ideally should represent a period of at least five to ten years in the historical development of the fishery and include years of high and low exploitation. Time series catch and effort statistics are analyzed to generate estimates of maximum sustainable yield and the corresponding amount of fishing effort.

Catch data are usually estimated from the weight (or, in some cases, volume or even numbers) of fish which is sold to primary dealers plus estimates of how much fish is caught, but not sold, to primary dealers. Sources of post-harvest loss include fish which spoil and fish which are discarded at sea, gutted and either sold, given away or kept by the fishermen before they reach the primary dealer (see Brander, 1975). For most small-scale food fisheries, the quantity of fish which is discarded at sea is not significant. Losses due to spoilage, however, can be substantial when proper storage and handling procedures are not followed aboard the fishing vessels. Furthermore, when catches are low, fishermen are more likely to sell a larger proportion of their catch directly to retailers or consumers in order to increase their income.

Fishing effort is frequently estimated either as the number of operating units (vessels, gear, fishermen) in use during a certain period of time or some measure of the time spent fishing such as the number of trips, days, or hours. More useful estimates of effort include both a time component and an estimate of the relative capture efficiency of different gear and vessel combinations. A net which measures 50 x 100 m and is fished for six hours, for example, should catch approximately twice as much fish as a 25 x 100 m net which is fished for the same period of time, assuming each net is identical (same mesh size, material and construction) and is being used by equally skilled fishermen under similar conditions. The best estimates of the amount of time actually devoted to catching a certain quantity of fish are defined by the nature of the fishery. For a handline fishery, for example, the time that the hooks are in the water would be most reliable whereas for a pelagic purse seine fishery it could be the time spent searching for schools of fish. Guidelines for estimating fishing effort for five selected small-scale fishing gears are presented in Table 1. For further advice on how to estimate effort for different types of fishing gear, see FAO, 1976.

Standardization procedures are aimed at correcting for changes in fishing power which take place over time as improvements in gear and vessel technology increase capture efficiency. Thus, if 100 hours of fishing in 1970 was twice as effective, because of improvements in gear design, as 100 hours of fishing in 1960, standardized effort in 1970 would be double the amount of effort in the reference year (1960) even though the number of hours fished remains the same. Effort standardization procedures have not generally been applied to small-scale fisheries, mostly because historical changes in capture efficiency have been minimal or difficult to quantify.

A problem which is often ignored is the capture of species which are harvested inciden-

Table 1: Some factors affecting the performance of five selected small-scale fishing gears and appropriate definitions of fishing effort and catch per unit effort for each one.

GEAR	PERFORMANCE FACTORS	EFFORT DEFINITION (time x power)	CATCH PER UNIT EFFORT
Gill net	Mode of fishing (surface or bottom; drifting or anchored), type of twine, mesh size and shape, area of net	Time fishing[1] x area of net	Catch/hr/standard net area
Handlines	Type of bait (or lure), hook size, mode (trolling, bottom, by hand or mechanical reel), number of lines or hooks	Time fishing[1] x number of fishermen, lines or hooks	Catch/hr/fisherman, line or hook
Longlines	Bait, hook size, mode (surface, mid-water or bottom), number of hooks	Time fishing[1] x number of hooks	Catch/hr/standard number of hooks
Fish pots	Volume, bait (if used), mesh size or opening between laths, design, entrance size	Submersion time x number of pots hauled	Catch/pot/day
Beach seine	Mesh size, length of net	Number of hauls	Catch/haul

[1] Estimated as the time the gear was actually in the water or the time spent on the fishing grounds

tally to the predominant species. The catch of certain species bears little or no relation to the fishing effort expended during a given trip if they were not the primary species which were being sought. Catch and effort data for incidental species should not be compiled for assessment purposes. An acceptable procedure for eliminating these species is to only compile catch and effort data for species which make up more than some minimum percentage (say 10-20%) of the catch during a given fishing trip.

An additional problem is posed when a single unit stock assessment is performed using effort data which are compiled from more than one gear type. This is a particularly relevant problem for small-scale fisheries which harvest many species using a variety of gear types and for stocks which are exploited simultaneously by small-scale and industrial fisheries. Stock assessments which rely on combined effort estimates require comparative field studies of the catch rates of different gear types used to exploit the same stocks during the same period of time. A description of techniques which might be used in such studies is beyond the scope of this guide. In the absence of this information, unit stock assessments are carried out for individual unit fisheries, i.e. fisheries which are characterized by a single gear type and fishing location.

4.1.2.3 Vital Statistics

Quantitative assessments which generate predictions of maximum sustainable yield for a given amount of fishing mortality and minimum size (or age) at which fish are first captured through use of dynamic pool models (see section 3.2.4.2 (b)) require a considerably more complex set of data than surplus production models which are applied to a time series of catch and effort data. Although the data required for dynamic pool analysis are more difficult to obtain, they can be collected during a fairly short period of time (perhaps one or two years); no time series is required.

Parameter estimates which are required for dynamic pool analysis refer to exploited populations or unit stocks, but they are obtained from observations of individual fish which are caught by fishermen or from fish which are collected for research purposes or during exploratory fishing surveys. Some of the necessary parameters are listed in Table 2. They are generally of two types: 1) those which refer to the rate at which some biological process (birth, death, growth) takes place and 2) those which refer to ages (or sizes) when these processes begin or end. Because the processes have a biological origin, the data are referred to as "vital" statistics.

Although it is not the purpose of this guide to describe data analysis techniques, some of the more common conceptual models and analytical procedures will be mentioned and briefly described in Chapter V since they are used to convert observations into more refined data which are in turn analyzed to produce information useful for the

Table 2: Definitions of key parameters used in dynamic pool models and data required to estimate them; data requirements are limited to methods discussed in this guide.

PARAMETER	DEFINITION	DATA
Growth rate (K)	Rate of increase in size per unit time, expressed as a time-dependent coefficient without units	Size frequencies of catch samples by gear type and location over time; sizes of individual fish at tagging and recapture and dates of release and recapture; size, distances from scale (otolith) focus to annual radii and scale edge for individual fish
Maximum limiting size (L_∞, W_∞)	Theoretical limiting size attained by an average individual in the population, expressed in terms of length or weight	Same as above *or* can be assumed to equal maximum observed size when exploitation is not severe
t_0	Theoretical age at which growth begins	Same as above *or* can be assumed to equal zero
Total mortality rate (Z)	Instantaneous rate at which numbers in the population decline per unit time for any reason	Relative abundance (CPUE) of a given age group over time *or* relative abundance of two more successive age groups at any point in time; number of tagged fish recaptured per unit effort in successive time intervals
Natural mortality rate (M)	Instantaneous rate at which numbers in the population decline per unit time as a result of predation, disease, etc.	Relative abundance of an age group over time *or* relative abundance of two or more successive age groups at any point in time *for an unexploited population*; annual changes in Z and fishing effort; by subtraction if Z and F are known
Fishing mortality rate (F)	Instantaneous rate at which numbers in the population decline per unit time as a result of fishing	Number of tagged fish recaptured per unit effort in successive time intervals plus total number tagged initially *or* by subtraction if Z and M are known
Recruitment (R)	Number of recruits (juvenile fish) entering the exploitable population per unit time	Relative size of recruiting age classes can be estimated from repeated survey data (CPUE) or catch rates in a fishery which harvest pre-recruits
t_r, l_r	Age (length) at recruitment	Age (length) composition of commercial catches
t_c, l_c	Age (length) at first capture	

management of fishery resources.[2] Parameter estimates, by themselves, are of no use for management purposes; they simply provide data necessary for assessments. Furthermore, assessments will not be feasible unless a minimum set of parameter estimates is available. As mentioned in section 3.2.4.2(b), not all of the statistics listed in Table 2 are necessary in every case. Modified versions of the original model only require, for example, estimates of mortality-/growth ratios and size instead of age-specific estimates.

Once all the necessary parameters are estimated, maximum yield can be predicted as a function of fishing mortality and the age or size at first capture from yield tables such as those compiled by Beverton and Holt (1966). Since recruitment is frequently unknown, yield estimates are given on a relative per-recruit basis and must be multiplied by the number of recruits which enter the exploitable stock during a particular time interval in order to produce actual biomass yield estimates.

4.1.2.4 Exploratory Fishing Surveys

Biomass estimates of exploited or unexploited stocks can be based on catch rates obtained during exploratory fishing surveys. Mean catch rates are calculated from repeated sampling with the same gear following the same fishing procedures and are converted into catch per unit area estimates which are in turn multiplied by the area which the stock inhabits to produce biomass estimates. Surveys can be used to estimate biomass only if catch rates can be calculated on a per unit area basis and if some reasonable estimate of the capture efficiency of the gear is available. For best results, therefore, some preliminary data concerning gear selectivity and capture efficiency for individual species and sizes of fish are necessary before it can be assumed that the catch rate of the gear which is used

[2] A more complete discussion of methods used for compiling vital statistics is given by Gulland (1969) in a manual which is available in both English and Spanish versions. Another very useful reference is in the handbook by Ricker (1975).

is directly proportional to the abundance of the exploited population in some defined area. In practice, exploratory fishing surveys are carried out in the absence of such information; in many cases, they are designed to answer more basic questions of interest to fishermen such as what sizes and species of fish are available, where and when they can be harvested and in what quantities. Biomass estimates are usually a secondary objective of such surveys.

4.2 SOCIOCULTURAL DATA

4.2.1 Introduction

Specific types of sociocultural information were identified in section 3.3 which describe some of the general elements of the harvesting sector of small-scale fisheries and which are also important factors to be considered in making appropriate management or development decisions. In this section, the types of data necessary for generating this information are described.

4.2.2 General Background Information

As noted in the preceding chapter, general background information is needed in order to understand how the fishery functions and to evaluate the effects of intervention in the fishery. The basic sociocultural information generated is such that it will be of use to biologists and economists as well as to fishery administrators. The following discussion describes data needed for specific information types.

4.2.2.1 Identification of Groups

It cannot be assumed that all small-scale fishermen in a given country or region are identical. Sometimes they belong to different tribes or ethnic groups, sometimes they practice different religions, sometimes they manifest different political loyalties, and sometimes different groups are defined by their technology and style of fishing (such as net versus line fishermen or inshore versus offshore). In some cases, the position of the fishermen as a group distinct from other groups will be important. The key factor is that the groups identified often act on the basis of their own perceptions of their differences from other groups. The data which are needed include location, numbers, and specific identifying characteristics for each group.

4.2.2.2 Degrees of Intergroup Tension

It is not enough to simply distinguish different groups. Development projects may fail in cases where tension exists between groups (Cochrane, 1979). Tensions are manifested by various types of behavior ranging from discrimination all the way to open warfare. The degree of tension should be evaluated by examining intergroup attitudes, beliefs, and values and by describing overt manifestations of these tensions, such as employment discrimination or economic subversion.

4.2.2.3 Numbers and Locations of Potential Project Participants

In the planning stages of a development project where it is uncertain whether new technology will be introduced or the numbers of fishermen increased (or both), it is essential to determine numbers of (a) active fishermen, (b) unemployed fishermen, and (c) unemployed or underemployed non-fishermen who could potentially become fishermen. Data should be prepared which indicate where individuals who belong in these three categories are located.

4.2.2.4 Traditional Communication Channels

Data concerning traditional communication channels will consist of a listing and distribution of available media (newspapers, magazines, radio, television, cinema) and locations where information is disseminated (such as meeting halls, public square, market place, school house, the mayor's door). The language used in communications should also be noted. This is especially important in multilingual communities where different languages have different statuses and functions. Basic data on information networks should also be delineated. This includes identification of key individuals who are trusted information sources for networks of individuals. Attitudes and beliefs which relate to the various communication channels and languages should be determined in order to identify the most appropriate means for disseminating project information.

4.2.2.5 Level of Community Development

A listing of available services, many of which are also needed to evaluate infrastructure, is required in order to determine the level of community development. Services include schools, government offices, utilities (water, electricity), banks, transportation facilities (trains, buses, roads, shipping lines), mass media, medical services, and wholesale and retail outlets.

4.2.2.6 Occupational Structure

Occupational structure is determined by examining data which summarize (a) types of occupations which are available; (b) distribution of workers in the various occupations; (c) skills required; and (d) degree of demand, underemployment and unemployment for each occupation.

4.2.2.7 Numbers of Small-Scale Fishermen

Numbers of employed and unemployed small-scale fishermen are considered above (4.2.2.3 and 4.2.2.6).

4.2.2.8 Availability of Alternative Occupations for Fishermen

This information can be provided with data which describe the skills which are required for other occupations and the demand for workers in those occupations (4.2.2.6).

4.2.2.9 Temporal Distribution of Fishing Effort

The amount of fishing effort usually varies throughout the year. Data required include the time of day, days of the week, and months (or seasons) of the year which are devoted to fishing and the times when fishing is more or less intensive. If the variation in effort depends on the gear types or fishing practices which are used, data should also be recorded for specific types of fisheries. Finally, reasons for changes in effort, gear, or style of fishing throughout the year should be determined. Explanations would include factors such as the weather and holidays.

4.2.2.10 Local Knowledge About Fishing and Fish

Primary data needed here include a description of principal gear types and the ways in which they are employed. Local names for all gear types should be recorded along with the common names of all fish known to the local fishermen. Fish which have commercial and/or subsistence value should be described at least in terms of their habitat, ecology, behavior, and relative availability as perceived by the local fishermen.

4.2.3 Social Structure of the Occupation

Once basic data are collected and a decision is made to intervene in the fishery for development or management purposes, it is necessary to evaluate the social structure of the occupation of fishing. These data will be useful for determining the social impact of proposed changes as well as facilitating their communication to the target population.

4.2.3.1 Fishing Gear Types and Ownership Patterns

Data on fishing gear types should include local names for all types of equipment (such as boats, nets, lines, hooks, harpoons, motors, and sails) along with descriptions of where different types of equipment are used, how they are used and by whom. A description of ownership patterns should include an evaluation of the relative importance of different types of ownership (i.e. individual versus joint ownership, lease, or rent). Descriptions of ownership patterns should be prepared for individual regions and gear types. Procedures for transferring ownership should also be investigated. In some cases, it may also be important to know how many owners operate their own equipment.

4.2.3.2 Crew Size and Social Composition

A description of crew size and social composition begins with a classification which shows the relationships between the positions held by different crew members (captain, cook, net man, engineer) on each type of vessel. The number of each type of person aboard each type of vessel should be determined along with data summarizing the kinship links between crew members.

4.2.3.3 Criteria for Crew Selection

Data collected as a part of 4.2.2.6 will provide some information which reveals skills required of different crew members. Additional information is needed to determine what criteria are actually used in crew selection. It is important to learn the relative importance of kinship, friendship, and/or occupational efficiency in the selection of crew members. It is also essential to determine whether or not other criteria such as ethnic group membership are used as criteria for selection of fishing crews.

4.2.3.4 Degree of Occupational Mobility

It is important to determine whether or not the different classes of fishermen have an opportunity to improve their position. For example, is it possible for a deck hand to own a vessel of his own some day? Do hard workers obtain better positions, more income, or the opportunity to borrow funds to become owners? The degree of occupational mobility should be determined for various fishing types, equipment classes, and distinct geographical regions.

4.2.3.5 Interaction Between Crew Members and Between Owner and Crew

The social relations (such as relative status and the degree of power one individual has over another) which exist between the crew members (4.2.3.2) and between the crew and the owner should be determined. A description of these interactions should include time spent at sea and on shore.

4.2.3.6 Degree of On and Off Vessel Occupational Specialization

This information consists first of the job description — both on and off vessel — of each vessel position (4.2.3.2). Additionally, all shoreside occupations directly related to the capture fishery should be abstracted from data collected as part of 4.2.2.6 (for example, middlemen, boat builders, outboard engine mechanics), and a more detailed description of the skills required for these jobs, as well as an estimate of the time each worker devotes to the fishery, should be provided.

4.2.3.7 Relationship of Fishing Groups with other Social Groups in Society

Data are required which describe the fishermen's social relationships with other social and occupational groups in the society. Relationships such as group membership, cooperation, noninvolvement and hostility need to be identified (groups are identified as part of 4.2.2.1). Types of relationships which represent different small-scale fisheries and geographical regions should be defined. Important distinctions may exist, for example, between urban and rural areas.

4.2.3.8 Local Distribution of Wealth and Power

The primary data needed here first of all require a determination of what is locally considered as wealth. Is it money, land, cattle, many children, boats, many followers or friends, or some combination of items? Once the definition of wealth is known, the local distribution of wealth must be determined according to the various social categories defined in sections 4.2.2.2, 4.2.2.6 and 4.2.3.2.

Power is defined as the ability of one person or group to influence another's behavior. Data requirements include a description of both the official and unofficial political organizations which exist at the local level, as well as an identification of opinion leaders who influence the behavior of fishermen. As applied specifically to fishermen, data requirements also include a description of formal government power groups, the services they provide to the fishermen, and the local attitudes towards these services and government personnel. They also include formal laws governing the use of the ocean by fishermen, as well as informal agreements affecting who fishes when and where.

4.2.4 Innovation Data Needs

For purpose of the data collection scheme presented here, an innovation is defined as a new object or idea; thus it includes such things as a new piece of equipment, a new way to use an old type of equipment, a fishery management plan, or an institution such as a fishermen's cooperative. The data included in this category serve to determine factors which can either facilitate or impede the introduction of an innovation.

4.2.4.1 History of Innovative Behavior

It is helpful to understand the events surrounding recent attempts to introduce changes which have affected fishing communities. Important data include historical sketches of the types of innovations which were attempted, the way they were introduced (i.e. by whom, who were the first users, how long did it take until most fishermen used it, why did most fishermen adopt — or not adopt — it?), including descriptions of failures and explanations of why certain innovations failed.

4.2.4.2 Attitudes Towards Risk, Change, and Investment

Data requirements include descriptions of variations in attitudes toward risk, change, and investment in the fishery. For example, under what conditions would fishermen try a new gear type or invest in a more expensive vessel? Would they make such changes today, and why or why not?

4.2.5 Occupational Preference and Training Data Needs

A great deal of research has clearly demonstrated that a person's occupation and attitudes towards the occupation play a large role in self-perception, health and social adjustment. Job satisfaction has been related to a wide range of social, psychological, economic, and health-related variables ranging from level of productivity, job turnover, family violence, and psychosomatic illnesses to longevity (HEW, 1973; Gelles, 1974; Pollnac & Poggie, 1979). Thus, one cannot assume that non-fishermen will willingly become fishermen, or vice versa, and/or that they will adjust satisfactorily after such a change. It is therefore essential to understand what determines job satisfaction and job preferences in situations where occupational changes are anticipated.

4.2.5.1 Attitudes Towards Fishing by Non-fishermen

If proposed changes require addition of fishermen to the workforce, it will be necessary to determine attitudes towards fishing among the pool of available workers. Secondly, analysis of relationships between fishing groups and other groups in the society (see 4.2.3.7) may also indicate attitudes towards fishing. For example, if fishing is a low status occupation, non-fishermen will probably not be very interested in becoming fishermen.

4.2.5.2 Attitudes of Fishermen Towards Fishing and Alternative Occupations

If development or management policies are expected to result in displacing fishermen, then it is essential to determine attitudes towards potential alternative occupations in comparison with fishing.

4.2.5.3 Attitudes Towards Income Changes

Sometimes proposed changes in the fishery may have a negative effect on incomes. People usually react negatively to decreasing incomes, but it is necessary to examine their perceptions of the impact of such changes. This will facilitate the development of educational programs to implement the changes as well as the development of programs to mitigate the perceived impacts. Once the magnitude of potential income changes have been determined, a sample survey can be used to assess the impact such changes would have on the lifestyle of the people who are affected.

4.2.5.4 Perceived Innovation Complexity

It is important to determine whether or not fishermen who are intended to benefit from the innovation believe they have the necessary skills to implement the necessary changes or can learn them. Variations in these perceptions across fishing types, geographical regions, and in relation to individual attributes such as age, education, and status must be determined.

4.2.5.5 Perceived Innovation Compatibility

It is important to determine whether fishermen feel that they will be physically and mentally comfortable adopting a particular innovation. Will the use of the innovation affect valued social relationships (such as relationships between owners and crew, between crew members and between fishermen and the middlemen), and if so, can these problems be resolved? Will the temporal demands of the innovation (night fishing instead of day fishing or long trips versus short trips) fit their present lifestyle, and if not, is it possible to adjust the innovation or the fishermen's behavior? Compatibility covers a diverse set of issues ranging from physical, social, economic, and psychological concerns to the environment. The key is determining what the fishermen perceive as the compatibilities and incompatibilities. Areas where data indicate that potential problems might develop can be emphasized as critical points in development projects.

4.2.5.6 Perceived Relative Advantage of Innovation

Data required here would indicate whether or not fishermen feel that they would be better off in terms of such concerns as their financial position, work schedule, nutrition and/or status as a result of adopting a certain innovation. The variability of these data across fishing types, geographical regions, and in relationship to individual attributes such as fishing status, age, and education is important.

4.2.5.7 Perceived Trialability of Innovation

It is important to determine whether or not the fishermen feel that they could actually try out the innovation if they wanted to and why they do or do not believe so. The variability of responses to this issue should be examined as a function of different fishing types and geographical regions, and in relationship to individual attributes such as age, education and fishing status.

4.2.5.8 Perceived Observability of Innovation

It is important to determine whether or not the fishermen feel that they have the opportunity to adequately assess the results of the innovation. Some will accept verbal descriptions; others need to witness actual demonstrations. The variability in responses across fishing types and geographical regions, and relative to individual variables such as age, education and fishing status should be evaluated.

4.2.5.9 Individual Attributes Associated with Innovativeness

Perhaps the most important data are those which demonstrate which individual attributes are associated with the willingness to adopt change. Important variables include years of formal education, degree of literacy, exposure to mass media, cosmopolitanness, social status and degree of social mobility. Important personality attributes include attitudes toward change and risk (see 4.2.4.2), gratification orientations, achievement motivation and level of aspirations. The relative importance of these variables should be determined for the various subgroups in the population.

4.3 ECONOMIC DATA

4.3.1 Orientation

It is worthwhile to reemphasize here that the scope of this guide is limited in two ways: first, it encompasses only a portion of the entire fishery system — the harvest sector. The importance of that sector was discussed in the context of the fishery and the economy, of a decision process to "develop" the fishery's role in protein supply and in the context of that sector's relationship to the entire fish delivery system. Secondly, within this sector the scope is limited further in that the data identified for collection and the information developed from them are primarily concerned with the interaction of man and resource: how the harvest sector operates in biological, economic and sociocultural terms and how it might respond to changes.

Most of the data identified for collection is relevant to analyses of other portions of the system and has multiple uses for a variety of analyses particular to the harvest sector. It should be clear that this guide is not intended to define the entire scope of fishery department's data collection responsibilities. Furthermore, to differing degrees, the biological, sociocultural and economic data identified will be found to be necessary but not sufficient to constitute the department's contribution to more broadly defined programs, those which require the coordination of several departments and/or ministries. Among these are 1) a thorough examination of fishermen's welfare and of ways to improve it (see Smith, 1979), and 2) the identification, design and evaluation of investment projects (see Campleman, 1976).

The limits to the data are not so apparent in the first section of this chapter because the fish population is "totally involved" in the interaction between man and resource. The second section, as we have seen, concerns itself with the population of fishermen; how culture affects the fishing process, its organization, etc., and how cultural factors might condition the acceptability of innovations. These factors are clearly important to issues affecting fishermen's welfare and to the design of investment projects. The limits on data will be most clear in the present section. The "population" we seek to describe with economic data is the "population" of fishing activities, its state (the private and social benefits and costs of its operation) and its potential response to innovation (much of the same data regrouped to lend itself to analyses of cost, supply, etc.).

This orientation precludes a discussion of the problems of collecting a set of data which is, by its nature, intimately tied to the operation and response of the harvest sector, i.e. consumer or retail demand data. Data on the primary sales of fish or other marine products is identified for collection below, hence the link between the harvest sector and the rest of the system will be made. However, to be able to appreciate the performance and the benefits society derives from the performance of the entire system, data on final demand determinants should be collected.

The responsibility for collecting much of these data, (for example, that on prices of substitutes for fish, on consumer incomes, the food or general price index) usually lies with other departments. However, responsibility for collecting the important time series of retail fish prices and quantities probably does lie with the fisheries department. Final demand data are especially important, for example, if by-catch from an industrial fleet competes for the first time with the artisanal catch at the retail level. Some approaches to the problems associated with collecting data for demand analysis are contained in Sutinen and Pollnac (1980).

4.3.2 "Economic" Data

Given this focus on the harvest sector and fishing activity, what economic data shall be collected? If we review, briefly, some of the uses of what we have called "economic" data, we will see that we can collect a set of data that has multiple uses and can be analyzed from different viewpoints.

The figures used in the last section of Chapter III show a simplified bioeconomic relationship between the small-scale fishing fleet and the resource. We discussed these figures in terms of the relative merits of various long-run equilibria for the fishermen as a group, consumers, society, and the resource. The standard empirical economic analyses of supply, cost, production and demand data, i.e. data on transactions and productive processes, yield the particular information for a given fishery.

This information, which is based on assumptions of individual consumer and producer behavior, is used to determine the state of the fishery and to predict the response of the fishery to changes, i.e. where the new equilibria will be.

In the "perfectly" functioning economy there are no distortions in the optimal allocation of the nation's resources, including capital and labor, to one use or another. Some further assumptions are that all participants are aware of the alternate opportunities for their capital and labor services, that there is no monopoly (or monopsony) power being exercised in the markets, and that transfer of these services from one use to another is costless. As a result, the market prices for goods and services in their current use are exactly equal to their opportunity cost in any other use in the entire economy. Because these assumptions were in effect when we discussed the figures in the last section of Chapter III, we were able to identify the point of maximum economic yield (MEY) based on the total revenue curve and the total cost line. We were able to identify the economy-wide (social) optimum on the basis of fishing industry market prices for outputs and inputs. In other words, the industry determined prices were assumed to be the same as economy-wide (social) prices. In reality, for some goods used in the fishing process, market prices do reflect their social opportunity cost. But for the most important services, notably those of capital and labor, the market prices are frequently either lower or higher than their social opportunity cost.

In fact the equilibrium which comes about in an open access fishery or which is established as a result of biological or bioeconomic regulations, is arrived at because fishermen respond to market prices — to the prices they encounter day after day. Taxes, subsidies, import duties, market power, etc. are reflected in these market prices. A central planning unit in the government may see a considerably different total cost curve (or even total revenue curve) based on true (social) economic costs. As will be seen below, however, the fisheries department can contribute to the calculation of at least one social cost, i.e. the true resource cost to society of the operation of the fishery.

Another set of analyses, called project or investment analyses, examine various methods for evaluating the costs and benefits of private and public investments, i.e. for evaluating whether it is worthwhile to move to new equilibria. Economic project analyses evaluate the benefits and costs from the point of view of the entire economy. Financial project analyses are concerned with the return and the timing of the return to the investors. Obviously, any "worthwhile" project must be judged so from the point of view of society as a whole as well as from that of the participants.

In economic project analyses frequent use is made of prices other than those we experience in the marketplace — particularly the prices of capital and labor. The view taken in this type of analysis is that of a "general manager" of the economy who is, theoretically, knowledgable about all of the alternate uses of capital and labor in the entire economy; he is aware of their true social or national opportunity cost.[3] Financial project analyses examine, among other things, whether a project can be carried out by the

[3] This per unit social opportunity cost is often called a "shadow price."

participants. They use market prices exclusively in determining the profitability to the participants of investing in, for example, a new boat or ice house.[4] Notice that both types of analyses examine the net benefits of already identified projects — often an array of projects — which address an identified problem. Furthermore they attempt to evaluate the flows of benefits and costs of the predicted outcomes of the projects. The accuracy of these predictions is dependent on a thorough understanding of the biosocioeconomic operation of the fishery and its response to proposed changes.

In the context of small-scale fisheries two particular aspects of project evaluation need to be mentioned.[5] Both concern what are called secondary effects — the benefits and costs which occur outside a project's boundaries but which are brought about as a result of the project. The first, the employment impact (either positive or negative), is considered by many economists to be properly included in economic (but not financial) project analyses when a particular sector has an unemployment problem. The second, which is strictly termed a technological externality, is known to us as the project's effect on the resource and the resulting effect on catches in the fishery.[6] In this case both financial and economic analyses should consider the long run possibility of diminished or increased catches as a result of increased or decreased pressure on the stocks. Economic analysis will take the broader view of the impact of investments on society including the production impact on participants and non-participants alike. Financial analysis will consider production changes only in as much as they affect participants.

In Chapter III we discussed some of the adjustments that would take place in moving from one equilibrium point to the next. While we will always consider points such as MEY and MSY as "better" in a number of aspects when compared to an over-exploited, open access equilibrium, we know that from society's viewpoint it is not always beneficial to undertake these moves. Project analysis provides the tools to evaluate the economic and financial costs and benefits of these proposed changes. It is not limited to examining the effects of investments.

A third use of the economic data is in inter-firm or firm type comparisons of private profitability (returns).[7] As noted in Chapter III, the decision to participate in the fishery, to enter or to leave it, depends upon the return each fishermen thinks he can make with his capital and labor in its next best employment. He looks at his opportunity cost of fishing. What are the quantities whose sum must equal or be larger than the opportunity cost of fishing? Put another way, how does (or can) the individual fisherman decide to continue in this employment of his labor, his fishing and organizational skill and his invested money? There are many accounting measures used to portray the status of a business. The individual fisherman is concerned with the annual return to his labor, management and investment and with his cash flow situation, among other measures. Whether a fisherman, in fact, explicitly does such calculations or not is beside the point. His decision to participate in the fishery is based in part on the former measure. His ability to meet expenses on a continual basis is measured by the latter.[8]

The prices used by an individual fisherman in these accounting exercises are, with a few specific exceptions, market prices. The exceptions in this case are not economy-wide opportunity prices, but private, temporary prices. For example, a particular fisherman may have borrowed from family for some equipment at a very favorable

[4] A widely used reference which examines these two types of analyses is the World Bank publication by Gittinger (1972).

[5] See Campleman (1976) for a discussion of these analyses applied to fishery investment projects.

[6] We can easily choose some time frame within which the benefits to an investment in the fishery — such as one which increases yields — will exceed the costs. This temporary net benefit or industry-wide profit is the legitimate objective of many investment projects. To be properly evaluated, however, it must be weighed against the consequences of the eventual long-run equilibrium situation.

[7] We use the word firm here very broadly to encompass the organized enterprise of cast net fishermen to that of much more capital intensive trawling operations.

[8] The repayment of principal on a loan is not part of the calculation of return but is a significant part of the cash outlay. Meeting a monthly loan repayment provides a great incentive to fishing. In cases when fishing is seasonally dangerous because of weather conditions, this incentive may increase the number of fishing accidents.

interest rate or, more commonly, fishermen may use family labor paying them less than market rates.[9] The prices used in comparing two or more firms are market prices so that the advantages of having larger families, for example, are discounted. The prices used in any analysis then, depend on the context or the scope of that analysis.

The answer to the question about which economic data to collect, then, is that we seek data which will satisfy all of these uses given the limitations discussed above. We seek the data that individual firms would use (if they kept detailed records) in calculating their annual return to labor management and invested money and in evaluating their cash flow situation; market price data when private and market prices diverge; data on certain other quantities we need in order to calculate the social or true economic cost of this private activity (wasted fish, for example); and data on the physical nature of the effort expended by the firms.[10,11]

The data collected will provide the basis on which the fishery department can 1) understand the financial circumstances of fishing firms of particular types, 2) monitor these circumstances from year to year, 3) make comparisons among firm types, and 4) identify projects or regulations to improve these circumstances. Furthermore, these data will provide the input for the economic and bioeconomic analyses necessary to determine the state (and potential) of the harvest sector and to predict its response to projects or regulations.

4.3.3 Harvest Sector Activity

One goal of data collection is to account for the total amount of fishing activity carried out by the entire fleet (or by all participants in the fishery) and what this means in financial and societal terms. For biological reasons and because of legal and business conventions, the year (any twelve month period) is the longest and generally most useful period of time over which we aggregate data in order to make comparisons or recognize trends. Many of the figures in Chapters I and III show the long run equilibrium relationship among quantitative economic, physical and biological variables. Given the proper data set, these figures can be estimated using annual total quantities of these variables. As one cannot possibly hope to collect all of the data generated by each individual firm and all its fishing activity nor rely on the existence of complete records kept by those who fish, we will use various sampling schemes to estimate weighted sample means or averages of the many quantitative (kilograms or money amounts) variables which describe this activity.[12] The weights to be used will be chosen and the sampling strategy will be planned on the basis of qualitative variables such as firm types, species, locations, etc.

The fishing activity of an entire fleet occurs as a flow through time, i.e. over the course of the year. It is possible to define a unit of this activity in many ways. For reasons which will be clearer as we go on, we *define a unit of fishing activity as a single day's fishing by an individual firm.* This is the smallest meaningful unit that can be used.[13] A trip or a landing represents a set of units of fishing activity. For those variables whose annual totals are tied to the amount of fishing activity that takes place, the better data collection scheme is the one which, for the same cost, properly accounts for the total amount of fishing activity. This implies the ability to monitor the distribution of the units of fishing activity over time and space.

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[9] Interest rates on loans for fishing are generally higher than those for "safer" ventures. The difference in rates is called a risk premium.

[10] Note that we said "quantities" needed in order to calculate the social or economic return, and not "prices." We will be gathering private and market prices. But regardless of which prices are used (i.e. which level of analysis we are doing), the quantity values must come from data on the private activities of firms. The decision to use shadow prices (economy wide opportunity prices) is one taken with some consultation with those ministries or departments concerned with planning — those which calculate these prices.

[11] Catch and effort data provide the bioeconomic link. It is required by both the economist (in studying production and cost) and the biologist (one of several tools for population studies).

[12] We will see below and in Chapter V that if certain data are available we may be able to estimate total annual quantities of certain variables — particularly those related to catch — with greater confidence than we can have in estimates based on sample means.

[13] The unit of activity, a day's fishing by a single firm, is the "unit of analysis." This is distinguished from the "sampling unit" which is, ideally, a landing.

The proper sampling of activities on this basis will result in better estimates of the sample means of, for example, variable costs and revenue and in better estimates of the weight and species composition of the catch. The bioeconomic compatability of biological and economic data will also be enhanced if one can calculate catch, variable cost and revenue per-unit activity. Furthermore the opportunities for simultaneous and/or complementary biological and economic data collection efforts will increase.

In what follows we will 1) identify all the variables of interest, 2) define what constitutes a "good" observation on these variables as if the situation at hand would permit them to be measured in their "best," detail-revealing setting and, 3) discuss the economic context of the variables. If the fisheries situation faced will not permit observing these random variables in detail, then the remainder of this chapter will at least give some idea of what is being missed and how these missed quantities may bias sample means. Chapter V will examine how to relate this detailed data to the rest of the units of fishing activity which have not been observed. If one is unable to monitor the distribution of fishing activity over time and location, then Chapter V will provide some idea of the biases which may be introduced in using sample means (or other measures) to calculate the desired total annual amounts.

4.3.4 Variable Definitions

4.3.4.1 Identifiers

Depending upon the situation in which the data are being collected, one should attempt to record or have recorded as many of the following identifiers as possible: date, time and place of collection; the name of the person responding; the "type" of boat; type of gear(s) used, the boat name and/or registration number; the home port of the boat; the name of the boat owner if different from that of the respondent; the number of persons fishing; the area(s), or zone(s) fished; and the trip length.[14] The data recorder should be as observant as possible. In an interview setting, for example, it should not be necessary for him to have to question the fisherman about every identifier. The more identifiers associated with the data, the more possibilities there are for making different statistical comparisons, for analyzing different aggregations of the data and for supplementing data collected by others.[15]

The respondent may not be willing to identify himself, the owner, the home port, etc. This reluctance is often related to the existence of or threat of the imposition of taxes, registration fees, etc.[16] In general it is more important to get as many data as possible in this situation and to be well received on subsequent visits than to sacrifice future cooperation for a few additional identifiers.

In succeeding sections a narration is used to identify and define observations of the variables of interest so that the material flows logically. This narration follows fairly closely the data collection forms included in the appendices. Slight variations of these forms were used in Central America.

4.3.4.2 Revenue and Catch

The revenue we seek to measure is the value received for the trip. Most of this is directly related to the catch and the prices received per pound or kilogram of fish.[17] Some of it can come from sources other than from the sale of catch. If one or more of these other sources (for example, transporting people or cargo) is significant, regular and widespread, some attempt should be made to estimate it. This fishing-related income is more important to questions of fishermen's welfare and to investment project considerations than to the bioeconomic operation of the fishery. Its existence may also allow

[14] By "type" we mean one of the subdivisions of the fleet that the fisheries department has decided to use. For example, there may be length or configuration types further distinguished by gear type in use.

[15] See the appendices for the various identifiers used on the different sample forms.

[16] Any noticable increase in the data collection activities of the fisheries department is subject to being viewed by fishermen with some suspicion. Some department communication about its activities by leaflet, radio or other means prior to a data collection effort may allay this suspicion.

[17] In some fisheries what appear to be non-weight units are used in selling fish, for example "strings" of gilled fish or baskets or canoe-fulls are sometimes used. There is, in all probability, a weight range within which these other measures fall. It may vary by species and be subject to "inflation" over time, but with some effort the average weight can be estimated.

more boats to remain in the fishery than would ordinarily be supported exclusively by the revenue from catches. From the collection of background information one can gain some idea of its existence, frequency, seasonality and significance.[18]

To be more specific, the total revenue received from selling or using the catch is the sum of the actual or potential prices received for each qualitative subdivision (species or class) of the catch multiplied by the weight of that subdivision. For example, total revenue = (price of species 1 (or class 1) per pound (or kilogram) X weight of species 1 (or class 1), plus price/kg. sp. 2 X kg. sp. 2, plus...). In order to get an exact measure of the revenue (from fishing) for a unit of activity it is necessary to have an observation on the species' (or relevant subdivisions') prices and on the amount actually and/or potentially (see below) sold.

There are several possibilities for under-counting or over-counting quantities of valued fish in trying to get a good measure of revenue. Over-counting results from including the catch of other boats, e.g. purchases at sea or simply the transporting of other vessels' catches for sale. Under-counting results from: 1) ignoring the sales of some fish prior to the sale at the point of observation, e.g. sales at sea or sales at other landing sites; 2) ignoring quantities of fish not sold but valued, i.e. that rejected by (or simply withheld from) buyers but valued by the owner or captain and used a) to pay the crew, b) to sell at some other site, c) to be consumed at home, d) to be processed (dried, smoked) and sold later, e) to be paid to those who bring the fish to final sale such as unloaders, sorters, cleaners, f) to be used to pay for goods or services used during the trip, or g) simply given away. The objective should be to arrive at a figure (a monetary amount) which represents the value of all of the fish which is, in fact, valued (all that is not discarded) and which is the result of that particular firm's fishing trip.

Those quantities which will lead to over-counting should be eliminated, and the value of that which is potentially under-counted should be determined. In those data collection settings where questions can be asked about the disposal of fish withheld from sale, they should be asked. It will often be possible only to observe and estimate quantities not sold but valued. It will require some experience to be able to estimate the quantity of fish being so distributed. With experience one should be able to determine where and why these various under-or over-counting possibilities occur. Many of these potentially under-counted quantities of fish, especially those in "e" and "f" above, are used to pay for variable costs (see 4.3.4.4, 5, and 6). In order to be able to apply estimates of these quantities to similar fishing activities for which there is much less detailed information, it is important to *record separately* 1) the quantities and value of the various amounts withheld from sale and 2)the quantity and value of the fish which is sold in the "normal" transaction, i.e. the quantity and value (by whatever breakdown is available) purchased by the middleman or primary buyer. The prices of the fish actually sold at the landing site are reasonable estimates of the value per unit weight of the fish withheld from sale.

An estimate of the resource cost of this value-producing quantity of fish is the quantity of all fish killed in order to get that value, multiplied by the current price of that wasted fish. If one considers the dynamic case the cost is higher. This resource cost is part of the cost to society of individual fishing activity. It does not enter into the private calculations of a fishing firm, yet it is an important quantity. The difference between the weight of fish which is killed and the lesser amount which generates value (in money or use terms) results from 1) discards at sea, 2) traditional forms of evisceration and other preparation, and 3) spoilage (fish landed but discarded). The quantity of discards at sea is best estimated by sea sampling. It is the less or non-valued species which are discarded for reasons other than spoilage.[19] The form and extent of preparation, including evisceration, is usually tied to the appearance (look, smell,

[18] We distinguish this income from that earned by, for example, seasonal farming, i.e. from sources not related to the fishing activity. These latter income sources are of great significance in examining welfare, entry and exit flows in the fishery (they are measures of the opportunity cost of fishing) and the seasonality of fishing effort. This last aspect is important to the operation of the fishery, and sampling methods we discuss below will take account of it. Questions concerning alternate employment can be included in the appendix on background information. A discussion of sampling procedures to measure this "other" income is, as noted above, beyond the scope of this guide.

[19] It is very unlikely that the cost of sea sampling to estimate discards in the small scale fishery can be justified. The opposite may be true of sampling discards from an industrial fishery exploiting highly valued species such as shrimp. Shrimp fleets frequently discard relatively low valued finfish caught in all but the last few tows.

gut contents, dangerous parts, etc.) of groups of species and is reasonably consistent in a given fishery. Biologists work with either whole weight or landed (prepared) weights. Conversion factors can be established relatively easily at any point before or during the data collection effort. However, it is essestial to maintain consistency in recording and converting data.

Since fish that is spoiled had commercial value, the quantity of this fish which is discarded at sea is probably much less than the quantity which is landed in hopes of being sold or used. The quantity of fish landed but rejected for sale or other uses because of spoilage can be very significant in small scale fisheries. This fish, part of the resource cost to society, represents foregone revenues to the individual firm. As we have said, it is not treated as a cost to the individual firm. However, this quantity is probably the easiest to observe and measure of all the quantities that make up the difference between what is killed and what is sold or used. Given this, and the importance of this data in suggesting improvements in the fishery, it is clearly a quantity which should be recorded.

So far we have discussed the problems of getting accurate observations, i.e., the problem of over-counting or under-counting quantities of fish — principally those quantities of all fish that make up the difference between what was killed and what was sold to the primary buyer. We will also face the problem that the things we want to measure will not be available to be measured in the preferred subdivisions. The divisions by which fish is sold to primary buyers are based on a commercial classification of the catch. Depending on the fishery in question and the nature of the catch, we will see sales: 1) of all fish at the same per-unit price, 2) of a few commercial classes of fish (two or more species per class), or 3) of a few important species each priced differently and separated from the rest of the "other" fish. The methods used to distinguish fish in the delivery system are usually a matter of tradition and are fairly stable though complex.[20]

All of these commercial divisions have economic meaning in that they are based on price differentials which reflect how consumers value various types of fish. In order to maximize the multiple uses of catch data, the divisions or subdivisions of catch should have biological as well as economic meaning. The most commonly used divisions of catch which have biological meaning (in the sense of relating catch to the population(s) of fish or to a measure of potential catches through some population dynamics model) are individual species, cohorts of individual species, and, to a lesser extent, all catch (total biomass yield). There is rarely a one-to-one relationship between the biological distinctions of catch and the economic distinctions (e.g. commercial classes).

To make this commercially disaggregated data useful for biological and bioeconomic analyses, one can either coordinate economic and biological data collection or apply a recent or soon to follow species breakdown (see Chapter V). The accuracy of this latter procedure is directly related to how close in time, location, boat size, gear type, etc., the breakdown is to the other catches it is being applied to.[21] Economic data can be extracted from biologically aggregated catch data — such as that which would result from either a catch and effort sampling scheme or one designed to determine, for example, length frequencies — if the relevant identifiers accompany the biological data. In this case one can determine the probable prices that prevailed at the time the biological data was collected and estimate the costs of the trip.

Determining the species composition of the catch is difficult, costly, time consuming and inconvenient to the buyer and seller of the fish. Two hundred or more species may often be represented in the catch. If the composition is determined too infrequently, strong biases may be introduced in the estimates of annual totals of species caught. A reasonable compromise is to survey the catches frequently but to sample only a percentage of each catch. One can begin by sampling the most highly valued classes (or whatever commercial classification is in use) and working through the less valuable (in terms of price per pound) classes until

[20] A much greater degree of differentiation of fish products is evident in the retail market than in any other part of the system. This often complicates the collection of consumer demand data.

[21] Another composite variable we will encounter is nominal effort. We will see later that there are steps we can take in designing our sampling scheme which will automatically decompose this measure into somewhat more economically and biologically meaningful components.

the classes of fish which constitute about 80% of the value of the catch have been sampled. Because of the possibility of changes in the importance of species in the catch, a more thorough breakdown should be done periodically (see (5.2.2.1 (b)).

It's obvious that each post-trip interview will not be coupled with a sampling of the catch. The economic data collector, while perhaps unable to distinguish similar species, should be able, or be trained to be able to recognize the commercial classes of the different quantities of fish withheld from sale.

The quantitative observations (weights and prices) and qualitative observations (commercial classes and species) which make up the data on revenue and catch are the most changeable observations to be collected. They will be different for each individual firm with each unit of its activity — day to day, trip to trip. They are also among the most difficult to collect, especially in the initial stages of the scheme. The variety of arrangements for dispensing fish, the speed with which it is done, the need to make very quick estimates of the weight and commercial class of this fish and many more factors will generate some early frustration. This is understandable. The effective collection of detailed data is an acquired skill. It is a skill which requires, at a minimum, a willingness to interact with fishermen.

4.3.4.3 Costs in General

A given firm's net return from a fishing trip equals the revenues received less all of the private costs, i.e. those incurred in fishing and those incurred in being able to fish. The traditional distinction of costs is between variable and fixed costs. Fixed costs are incurred whether or not the firm fishes. Variable costs are those which increase as the amount of fishing per time period increases.

Our approach to identifying and describing costs rests on the traditional economic distinction modified somewhat because we assume that no records are kept by fishermen. Consequently we will define variable costs for a fishing trip and fixed costs for an individual firm. We will describe ice costs, a variable cost, in the context of an interview setting at the end of a fishing trip, and depreciation costs or interest on loans in a context suitable for calculating the annual/monthly cost to the firm.

Two of the more important uses for cost data mentioned above are in determining the returns from fishing to a firm or a firm type and in understanding the demand for inputs used in the fishing process. If each firm consisted of a single fisherman and his boat and gear, then the determination of returns would be fairly simple. Many fishing firms use crew services however, and, as a result, the determination of returns to a day's fishing become complicated. The hired crew, which may or may not include a captain (not the owner) frequently share in the costs of the trip just as they share in the revenues.[22]

If, in a given fishery, the crew traditionally pay all ice costs, one cannot correctly conclude that the firm (from the owner's perspective) does not consume ice in its fishing process nor that there is no demand for ice in the fishery. For consistency, and to avoid either missing or double-counting costs, the recording of costs should be separated from the recording of who bears these costs.

4.3.4.4 Variable Costs — General

The costs which increase with fishing activity, while they vary from fishery to fishery, include the costs of ice, fuel, oil, food, bait, labor, unloading, etc. This list can be long. Many of these costs are paid in fish rather than in money. Nonetheless they are real expenses. Some background work is required before observations on these variable costs can be collected. At least three problems must be addressed. The first problem is to know what to look for or what questions to ask. Items which should be counted as costs will vary by boat/gear combinations and also by location. It will be fairly easy to see that a given boat/gear combination uses ice or bait or fuel and oil. The more difficult part is to determine what costs a firm incurs in landing the catch and in bringing the primary sale to a close. For example, are there unloading fees or scale use fees?

The second problem lies in determining where costs end and where "give aways" begin. The former are obligations incurred for receipt of necessary goods or services.

[22] Recall that we counted as revenue to the firm fish which was given to the crew as payment. In this section we will count this fish as a cost to the firm for crew services. If we fail to do this, we will underestimate labor costs.

The latter are more properly viewed as choices made by the fisherman in disposing of some of this revenue even though these quantities may be dispensed prior to the sale.[23] In some fisheries this disposal of income is mixed in with the payment of fish to meet expenses or fees. Fish used for either purpose need to be observed or asked about and then recorded as part of the catch and revenue. That used to pay costs needs to be recorded a second time.

A third problem is concerned with determining whether the size of these different variable costs is or is not related to the value of the catch. It is necessary to make this distinction if we are to keep open the possibility of using several methods for calculating annual total amounts of these costs from post-trip interview data. Some of these other methods may prove to be more accurate than the one which generalizes from sample means (See 5.4). We will divide the variable costs discussed below into those independent of the value of the catch, those solely dependent on that value, and those whose magnitude is determined in part by the value of the catch.

4.3.4.5 Variable Costs Independent of Catch

The costs which concern us here are the costs in the first category. They consist of the cost (quantity multiplied by price) of ice, fuel, oil, bait, food and any other costs uncovered which are independent of the catch. The factor which most determines which of these costs exist for a given trip interview is the boat/gear combination in use. The size of the various costs for any of these combinations is a function of the length of the trip, distance to fishing area, etc.[24]

There may also be catch-independent costs which are more closely related to the fact that there was a trip — for example a flat fee for unloading — than to the nature of the trip, for example the cost of fuel consumed.

Most of these costs will have been paid prior to the trip. Frequently, however, some costs for goods or services used during the trip are paid afterwards, even after the sale of the catch. Our only recourse is to ask if some costs of this trip will be paid later.

There may be some difficulty in calculating the quantity used of goods which are not completely consumed during the trip, particularly in calculating the amount of fuel and oil used. These are the desired measures, however. The amount consumed will depend on the boat and motor combination, the motor's age and condition, the gear used and the traveling time to the fishing site. Thus there are many reasons why fuel and oil consumption for a given boat/gear combination will differ. The fisherman's estimation of the amount of each used should be recorded. As with many of the costs examined, unusual answers can be spotted after some experience is gained in collecting data. One may be able to assist the fisherman in estimating the per-trip quantity of fuel or oil or other inputs not completely consumed during the trip by asking him how frequently he purchases the input, in what quantity, and how many days he fishes, on average, between purchases. If the prices quoted by the fisherman are significantly lower or higher than the interviewer knows to be the "going price" at other locations, it may be worthwhile to ask from whom the purchase was made and note the response on the back of the questionnaire. This will prove helpful should the department wish to look into the nature of the relationships between buyers and sellers of inputs.

The cost of food is traditionally counted as a cost of fishing. As with all of the costs mentioned so far, it should be recorded as if the boat owner (firm) were responsible for it. Adjustments can be made later. For this cost, more than any other, an "educated guess" may be the best estimate. Since the arrangments for purchasing food are so varied, it is probably not worth the time to try to get an accurate measurement. It is easiest to settle on a money amount of the value of the food for one person and multiply by the total number of people who went fishing. One should include in this amount any food brought on board by the crew. If food costs are generally substantial in relation to the gross receipts from the trip then more effort

[23] Strictly speaking this "distribution" of catch is not the same thing as the economic concept of distribution. Economic distribution is concerned with production possibilities based on initial endowments and with the share of output the productive factors receive for their services (See Samuelson, 1973 or any edition).

[24] We should be sure that the identifier (or nominal effort measure) "number of days of fishing" is associated with each observation on variable costs. In the discussion of effort data we will see that more specific data on the effort expended will allow us to approximate the cost of "effective" effort.

should be invested in determining the true cost.

Two additional costs which are properly included in this section are random costs: the costs due to losses of, or damage to equipment, gear, hull, sails, motor, etc. One can ask if there have been any losses or damage incurred during this trip. What specifically was lost or damaged, and the estimated replacement or repair costs (parts and labor) should be recorded. The labor costs should be recorded as the actual amount paid and again, but not as regularly, as the market would value those services. All of these costs should be recorded as if the owner would bear the entire amount. For an alternate treatment of damage costs see section 4.3.4.10.

There may well be other catch independent costs to be considered which have not been mentioned here. The background information exercise and an increasing familiarity with the fishing operations of the fleet should make one aware of their existence and how they can be handled. Remember that the goal is to identify and get good detailed measures of these costs and revenues. The revenue (value) and the variable costs identified above and those to be identified below are defined for interviews at the end of fishing trips. Some of the data will have to be estimated either by visual observation (e.g. weight and commercial class of fish), through post-trip conversations with the fisherman (e.g. quantity of fuel and oil consumed) or by more extensive post-trip interviews when costs and revenues are hidden by complex relations with creditors. As much of the calculating work as possible should be done before leaving the interview site. Simple, inexpensive four-function calculators make these calculations less tedious and provide and incentive to their being done at the site. Standard units such as liters, kilograms, etc. should be agreed upon before the data collection starts so that decimal amounts are not misunderstood in later coding work.

4.3.4.6 Costs Which Vary with Catch Alone

The priorities in getting data on these costs should be to 1) discover what these costs are, 2) determine their size, 3) find out what measure of catch they are related to and 4) determine the relationship.

The costs which depend only on catch may include the costs of unloading, sorting, scale use, brokerage, fish preparation, landing taxes, etc. Which of these costs is present for any landing is probably more related to the landing site than to any other factor. More frequently than with other costs, these are paid with some of the catch. Recall the section above where potentially under-counted quantities of fish were discussed. The value of these quantities of fish was then classified as revenue. These values must now be accounted for in the payment of costs. The easiest way to determine these costs is to ask the owner/captain about them. Alternatively one can question all those who were paid. This approach is more convenient for the captain/owner. Frequently it will be necessary to settle for merely observing the often rapid distribution of fish and noting the quantities dispensed. Some time must then be spent at the site to discuss the distribution (distinguishing payment of costs from the distribution of revenue) with whomever is available to discuss it.

The reason for asking about which measure of catch (for example, total value of the catch, value of that sold to the middleman, etc.) these costs are based upon is, as we have said before, to keep open the option of having alternative methods for calculating total annual amounts of these costs. This holds for the fourth priority as well. These questions should be posed only until a representative sample of responses from the different landing sites is acquired. It is probable that the basis upon which these costs are determined and the rule for determining them will vary so much as to be useless to us. However, one should make the effort to get a sample before making that determination. If the basis for these costs is fairly consistant across landing sites or if the number of sites is small *and* it is possible get a consistantly good measure in the post trip interview setting of the quantity of fish on which these costs are based, then the chances for more accurate annual measures are improved (see 5.4).

4.3.4.7 Labor Costs

The cost of labor or crew services for a given trip is somewhat more difficult to determine than other costs. It involves getting good measures of some of these other costs (usually the non-catch related costs) and of the value of the catch. This cost is calculated from the viewpoint of the owner(s) of the boat and gear. It is the sum of the value (money and fish) paid for all crew services (including those of the captain, regardless of whether or not he is the boat owner) less whatever costs they have paid or will pay in connection with the fishing trip.[25]

The systems, rules or arrangements used to determine how much the different participants in the fishing trip will receive are called by various names including "share" systems or "lay" systems. Share systems are usually established by tradition and modified as newer technologies are adopted (as the balance of labor and capital in the operation changes) or as the risk involved in the fishing venture changes. These systems usually vary by firm type (boat/gear combination), by location of the home port of the boat but not by landing site (if it differs from the home port).

The authors encountered approximately thirty different systems for determining crew shares in the Gulf of Nicoya fishery in Costa Rica. All obligated the crew to pay a percentage of different (catch independent) trip costs (a certain cost to the crew) and a right to a percentage of the catch's value (an uncertain revenue). In this way all who fished and all who owned capital in the firm shared in the risk of the fishing venture; in this case the risk of small catches. Just as fishermen enter and leave the fishery in relation to their opportunity cost of fishing, so, too, crews of artisanal boats are aware of share arrangements in other ports or on different boat/gear combinations in the same locale. No one arrangement is too inconsistent with the rest in terms of the potential reward to fishermen for their labor and risk. If one were, movement to or away from that arrangment would be expected. These descriptions of share systems should be recorded. They provide useful data for analyses of risk bearing, of economic distribution to the factors of production, of the social organization of the fishing activity and of potential socioeconomic changes to crew and firm arising from technical innovations.[26]

A hypothetical share system might have five shares to be distributed; two for the ordinary crew (captain excluded) regardless of their number, one for the captain (regardless of whether it is the owner or not), and two for the "boat" (the owner(s)). The shares might be based on the total value of the catch, some of which might be sold at sea before the landing, some of which is withheld from sale for various reasons. The two crew shares might be "net of" ice, food, bait and one-half of the fuel costs. In other words, these costs are deducted from the two-fifths of the total value of the catch intended for the ordinary crew. The captain may be responsible for the remainder of the fuel costs and the "boat" for the rest of the costs, e.g. unloading. While this system is of moderate complexity it could be "explained" to the recorder in less than clear terms. If one wishes to record a description of these systems it is helpful to ask that the system be unscrambled: to ask for the rule for dividing all costs involved and then for the rule governing revenues (see below). Use of this approach will usually result in a more detailed description.

Should share system descriptions be used as a guide to determining the labor costs for a particular trip or for reducing interview time for future trips or in devising ways to estimate labor costs for unobserved trips? We think the answer to each question is no. Because these systems are so varied and are particular to both boat/gear combinations and to the home port of the boat, it is safer to measure the labor costs directly. These rules may be used to indicate that we are not asking the proper questions. After conducting a reasonable number of interviews, one can see if the amounts received are greater than those calculated from the rules. This might reveal that a greater amount of fish is being sold or distributed before the sale than is being reported by the fishermen.

In order to calculate labor costs for a particular trip one must determine 1) whether the captain is the owner, 2) the amount of the shared costs paid by all of those in a particular payment category, and 3) the total revenue (value) paid to everyone in a particular payment category. If the captain is also the owner, his payment of costs and receipt of shares should appear in two categories, in one as captain and in one as owner. The

[25] The share of revenues to be received and the share of costs to be paid are different, usually, for different roles or jobs. Frequently encountered divisions are 1) the boat's share (representing the owner), 2) (possibly) the gear or motor owner's share (if these things are not owned by the boat owner), 3) the captain's share, and 4) the crew member's share. The owner who is also the captain therefore gets a larger return than the owner who is not captain.

[26] If such studies are anticipated, these systems need to be investigated in detail in some other setting as they are often complex. The simple, verbal communication of these arrangements at the end of a fishing trip will often lack elements such as the obligation of the crew to provide free labor and perhaps parts for maintenance and repair.

owner's costs and revenues can be calculated after the interview is over as these amounts are "what is left" of the total costs and total revenues after all payments have been subtracted.[27] The net payment to people in the various payment categories can be determined by subtracting from their revenue any costs they have paid.

If an attempt is made to obtain a verbal description of the share system while determining labor costs, it is necessary to be sensitive to both the ordering of the questions and those whom we question. In other words one should avoid undermining the credibility of respondent(s) by appearing to be "checking up" on his (their) responses by asking both the captain and the crew the same questions. Verification of amounts received is important and can be done discreetly.

In one method used in Central America the interviewer asked each of the ordinary crew members how much he had been paid prior to any deductions for the trip (including the value of fish received) and then how much he had paid or would pay in expenses for the trip (including food costs if he paid for it himself). Alternatively each member of the ordinary crew could be asked how much (net) he had gained or would gain from this trip. The captain was then asked about the total value of the catch, how much each division of the crew would receive of this amount (including fish) then the general rule for dividing revenues. Afterwards we recited a list of possible costs, beginning with trip independent costs, and asked the total amount of each, whether it was a shared cost and lastly if we had missed any other costs of the trip. The captain was then asked the general rule for dividing costs. One can see from this that we are not interested in how much a particular individual paid for, say, ice, but rather in the total cost of the ice and how much of it was paid by each payment category.

In another method, reflected in the trip questionnaire in the appendix, the interviewer questioned the captain exclusively. The set of questions asked was similar to the set asked above except that when a shared cost was identified, the amount that each division of the crew actually paid (or would pay) was recorded. The general rule for costs was determined only after the particular trip's costs and their division were recorded.

4.3.4.8 Other Considerations

Before closing this section on variable costs a few important points need to be mentioned. The first, and most important, concerns the use of family labor in the fishery. This is properly a study in itself. The major implication for data collection, for economic analyses of the operation of the harvest sector, for project evaluation and for interfirm comparisons is that this family labor is often underpriced. Frequently the service of family members, especially that of wives and children, is not rewarded at the same rate as are the same services rendered by hired laborers. While this may be to the private advantage of a particular fisherman-/owner, it obscures both the true measure of that firm's profitability or efficiency in comparison with others and the market value of labor services in the entire fishery. How this problem is dealt with in order to maintain the accuracy of the data and yet minimize the inconvenience and cost of that accuracy, depends upon how widespread this usage is. First of all, it is necessary to inquire about family member participation in both the background information exercise, and, initially, in the interviews at the end of fishing trips. During an interview, the amount actually paid should be recorded as zero if there is no remuneration. Afterwards, the roles family members have played in either the fishing or in bringing the fish to sale should be determined. If family members are involved only occasionally, then these questions should continue to be included in the interview. If there is extensive use of family in established roles in, for example, unloading, there is no need to continue the questioning. But this use has to be documented so that market values can be attributed to those services prior to any economic analysis.

Secondly, we have tried to minimize the time and inconvenience of the interview by omitting questions, the answers to which can be deduced from already recorded data. For example, the return to the boat owner for a given trip is the difference between the total revenue (value) received less all of the variable costs. Likewise the salary of an ordinary crew member can be calculated once the number of people in that category and the net amount of the revenues received

[27] In some cases it will be found that an owner is providing services such as housing, food, etc. to crew members. We can uncover this situation in our background survey of the fishery. If this situation exists the annual costs to the owner should be determined and treated (sampled) as a fixed (labor) cost (see 5.4).

from all people in that category have been recorded. These calculations can be done in the fisheries office. When they should be done depends upon how the data are to be stored. If computer facilities are available which can store *and* manipulate the data, then the need to do the desired calculations as soon as possible after the interview is reduced. What calculations should be done, of course, depends upon what the data will be used for. It is worthwhile to do at least the obvious addition, subtraction, multiplications and division necessary to complete the description of a given fishing trip e.g., total revenue, total variable costs, labor costs, etc.. Regardless of how the data are stored, the ability to generate interesting data from a given interview weeks or months after the fact, or to generate data (e.g. sample means) by aggregating over many interviews, is directly related to the number of consistently recorded identifiers which accompany the data.

Thirdly, it should be obvious that compiling the suggested data in the detail we have specified is not easy. The burden of gathering this detailed data will fall on those planning the sampling scheme (Chapter V) but more so on those actually collecting the data. There will be a tendency to estimate amounts (or worse yet, guess at amounts) of catch revenue and costs when they should be properly measured by interacting with the fishermen. This tendency will increase as data recorders become more and more familiar with the data.

Lastly one should be aware that the amount of detail specified in defining a good measure of revenue and variable costs and the amount of time and energy that we suggest be spent in getting that detail, reflect the authors' experience with the magnitude of the cost and revenue elements. It is very likely that the *relative* size of these different costs and of the different amounts of fish that constitute the total value of the catch will be different for different fisheries. One should keep in mind the multiple purposes which the data will serve, the amount of detail this requires and then allocate available data collection resources on the basis of the relative magnitude of the quantities involved.

4.3.4.8 Physical Production and Effort Data

Post-trip interviews can be used to collect a reasonably detailed description of the various components that contribute to the physical production process of fishing. Observations on these components contribute to the quantity of data available to determine fishing effort. The greater the specificity of the effort data, the closer we can come to approximating effective effort and its cost. Prior to an interview the recorder can observe the boat type (and approximate its length and width), the number of people who fished, the kind of propulsion used (sail, motor, etc), and some of the gear used. In the interview one can determine the total length of the trip, the specific kinds of gear used, the actual fishing time each gear was employed, the area in which each was employed, and the motor's power. Our experience has been that most fishermen are willing to talk freely about almost all of these details except for the exact locations fished. They have been willing to indicate in which zone they fished, however.

After gaining some familiarity with the kinds of gear(s) employed, it is possible to prepare the questionnaires to include a set of specific questions for each gear type — questions seeking detail on the fishing power of the various gears (see the questionnaire in Appendix C). For example, some questions specific to gillnet use concern how it was hung, the stretched-mesh size, its area (length and height), and the number of meshes between ties on the support line. In general, these questions address those aspects of the gear and its use the investigators and the fishermen think contribute to its effectiveness. Every aspect of fishing effort contributes to either the economic or biological significance of the firm's fishing activity. Many contribute to both. We will miss some interesting economic data if we fail to record, for example, the motor size (H.P. or displacement), simply because the fisherman uses a stationary gillnet.

Because the number of days of fishing will be difficult to determine for any one firm type and/or the entire fleet, the number of days fished in the previous 30 days should be determined.

Once again, it is helpful to have established a set of standardized measures to avoid confusion in recording and interpreting data. Specifically, it is helpful to establish classes of boats and gears, fishing zones, methods of employing gear, materials used in the gear (e.g. mono- or multifilament line), and standard units of measurement.

4.3.4.10 Maintenance and Repair Costs

The cost of maintenance and repairs is usually significant for the individual fisherman. For a given firm this cost increases as the amount of fishing in a period of time increases. Regardless of how much fishing is done, some expense is always incurred because of the need to combat the effects of sun, rain and sea on assets such as the hull, sails, motor, and gear.[28]

How can the annual total of this cost be determined? Should it be separated into two components — regular maintenance, (implying a schedule) and randomly occurring repairs? How shall it (they) be sampled? Since written records of this (these) costs are lacking, one must depend on the memory of the fishermen. If maintenance is separated from repair costs we *may* be working with a distinction that is not recognized by the fishermen. While there is no general rule, we suggest considering them as one and treating this one cost as a variable cost. Damages, of course, occur randomly but we suggest treating them as part of these costs as well. This was done, in fact, by including damage costs among those trip-related, catch-independent costs above.

Are the costs of keeping the boat in working order incurred as they arise or are they (aside from damage costs) put off until a slack period of fishing activity permits the work to be done at a smaller real loss of fishing time?[29] The answer is probably that those things which need to be done are done as they arise and that recaulking, repainting, etc. is done in relatively slack periods. The question then becomes which sampling procedure — one which samples fishing trips or one based on the population of firms (represented by fishermen at home) — will capture these costs better. It is suggested that the better procedure is the former because post-trip interviews will be more evenly distributed over time and type than the sampling of firms for fixed cost information. Furthermore, a set of consistent questions can be posed which will, in effect, cover the entire year's distribution of maintenance and repair costs and yet not tax the fishermen's memories for detail.

By including maintenance and repair questions in post-trip interviews we make them longer but gain detail and accuracy. If this approach is unacceptable for whatever reason then one should at least be aware of the biases which are introduced in extrapolating from sample data to annual total amounts of these costs. The less mechanized the fleet, the more likely that maintenance costs will be larger relative to repair costs, and the more likely that these costs will be incurred during a short period of time — perhaps in a season when fishing is dangerous. If this is true then it may be possible to arrange the fixed cost data collection schedule to minimize potential biases.

Let us review the necessary data. The following data items apply to all capital equipment. They should be recorded for one major item at a time, i.e. one should ask all the questions concerning the hull and repeat them for the motor or sails and again for the different gears used. During the post-trip interview one should begin by indicating interest in all maintenance and repair costs *since the last trip* (including that caused by damage). It is worthwhile to suggest, for each major capital item, several likely repairs which might have been made. One needs to record the item or task under discussion, (for example, caulking the hull) the actual cost of materials, and if the costs were shared, and what fraction was paid by each of the groups of people who shared in the cost. One then inquires about the actual total cost of labor, how many hours (or possibly days) were involved in the work, and again if the costs (the amount actually paid) were shared and how. One should then ask who provided the labor: was it hired or was it done by family members or crew? The cost of labor may well be zero. If so, it should be recorded as zero. However, if labor was provided by the crew or family members at no or reduced cost, a measure of the market value of those labor services should be obtained, i.e., the hourly market rate or what the entire labor cost for a task would have been had someone outside the crew or family been hired to do the task must be ascertained. It need not be done for each interview, however. Having recorded what the work was, who performed it and the

[28] Depreciation costs are accounting costs which can be evaluated at any point in time For this reason they are considered to be fixed costs and are sampled as such.

[29] Maintenance and repair costs are amounts paid to keep the boat in condition to fish. We should distinguish these from costs incurred for major renovations or refitting. These latter are more properly considered reinvestments of capital and will be reflected in the new (larger) current value of the assets. The cost of these investments is discussed in the section on interest and depreciation costs.

amount of time involved, we can independently obtain market rates for the type of work. Boat yards or boat builders are good sources for this information.

The market valuation of labor services is used differently if the labor was supplied by the crew rather than by family members. The market value of the family's contribution should be included as the labor cost of the repairs. If the crew provided the services "free of charge," we assume that this was taken into consideration earlier when crew shares were negotiated. Therefore there is no charge to the firm for labor in this instance as the cost has been essentially prepaid. Nor is there any deduction from the crew's share of the trip revenue. In this case the market value of labor services is a piece of datum not used in calculating trip profitability. It is used in other analyses as a measure of the expected labor costs for repairs. The share of parts costs paid by the crew should likewise be deducted from their trip revenues. There are no distortions created in the estimated annual amounts because these previously incurred costs are deducted from a subsequent fishing trip's revenues. Finally, one should ask how many fishing days were lost since the last trip due to repairs. This loss of fishing time is not a cost but foregone revenue. As such, it does not enter into the annual costs of fishing.

Since relatively significant expenditures on maintenance and repairs (including damage repairs) are important to the fisherman, they may be mentioned even though they occurred prior to the last trip. It is worthwhile discussing these repairs but we should record *only* those costs incurred since the *last* trip. Otherwise, we will overcount this already important cost.

When one attempts to get data on maintenance and repair costs in a setting suited to collecting fixed cost data, the time reference to the questions, which are otherwise exactly the same, changes. For example, the time interval in the following phrase is variable. "Let's discuss maintenance and repair costs you have had in the last ________ months." What number one puts in the blank space, as we have said, depends on the relation between the distribution of these costs and the distribution of our fixed cost data collection efforts through time. In fact, it is even more complex if we have a variety of boat/gear combinations which vary greatly in the amount of capital each employs.

If fishermen keep detailed records, maintenance and repair costs (including damage) should be determined once a year. These records, if measured from a proportional sample of the population of boat/gear combinations, will yield a good estimate of the annual maintenance and repair (including damage) costs (see Laxenaire, 1973). In the absence of log books or accounting forms, one should try to adjust the timing of the fixed cost sampling, as much as is reasonable, to capture as much of these costs as possible. This is easiest if these repairs are done in an interval of lessened fishing activity. If this work is spread out over the year, then an adjustment for capturing these costs (in terms of accuracy and not logistics and sampling cost) is to distribute the fixed cost sampling scheme in relation to the amount of fishing activity that takes place from month to month or quarter to quarter and to assure that each type of firm is sampled in each month or in each quarter. If one can assure this proportional representation of boat/gear combination in each month or quarter then one can ask that costs be remembered since the last month or quarter respectively.

Where no records are involved, the bigger problem will be in recalling what repairs were done, what parts purchased, the duration of the repairs and fishing time lost. It is likely that the rule for sharing costs, the probability that family or crew were involved, the market price for labor services and even the price of parts will not have changed much over the course of the year or quarter and certainly not the month. On the other hand many small costs will be overlooked using this fixed cost setting.

We will now appear to contradict ourselves by recommending that *both* procedures be used simultaneously in the first few (two or three) years of data collection. Because of the many factors affecting the occurrence of these costs, it will take perhaps five years before arriving at a reasonably accurate estimate of the annual cost of maintenance and repairs based on post-trip interviews (see 5.4). This procedure will pay off in the long run, but much can be done to augment data on these costs in the interim. We might add the costs collected in each procedure for the first year, take an average of the results of each procedure the second year and gradually decrease the role played by costs collected in the fixed cost procedure in succeeding years. Alternatively, and depending on the fishery, we might initially base our estimates of these costs on information gathered from boat building and repair enterprises.

4.3.5 Fixed Costs

Fixed costs are by convention annual costs. Some of them may be paid for weekly or monthly or at irregular intervals but they are discussed and compared on an annual basis. When collecting data on these costs questions will be asked about the year that ends on the date of the interview. The sampling of these costs should be carried out within a given year (any twelve month period). Regardless of how the sampling is distributed throughout the year, the data will refer to the 12 month period ending with the collecting of the last fixed cost data. If one had written records of these costs, for example accounting sheets, one could compile cost data for the same time period for all firms. This suggests that a more realistic picture of the fleet's annual total fixed costs could be gained by carrying out all of the data collecting for these costs during a very short period. Given limited manpower this would be difficult. This work should be concentrated only if there is a period in which very little fishing takes place. The regularity with which post-trip interviews and landings surveys are conducted should not be interrupted if there is no period of greatly diminished fishing activity.

Fixed costs can be divided into two groups: cash payments for services independent of the amount of fishing activity (such as mooring and protection fees, cooperative membership fees, accounting and legal expenses) and those related to the use of capital such as interest costs - also a cash payment - and depreciation - an accounting cost. For most of these costs the annual amounts are calculated from responses to questions about weekly, monthly or quarterly payments.

Under this broad category of fixed costs will be several other closely related variables which are relevant to the fisherman's cash flow situation and important in the consideration of investment projects. For example, questions about indebtedness, the amount (value) of capital equipment in the fishery, and the durability of boats, motors and gear will be included. The proper setting for collecting these data is one in which there is adequate time for the interview and an acceptable level of privacy for the respondent. These interviews can be combined with others aimed at gathering either sociocultural data and/or more detailed data on fishing methods. The questions require no training on the part of the recorder in matters of business or economics.

One should first ask questions about fees such as the amount and frequency of mooring and protection fees, cooperative fees and so on, and then begin the discussion of investments and capital equipment. For each piece of capital equipment, a *description* of the item is needed. This description should be as detailed as possible: the hull should be described by length, width, draft, capacity of the hold and construction material; the motor by brand name, horsepower, type of fuel used, etc.; and the gear by its material, dimensions, and so on. Record information on the age of the item, when it was bought by the fisherman, age when it was bought and his estimate of remaining working life. Follow this with questions about the item's historical and present value. One needs to determine the price of the item when it was purchased, the price he would sell it for now, and his estimate of the price of a *new* replacement identical in characteristics to the one he now owns. Determine whether he has made a *major* reinvestment in the item such as lengthening the boat, replacing the deck, adding new superstructure, etc., and the approximate date and cost of these renovations.

For major items such as the hull and motor, one should obtain estimates outside of the interview of the perceived present value. Local merchants or other fishermen should be interviewed concerning recent sales of similar items in that location.

Depreciation costs can be determined from the data above. These involve calculations which require some expertise, and will depend on the purpose of the analysis. There are several ways of calculating depreciation costs for any capital asset. A private cost can be calculated based upon the original puchase price and some standard depreciation methods such as the straightline or the declining balance method. Assets such as hulls and motors depreciate at different rates in part because they have different life expectancies.

Regardless of how the assets of the individual fisherman are depreciated, he must face market (current value) prices in replacing them. The current value of a boat depends on several factors including those which are used in calculating the private depreciation cost, i.e., its initial value, present condition and age. However, the current market value is also influenced by the general rate of inflation and what economists call the value of the marginal product of capital. This last factor is influenced by the state of the fish resource and this, in turn, by the supply of boats. Consequently, one should not be surprised to find that the current value of the boat and motor and perhaps of the gear, is in fact, greater than the original cost of the item. A portion of this larger amount may result from improvements in the item. To discount this effect, questions on reinvestments have been included. Without going into this further, one can see that it is worthwhile to get several opinions on the current value of the boat — aside from the one given by the fisherman himself (what he says he would sell for now).

Interest costs are cash amounts paid for the use of another's money capital in order to purchase capital goods such as the boat, motor and gear. As with depreciation costs these calculations require some expertise. To determine capital costs the following should be recorded for each capital item: whether a loan was involved in purchasing the item; when the loan was made (as precisely as possible); who, or what type of lender supplied the money e.g., family, middleman, a money lender, a bank, etc.; what the *stated* amount of the loan was; how much was *actually* received; the *stated* interest rate; the duration of the loan or how many payments are yet to be made; the frequency of payments (weekly or monthly); the part of the payment which represents repayment of principal; that part which is repayment of interest; whether these proportions are changing over time and how; whether the periodic payment is increasing or decreasing in size; the collateral used for the loan, if any, and its nature and value.

The private interest rate quoted by the fisherman may or may not correspond to the rate he is, in fact, paying. The market rate quoted by banks, while reflecting a risk premium, is usually standardized in that it is based on the nominal amount of the loan and holds for specific periods of time. The rate quoted by the fisherman may be lower than the bank rate and this, in turn, may be lower than the rate the fisherman is actually paying. His interest costs for the first year includes the (one time) difference between the nominal amount of the loan and the amount actually received plus the interest part of his regular payments.

Up until now, the private costs discussed have been less than market costs. In the case of interest, the true private cost is very likely greater than the market cost (the bank rate). It may be that fishermen do not have access to this regular lending market for a variety of reasons. If this is so we should use *our* calculation of the cost of borrowing (which is based on the rates they actually pay) for any analyses particular to the fishery.

4.3.6 Industrial Fishery Data

The industrial fleet is guided by the same set of economic forces which affect the artisanal fleet. However, the capital investment per firm is much greater in the former and, consequently, the opportunity cost of an industrial fishing venture is dominated by the alternate uses of this capital. The same kinds of biological, physical and economic data which describe small-scale fishery operations also describe the operations in the industrial fishery. The major difference, from the viewpoint of data collection, is that a greater percentage of most kinds of data is recorded by individual companies. For a thorough analysis of the industrial fishery, the same economic, biological and physical data need to be collected as are recommended for the artisanal fishery.

We will concern ourselves here with the interaction of the two fleets. This interaction can take place in the input market, at any place in the output market and in the fishing process itself. The impact on the artisanal fleet of participation by the industrial fleet in the input market can be both positive and negative. The kinds and amounts of inputs available to the artisanal fleet may increase because of the emergence of an industrial fishery. We can include in this the amount of infrastructure (ports, piers, etc.) and newer fishing technologies. On the other hand the prices of certain inputs such as fuel, ice and money may rise if the amounts supplied do not keep up with the joint demand.

In the output market — from the primary buyer through the retail level — large firms may supply their target species or by-catch to compete directly (same product) with the output of the artisanal fleet. This will depress prices to the artisanal fishermen if demand does not keep pace with the joint supply. An increased supply of substitutes for the small-scale fishery's output such as canned tuna or mackerel would also depress fresh fish prices — causing an outward shift rather than a rotation of the supply curve. On the other hand the industrial fishery may open opportunities for processing fish from the artisanal fleet, for creating export markets into which their supplies can be funneled or for creating an entirely new artisanal enterprise such as supplying baitfish to the industrial fleet.

In the catching phase the two fleets may be exploiting the same unit stocks of fish or different life stages of the same species (this production interaction works both ways, of course). The social resource cost is the amount and value of fish killed in the operation of the two fleets. There may also be gear conflicts or simply crowding on the fishing grounds.

We should be able to identify, in a general way, points of cooperation or conflict fairly easily by simple observation and discussions with key informants such as experienced fishermen, input suppliers and others in the delivery system. A detailed study of the effects of competition in any of the markets requires, ideally, a compatible time series of data on prices and on the amounts supplied or demanded by both groups. Commercial classifications of fish (not species) are required for an analysis of supply and demand in the output market.

Regardless of where the industrial catch or by-catch enters the delivery system, the impact of the increased supply will be reflected in prices paid to the artisanal fisherman at the primary buyer level. If a small scale fishery data collection scheme is in existence, the quantities supplied by the artisanal fleet and the prices will be known. What is lacking then is an estimate of quantities supplied by the industrial fleet. The obvious source of this data is the industry itself or, if a receipt system is in existence, the purchasers of their output. Any measure of the quantities supplied by the industrial fleet in a period of time is better than none. In several Central American countries, receipts from purchasers of the highly valued target species of the larger boats included space for a crude breakdown of the incidental catch sold. Likewise, trip reports made available to the fisheries office included amounts of by-catch landed (but not all that was killed).

If there is fleet interaction in harvesting it is imperative to attempt to get detailed data on both the quantity and species breakdown of the industrial catch. Otherwise, stock estimates or estimates of sustainable yield based on artisanal data alone are much less reliable, perhaps even useless, in bioeconomic analyses. The commercial fleet will, in all likelihood, keep fairly detailed records of locations fished, actual trawl times, etc., — several of the determinants of effort. The quantity and value of fish killed will, in most instances, be much greater than that landed and this greater than the amount sold. Sea sampling will be required in order to begin to estimate the amount and composition of fish killed and, therefore, not available to society nor the artisanal fleet.

The tools of project analysis are useful in evaluating the damage or good caused by fleet interactions. It is unlikely that any absolute decision can be made in favor of one fleet or the other since society and consumers are involved in the benefits and in the costs of the joint operation of the fleets. Any analysis must weigh, for example, reduced costs to consumers, employment impacts on the fishermen, increased or decreased long run catches, etc. Once again, economic analysis provides a backdrop against which essentially political decisions can be made.

Chapter V

DATA COLLECTION METHODS

5.1 INTRODUCTION

The purpose of this chapter is to describe methods and procedures which can be used to collect the data which were described in Chapter IV.

The required data can be obtained using six basic techniques: 1) examination of available records, publications or other written material, 2) key informant interviews, 3) census surveys, 4) sales receipts, 5) sample surveys and 6) research activities. Following a brief, general description of each of these techniques and a discussion of interviewing methods, specific data collection methods which generate biological, economic, and sociocultural data will be examined separately.

5.1.1 Written Records

Where possible, all available written records should be reviewed before any data are collected. Frequently, written materials exist, but can be located only after interviewing key informants (see section 5.3). These materials include reports completed by outside agencies, studies done by local University staff or students and statistics such as historical catch and effort data compiled by the national or regional fishery offices. In addition to data collected by previous researchers, development agencies, or fisheries offices, one may also find useful information in church or government censuses, local histories, newspaper files, records kept by wholesalers and retailers, records of fishing licenses or boat registrations, tax records or records of equipment sales and imports.

Attempts should be made to determine the reliability of all written records. Sometimes inadequate data collection methods have been used, sometimes statistics were inflated for political ends and sometimes observations were biased by the attitudes and values of the observers. If written materials are reliable, they can be used to check the validity of statements made by key informants. Detailed and accurate studies are not common, but if any exist, they should be located and used as long as their reliability can be verified.

5.1.2 Key Informant Interviews

This type of data collection technique involves intensive, detailed interviews with individuals who are selected because they can provide extensive, reliable information. For example, a great deal of important information concerning fishing activities can be obtained from a few, well informed local fishermen, shop keepers and fish merchants. Additional sociocultural data can often be obtained from religious or government officials who keep records on births, deaths and commercial establishments. As noted above, key informants can also be useful in identifying sources of written records. Finally, key informants provide information which can be used to develop questions that should be included in more structured sample surveys and interviews.

Identification of key informants is an important task which may require several weeks of preliminary research in the community by a competent social scientist, but the improved reliability of the data which are obtained will more than compensate for the costs of the research. It must be remembered, however, that key informants base their responses on their own experiences and that those experiences may not be shared by other members of the community. It is important, therefore, to gather information from several key informants and to be wary of information which is not confirmed by all those interviewed. Use of a sample survey provides an opportunity to obtain quantitative data which can be used to estimate the variability of information obtained from key informants.

5.1.3 Census Surveys

A census is designed to determine the total number of a variety of different units in the fishery such as landing sites, boats, fishermen, primary buyers or fishing gear. A census is limited to the enumeration of items which can be observed and counted at a particular point in time. It requires periodic up-dating as the number and mix of units change. Census (or frame) surveys provide information which can be used to design sample surveys. Sales receipts, if used extensively, can be viewed as a continuous census of fishing activity. For a more complete description of different types of census surveys, the methods which can be used to conduct them, and subsequent catch assessment surveys, see Bazigos (1974) and Banerji (1974).

When conducting a census, some attempt should be made to distinguish between 1) boats or gear which are actually in use versus those which are not, 2) part-time and full-time fisherman, 3) dealers who buy and sell large and small volumes of fish, and 4) important and not so important landing sites. Ideally, each landing site should be evaluated in terms of how much fish is landed, the principal species harvested, the types of gear used, how many boats normally land fish there, the number of buyers who purchase fish, distances from markets, communications and roads, facilities for holding fish, service facilities for boats and gear, etc. Similar information could also be compiled for fishing communities and include demographic information about the fishermen (ages, education, years of experience, other occupations, etc.), their families, and other members of the community.[1] In cases where it is not feasible to visit individual sites by road, data can be collected by using aerial photographs or boats. For a complete description of census methods, the reader is referred to the comprehensive manual by Bazigos (1974).

5.1.4 Sales Receipts

The quantity and ex-vessel value of fish which is sold to primary dealers are often recorded on sales receipts which are completed when fish are weighed and the fishermen are paid. Receipts are sometimes filled out by government officials for the purpose of assessing taxes. If they are used to record all (or most) transactions they can provide continuous direct estimates of total catch and effort and can be used as frame surveys for designing random sample surveys of individual landings. The most basic receipts will give estimates of total landed catch and revenue during a given period of time as long as estimates of the amount of landed fish which is not recorded and the number of receipts which are not collected are available.

Landings may be recorded by weight, volume or even number and are usually reported by price category. The ex-vessel value reflects the landed weight, number or volume times the price per unit weight, number or volume for each category and is summed over all categories to give the total value of the fish which is sold to the dealer. Since each receipt represents a single transaction, direct estimates of nominal fishing effort are only possible if it can be assumed that each transaction represents a single fishing trip by a particular kind of vessel.

The revenue represented by a receipt is the amount of money which is generated when fish are sold to primary dealers and should not be confused with the total value of the catch. Neither should the quantity of fish landed and sold be confused with the quantity which is caught at sea. Corrections must be made in order to infer catch or revenue data from landings data (see sections 4.3.4.2 and 5.2.2.1 (c)).

Additional information about the type of vessel or gear used can sometimes be deduced by examining which species were caught, and the name of the fisherman (or vessel). In the case of mixed-gear, small-scale fisheries; however, it may be difficult to distinguish catch, effort and revenue statistics for individual types of gear. It is sometimes helpful to know the location where the fish was landed, and the name of the buyer who purchased it.

Sales receipts can be designed so that much more information is obtained. Depending upon the degree of cooperation which can be expected from the dealers and the fishermen, a number of items — most of which relate to nominal fishing effort — can be added. These will be very helpful in the designing of biological and economic sample surveys. The most important items are 1)

[1] In practice, demographic surveys are extremely time consuming and expensive, especially if there are many remote communities which must be visited or if the fishermen do not live in permanent locations. Sample surveys are recommended as a preferable method for obtaining sociocultural information.

a receipt number, 2) the gear-type used, 3) the number of people fishing, and 4) the trip length (days or hours). Only one of these (trip length) requires questioning the fisherman. Additional important items which may be included but which may be more difficult to obtain are 6) the zone or area fished, 7) the home port of the boat, and 8) the name of the boat owner.

Several incentives can be [illegible] to encourage the cooperation of the primary buyers. For example, receipts may be designed, printed and supplied to the primary buyers by the fishery department. In Costa Rica, multiple copy (3-4) receipts in serial order were provided by the government for a one year period. The design, approved by several primary buyers, elicited a very high degree of cooperation.

5.1.5 Sample Surveys

Sample surveys are useful in situations where reliable estimates of total harvesting activity (catch, revenue, costs, effort) or sociocultural characteristics of the participants (dealers, fishermen) cannot be obtained by complete enumeration without spending considerable time or money.

Sample surveys are most often conducted according to the principle of randomization, a process by which observations are randomly drawn from a "universe" of all possible observations. The probability of selecting any single observation should be equal to the probability of selecting any other; the objective is to use sample data to estimate the real value of properties (such as means and variances) of the population of all possible observations. The reliability of sample data is evaluated statistically on the basis of the freedom from bias and the precision of the data. A biased estimate represents some subset of the observations in the population more heavily than another (for example, big fish rather than small fish, or successful fishermen rather than unsuccessful ones). Precision is a measure of the accuracy of the estimate, i.e. the degree of similarity between the sample estimate and the corresponding population parameter. Biased estimates may be precise, but they are not reliable. Precision increases as more samples are taken, but increased sampling effort will not necessarily eliminate or reduce bias. Precision can also be increased by dividing the sampling units into individual strata (e.g., landing sites within separate geographic areas) and estimating a pooled mean and variance for the entire population from means and variances of individual strata.

Three common types of sample surveys described in this guide are 1) landings surveys for biological and economic data, 2) surveys of fishermen for sociocultural and economic data, and 3) catch surveys. Data collected when fish are landed (unloaded from a boat) and sold to primary dealers are based on information gathered from examining the fish themselves (such as their size, species identification, and numbers), questions asked of fishermen and the buyers (fishing location, prices of fish, costs of operation) and observations of gear, time of day, etc. made by the interviewer.[2] These data are used primarily for resource assessment purposes and variable cost and returns analysis. Sociocultural and economic fixed cost data are collected from interviews of randomly selected fishermen. These interviews do not have to be conducted at the same time fish are sold since the anthropologist/sociologist is more interested in aspects of human behavior which affect the harvesting process, and the economist is interested in costs not related to the landing. Surveys of fishermen can, therefore, be conducted at any time to generate economic, sociocultural, and biological data, and be integrated.

Catch surveys are designed to provide important information for resource assessment purposes. Two major types of catch survey are 1) sampling aboard commercial fishing vessels and 2) exploratory fishing surveys. Because exploratory fishing surveys are usually carried out with gear such as bottom trawls which can not be used in many small-scale fishing habitats, and because trawl survey methods have been thoroughly described in other sources, exploratory fishing techniques will not be considered in this guide (see section 3.2.4.4).

Sample surveys should be designed so that they are relevant to location conditions, brief and easily administered.[3] A relatively small preliminary survey of five or ten respondents or landings will usually allow one to estimate how long it will take to complete each interview and to evaluate the appropriateness of each item on the data form. Key informants can often provide val-

[2] In some cases, of course, fish may not be delivered by boat. We will, nevertheless, refer to all deliveries to primary dealers as "landings."

[3] It makes no sense, for example, to ask questions which refer to shell fishing in the community if shellfish are not harvested or used by the local population.

uable advice during the pre-survey trial period.

Experiences in numerous small-scale fishing communities have indicated that interviews in excess of half-an-hour are not well received. If an interview takes more than half-an-hour to administer, it may be preferable to divide it into two parts or to ask certain sets of questions only occasionally to randomly selected respondents. Use of a brief interview is especially important when fishermen have just arrived from a fishing trip and do not want to be delayed. There is also a limit to how long fish can be held for biological data collection before they must be iced or, sometimes, before they are sold and taken away.

A number of factors must be considered when designing random landings surveys to obtain biological and economic data. In general, the biologist focuses on the landing as an opportunity to obtain information about the resource and the nature of its response to fishing pressure whereas the economist uses the landing as an opportunity to obtain economic information about the firm (individual fisherman or boat/gear combination) and its production activity. Biologists may be more concerned with compiling catch and effort data for certain species or unit stocks and may therefore randomize sampling effort over a slightly different set of landings — ones which are most likely to include the species of interest. Economists, who are also concerned with catch and effort data, will randomize their sampling effort over all landings. The objective, however, is the same in either case — to design a sampling procedure which will distribute sampling effort in proportion to the actual distribution of a sampling unit as determined from sales receipts or a census survey.[4] To the degree that biologists and economists are interested in the same variables, the same randomization procedure can be followed when designing and implementing a random landings survey (see Chapter VI).

In order to conduct sociocultural surveys of fishermen or owners of fishing equipment and vessels, respondents must be selected randomly from lists of names. Lists of fishermen and/or owners of equipment can be obtained from census data. For example, in some Catholic countries, the local parish keeps a list of all church members along with their occupation. A random sample can be drawn from such a list if it can be assumed that nearly everyone belongs to the church. Lists of households compiled by local governments for taxation or other purposes can also be useful. These lists must be checked for accuracy before using them for sampling purposes.

In cases where it is impossible to develop lists of fishermen without considerable effort, a quota sampling procedure may be preferable. In this procedure, all landing sites are visited and all small-scale fishermen (captains and crew) who are landing fish, working on their boats or simply visiting the site during the time when the interviewer(s) is (are) at the site can be interviewed. The interviewer should travel from point to point starting at a different site each morning so that interviews at the various sites will be distributed throughout the day. This system eliminates possible systematic bias caused by the landings of fish at any given site during a particular time of day.

The randomization of the sample survey for economic fixed cost data is based upon the major factor affecting the biological, physical, economic and sociocultural nature of the production process — the boat/gear combination (firm type). The set of firm types will overlap with the set of fisherman to be interviewed for sociocultural data just as a large percentage of the landings will be common to post-trip interviews and landings surveys, especially those which are designed to produce catch and effort data.

5.1.6 Research Activities

Research may be necessary to provide some of the background data necessary to describe resource habitats and ecosystems (see section 4.1.1) and for providing the vital statistics necessary for assessing and managing resources by means of dynamic pool models. The research activities and analyses which are referred to in this chapter generate estimates of growth and mortality rates and have been limited to fairly simple techniques such as tag and recapture studies, the analysis of growth rings on scales and otoliths, and the analysis of size frequency data. These techniques may require some degree of expertise and experience and are more time consuming than data collection efforts which are designed to generate a

[4] A sampling unit forms the basis for the sampling process: it may be a landing site, an individual boat at a landing site or an individual landing itself. A frame survey is a list of all sampling units from which a set of sampling units could be selected.

time series of catch and effort data. In situations where reliable catch and effort data cannot be easily obtained and exploratory fishing surveys are not feasible, these research activities may be the best source of resource assessment data.

5.1.7 The Interviews

One point that must be emphasized is the fact that not everyone can function as an effective interviewer. The selection, training and supervision of interviewers is a crucial aspect of any data collection program. Decisions based upon information generated from inadequate data or data which have been improperly collected can have negative impacts on the entire fishery. It is therefore important that careful attention be paid to all aspects of the interview process.

The best data are collected by mature, poised, and well-motivated interviewers who can establish some degree of rapport with the respondents. It is therefore necessary that the interviewer respect the respondents and be sensitive to social or cultural barriers which impede the collection of reliable data. Frequently, interviewers project an image of superiority which makes it difficult, if not impossible, to establish the type of relationship which makes it possible to obtain reliable data. If the respondent feels that the interviewer is treating him as an inferior of if he feels that the interviewer considers that data to be of little value, he will not make an effort to provide good information, and in some cases may even mislead the interviewer.

When training interviewers, it is important to provide a good description of the nature and significance of the data which will be collected. The interviewer should understand how the data will be used to make policy decisions which will affect the welfare of many people. If the interviewer understands the importance of the interview, he can pass the information along to his informants. The sharing of this information can result in the more willing cooperation of the informants.

Many of the problems encountered by interviewers occur during the first few interviews; hence, it is necessary to continue training sessions into the first stages of the interviewing process or to conduct presurvey trial interviews before compiling any interview data. Supervisors should examine initial interviews for inconsistent and/or inadequate data. Problems encountered in interviewing should be discussed with the interviewers so they will be aware that conducting good interviews is a difficult process that must be learned, and that a good interviewer is a valuable person. If the interviewers are advised that it is quite common for some informants to either mislead them or refuse to talk to them, they will be more likely to mention these problems during the review sessions, and the supervisor can then help develop strategies to minimize or eliminate these problems.

Interviewers need to be supervised. If the interview results are analyzed during a preliminary trial period as suggested above, the interviewers will know that their work will be reviewed. This kind of supervision helps discourage the falsification of data. Periodic, unannounced visits at interviewing sites or visits with informants after interviews have been completed are key elements of supervising activity.

5.2 BIOLOGICAL/ECOLOGICAL DATA COLLECTION METHODS

5.2.1 Habitat/Ecosystem Data

5.2.1.1 Biological/Ecological Inventory

Much of the data needed for an inventory of the more important exploited and underutilized species can often be obtained from published reports for these same species or for other closely related species. Since the collection of new biological/ecological data requires laboratory and field studies which can be expensive and time-consuming, first priority should be given to the retrieval of information from published sources.[5]

The first step which must be taken in preparing an inventory is an identification of the species which are harvested. Species identification must be based on accepted international nonmenclature, i.e. scientific names rather than common names. Identification requires the use of taxonomic keys and must be performed by competent biologists who are familiar with the technical terms used in describing the morphological characteristics of fish. Once a list of scientific names has been compiled, it should be cross-referenced with a list of common names thus facilitating the collection of

[5] An excellent series of resource inventories have been published recently by the United Nations Food and Agriculture Organization (see Fischer, 1978 for example).

species-specific biological and economic data from fishermen and dealers. Ideally, a reference collection of preserved fish should be maintained for identification purposes.

5.2.1.2 Extent of Fishing Grounds

An inventory of grounds where fish are or could be harvested can be compiled by examining bathymetric navigational charts. Calculations of area for fishing grounds on continental shelves, reefs or offshore banks can be made with a planimeter. Some information on bottom type is usually printed on these charts as well. Information concerning the gear types which are used to harvest certain species or groups of species in certain habitats can be obtained from fishermen or other key informants.

5.2.1.3 Production Rates and Ecosystem Dynamics

As much information as possible should be obtained from existing sources since research is time consuming and expensive. A rough evaluation of the relative importance of different sources of primary production can be based on an examination of coastal navigational charts which indicate depth, bottom types, the extent of reefs and mangrove swamps and the number and size of rivers, bays and estuaries along the coast. Reasonable estimates of average annual primary production can sometimes be obtained either from published reports (see FAO, 1972, for example) or by direct measurement. Several guides to field techniques are also available (Vollenweider, 1969; U.S. National Academy of Sciences, 1969). It is not difficult to measure primary production — the problem is that production rates vary considerably over time and from place to place. Thus, reliable estimates require use of a standardized technique and multiple measurements.

Feeding habits studies require the examination of fish stomachs collected during research surveys or from fishing vessels. Stomach content analysis should be quantitative at least to the extent of determining the relative frequency of occurrence of major prey taxa (for example, polychaetes, fish or crustaceans). The more specific the taxonomic identifications are, the more readily can the detailed feeding relationships within the ecosystem be defined. Methodologies which should be followed in stomach contents analyses were reviewed by Hyslop (1980). Once the ecological roles of individual species within the ecosystem are known, it may be possible to predict that the harvest of a particular prey species will reduce the growth and/or survival of a predator while the harvest of a particular predator species will increase the growth and/or survival of certain prey species.[6]

Since the feeding habits of fishes depend on the relative availability of different prey organisms and the feeding behavior of the predator at any particular point in time, attention should focus on the collection of qualitative data which simply indicate the major sources of food which the principal commercial species in the fishery depend upon at different times of year and, if applicable, at different ages. This information can be collected by observing and recording stomach contents or, frequently, by referring to published reports. Many of the illustrated field guides to the fishes of major regions of the world's oceans include information on major food organisms.

5.2.1.4 Hydrographic Data

Data on freshwater runoff for major rivers are often collected and published by international organizations or national agencies responsible for water resource management. Information on currents and tides is regularly published for use in coastal navigation (see U.S. Department of Commerce). Additional information on currents and upwellings is sometimes available in publications of oceanographic research.

5.2.1.5 Other Physical/Chemical Data

Since the development of empirical models which relate yield to some set of environmental variables would be largely an exploratory exercise, it is impossible to predict what kinds of data would be required. Collection of new data requires that environmental variables be monitored for at least a year. Efforts should first be made to utilize data such as productivity rates, areas of continental shelf within a certain depth range, temperature or salinity which are already available either to generate empirical yield functions or to provide general background information which describes habitat and ecosystem characteristics.

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[6] In reality, predator-prey dynamics are more complicated than this. Some predators, for instance, are much more specific in their dietary preferences than others while others easily switch from one prey to another, depending on the relative abundance of prey organisms.

5.2.2 Stock Assessment Data

5.2.2.1 Catch and Effort Data

5.2.2.1(a) Sales Receipts

Data which are usually recorded on even the crudest type of sales receipt when fish are purchased from the fishermen include 1) how much fish was sold, 2) when and where the transaction took place, 3) the names of the buyer and seller, 4) the unit price and landed value of the fish which was sold for individual price categories, and 5) the total value of the catch which is sold to the dealer. Additional data which may be recorded include the type of vessel or gear which was used, the number of fishermen who were aboard the vessel (or who caught the fish, if no vessel was used) and the general location where the fish was caught. Some of this information can sometimes be deduced by knowing when and where the fish was sold. All of these data, except price and value information, are useful for stock assessment purposes.

The quantity of fish which is sold during any single transaction may be recorded by weight, volume or even numbers. Since most resource assessment techniques are based on biomass estimates, landings data which is reported in units of volume or numbers have to be converted into units of weight (usually kilograms). In addition, the quantity of landed fish is usually recorded by price categories which include all species and sizes of fish of the same price at the time the transaction was made. The species which are included in any given price category at any particular time change as a result of price changes for individual species (or sizes). Because price can be a function of size as well as species, it is not uncommon for smaller individuals of the same species to be included in one price category and larger individuals in another. These groupings usually have no biological significance, i.e. they include fish of different species which share no common biological or ecological characteristic and which cannot, therefore, be considered to belong to a single unit stock (see section 3.2.2). Thus, in order to extract useful stock assessment data from sales receipts, conversions must be made to obtain landed weight data by species or species groups. These conversions require some information on the average weight of a given volume or number of fish and the species composition of different price categories.

Weight/volume conversions can be obtained fairly easily by calculating the average weight of a series of samples of known volume; weight/number conversions depend on the size distribution of the fish which are sold for a given price and therefore must be established for individual sizes or size groups. These conversion factors should be estimated from commercial catch samples collected at different times of year since the average weight of a given volume or number of fish of the same length may change during the course of the year.[7] Similarly, species composition data should be obtained from landings surveys which are repeated periodically during an entire year since the species mix in each price category can be expected to change as the availability of different species and their market value changes. For fisheries which harvest only one or a few species, landed weight data can be utilized directly for stock assessment purposes without landings survey estimates of species composition as long as each species has a unique unit price. Since most tropical small-scale fisheries harvest a variety of species, some random sampling of landings will be necessary to even get a rough estimate of species composition.

Once landings data are available by species or species groups on a weight basis, they should be converted to catch data by estimating the quantities which are captured, but not sold to primary dealers. This can be accomplished by estimating post-harvest losses which take place at sea (see section 5.2.2.1 [c]) or after the fish are landed (section 5.2.2.1 [b]). The most significant kinds of post-harvest loss in tropical small-scale fisheries are likely to be spoilage and fish which never reaches the primary dealer because it is taken home and consumed by the crew and their families, given away, or sold to someone else. Another important source of error when compiling catch data from sales receipts (or landings surveys) is fish which the fishermen are given or which they purchase from larger vessels such as shrimp trawlers. In practice, it may only be possible to make rough approximations of how much fish is caught, but not reported on sales receipts (or reported, but not caught). Stock assessements are frequently performed with uncorrected landings data.

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[7] These changes may reflect the development of reproductive tissue during the spawning season, for instance, or the fact that fish are more likely to have full stomachs when food is plentiful. Estimates of landed catch (weight) from volume or number data are much more straightforward if fish are gutted before sale.

Effort estimates obtained from sales receipts are usually crudely expressed in terms of the number of trips if it can be assumed that each transaction represents the sale of fish caught during a single fishing trip (see section 5.1.3). Again, information obtained during landings surveys may help to identify which kinds of fishing activity — defined in terms of gear type, species captured, fishing location or time of year — could be expected to violate this assumption and provide data necessary to estimate the average number of trips associated with a single transaction or the average number of hours or days associated with a single trip. Such refinements in fishing effort estimates are extremely important for making preliminary or quantitative stock assessments and permit a much greater utilization of sales receipt data.

Catch and effort data obtained from sales receipts should be compiled, as much as possible, for individual types of fisheries. Although stock assessments may, in fact, be performed by combining catch and effort data for different gear and vessel types, it is equally possible that the resources harvested by the gill net fishery, for instance, will be evaluated independently of the resources harvested by the handline fishery. For this reason, therefore, any additional information which reveals what type of gear or vessel was used is extremely valuable. By the same token, information which can be used to determine even the general location of the fishing grounds where the catch was harvested is very useful for unit stock assessments. Such information may be deduced by knowing where the transaction took place, an item which is usually recorded on the receipt.

Finally, knowing the date when each transaction takes place is crucial since catch and effort statistics must be compiled for certain periods of time (months, years) in order to reveal trends in catch per unit effort (an indicator of resource availability) over time as effort changes. The compilation of a time series of annual catch and effort data requires that changes in the capture efficiency of a given fishing technique be incorporated into annual estimates of fishing effort. Techniques for standardizing effort have been developed for some of the more common large-scale types of fishing operations, but not for most small-scale fisheries. Standardization procedures may be developed only when it is known what technological factors affect capture efficiency and when information exists which reveals historical changes which have taken place in these factors over time.[8]

Despite the problems which are involved in obtaining catch and effort data from sales receipts which are useful for stock assessment purposes, receipts offer a unique opportunity to directly estimate total catch and effort. If the data are complete and reliable, there is no need to rely on extrapolations of total catch and effort based on landings surveys which may not be truly random and which may only sample a small proportion of all landings. Implementation of a comprehensive procedure for collecting standardized sales receipts should therefore be the first priority of any effort to monitor the activity of a small-scale fishery which delivers the majority of its harvest to dealers who routinely keep some kind of records or who can be encouraged to do so. In situations where sales receipts can not be relied on to provide reliable estimates of total catch and effort, they must be estimated from landings surveys.

5.2.2.1(b) Landings Surveys

Landings surveys provide both complementary information for improving catch and effort data obtained from sales receipts and primary data for stock assessment purposes when sales receipts are not available. They are conducted by trained observers who record data as fish are delivered for sale to a primary buyer. Deliveries are usually made when the fish is "landed" by the fishermen, i.e. when the fishing boats are unloaded at the landing site and the fish is weighed and sold. Data are recorded by interviewing the fishermen and the buyer, weighing all the fish of any given species (or species group) which are landed, and making observations. The need to identify each fish requires that landings surveys be conducted by people who can easily recognize different species.

Ideally, the landed weight should be recorded by species within price categories. This rule should certainly be followed for the principal species in the fishery, i.e. those which account for the bulk of the landed catch and its value. If there are a great

[8] For example, if monofilament gill nets are known to be twice as effective as multifilament nets, standardization would require information on the relative number of nets used in the fishery which were made from both materials during each year when effort data were available.

many species within any given price category which are morphologically similar and difficult to distinguish from each other, those which are caught in small quantities can be weighed together and identified by genus or even family, rather than species. The weighing process can be time consuming if large numbers of fish are landed or if they are not easy to identify; care should be taken not to impede the buyer's efforts to sell the fish or to process them in order to prevent spoilage. In these situations, data can be collected rapidly by weighing a randomly selected subsample of each price category, being careful not to bias the sample by selecting large fish or particular species in preference to others (see Gulland, 1966 for a description of techniques for sampling large quantities of fish).

Valuable data are also obtained from the fishermen. The most important data which the fishermen provide are estimates of fishing effort. Effort estimates require some knowledge of the amount of time that was devoted to catching the fish which are being sold and a description of certain characteristics which affect the capture efficiency of the gear which was used. A summary of fishing effort estimates for some common small-scale fishing gears is presented in Table 1 (Chapter IV). Fishing time is usually estimated as the time the gear was actually in the water. Some important fishing power estimates are net size (length x width), number of fishermen, and numbers of gear units (pots, hooks) fished during a particular trip. These data are obtained by asking the fishermen several simple questions such as "how long did you fish," "what gear did you use," "how many (nets, pots, lines, hooks) do you use," and "what is the size of your gear?" If the fishermen are willing, these data can often be obtained (or verified) by examining the gear when the fish are landed. Examples of questions which were included on a landings survey form which was designed to generate catch and effort data from a small-scale fishery which was conducted primarily with gill nets, handlines and longlines is presented in Appendix C.

Additional information concerning the location of the fishing ground(s) which was (were) visited during any single trip should also be collected during landings surveys since it can be important for defining which resources or unit stocks were harvested. Although fishermen do not willingly reveal exact locations of favorite fishing grounds, this information can be obtained by dividing the entire area which is fished into fairly large areas. The compilation of catch and effort data by location is more critical when effort is dispersed over a large area or when unit stocks occupy small areas.

A great deal of useful information can also be obtained by simply counting the number of fishermen aboard the vessel and by noting the type of vessel and gear, how much of the landed catch is sold to the dealer and how much is given away, taken home by the fishermen, or discarded because it has spoiled. An important clue which helps in identifying the fishing location is the direction which the vessel comes from as it approaches the landing site.

A significant problem which impedes data collection when using sales receipts or a landing survey is that the fish which are landed on any single occasion sometimes are not caught on a single fishing trip nor with a single type of gear nor even by the fishermen who are aboard the vessel. The vessel may simply be delivering fish which were caught by a number of different fishermen on a number of different fishing trips. On such occasions, valid catch and effort data may sometimes be estimated if each fisherman's catch is weighed and sold separately and if the fishermen who are delivering the fish can recall approximately how much time each fisherman spent fishing, where he was fishing and what gear he used. In any case, it is up to the interviewer to record as much information as possible and to decide how reliable it is.

Since only a proportion of the total number of landings (or boats) is sampled, landings surveys must be designed to account for the spatial and temporal distribution of fishing effort and to randomly sample the full range of fishing activities which affect the catch rates of individual unit stocks. Factors which should be considered when designing random landings surveys for stock assessment purposes include the fishing location, the landing site, gear and vessel types which are used in the harvesting process and time considerations such as the time of year and the state of the monthly or annual tidal cycle. All of these factors can affect the abundance and availability of the resources and the relative success of the fishermen in capturing them. Landings surveys which allocate more or less sampling effort to a particular location, gear type, time of year or month can easily produce biased estimates of mean catch and effort for all locations, gear types, times of year or months.

In order to allocate sampling effort randomly, a primary sampling unit must be defined and an initial census (or frame survey) of sampling units carried out. The sampling unit should represent an element of fishing activity which can be easily quantified such as individual vessels, landings, or landings sites. A survey could be designed to randomly sample some proportion of all landings for different gear types. It would first require a census of the number of landings by gear type in all landing sites during some previous period of time so that sampling could be allocated representatively between landing sites for each gear type. Effective landings surveys can be designed if continuous information on total catch and effort by gear type, landing site, and time of year is available from sales receipts.

Frame surveys which are conducted at a given point in time must be periodically updated to account for changes which take place in the fishery. These changes could include an increase or decrease in the number of fishermen, vessels or units of gear or a shift in the distribution of landings by gear type among landing sites. Observations made during the landings survey itself can provide current information useful for updating static frame surveys and adjusting sampling strategies. In this mode, the sampling procedure is continually improved as new information becomes available and as conditions in the fishery change.

One of the most difficult variables to account for in designing a random sample survey of landings is the fishing location. Since samples are not obtained while boats are on the fishing grounds and since the distribution of landings in different sites along the coast does not necessarily reflect the distribution of effort between different fishing locations, the best solution would be to design a procedure for randomly sampling landings in which the same proportion of all the effort expended in each location per unit time is represented in each sampling period. In other words, fishing location should ideally be included in the definition of the sampling unit. This approach is not feasible unless repeated frame surveys could be performed which would permit the enumeration of vessels fishing in specific locations at particular points in time.[9] The size of these fishing locations would require some knowledge of individual unit stocks and the willingness of the fishermen to divulge information about specific fishing grounds when they are interviewed.

In practice, the logistical difficulties involved in conducting adequate frame surveys and the lack of sufficient biological information about the stocks which are harvested by most small-scale fisheries preclude the definition of sampling units which incorporate fishing location as a variable. Catch and effort data obtained from landings surveys which are randomized to account for the distribution of boats (or fishermen) and gear types by landing site should, however, still be compiled by fishing location. In the absence of adequate biological information, the definition of appropriate locations in most cases must be made on a purely geographical basis, although some attempt should be made to define locations in which most of the fishing effort is conducted by boats which deliver their catch to the same landing sites.

Landings surveys should be randomized to account for the number of boats which deliver fish to individual landing sites. Census surveys of the numbers of boats in use at each site or sales receipts which document numbers of landings made at each site per unit time can be used as frame surveys for drawing random samples. This information may be qualitative or quantitative (see Banerji, 1974); the more quantitative it is, the more precisely can the sample statistics (e.g. mean catch per boat) be estimated. Data collection procedures which generate catch and effort statistics for resource assessment purposes can be improved even further if sampling effort is allocated proportionally among boats (or landings) which use the same gear type since the type of gear which is used determines which species or stocks of fish are harvested. The allocation of sampling effort by gear type and landing site will also greatly improve the representation of different fishing locations in the sampling scheme since the fish harvested on certain grounds tend to primarily be caught with particular gear types and landed in particular locations. One of the problems which impedes randomization by gear type is that many boats use more than

[9] These surveys would have to be repeated frequently in order to account for changes in the spatial distribution of effort which take place over a very short time scale (months, weeks, or even days, depending on how specifically the locations are defined). The only practical method for conducting such surveys may be aerial photography; such a technique would be limited to day time fishing only.

one gear type over the course of the year or even during a single fishing trip. When this is the case, "mixed gear" elements must be included in the sampling scheme. By the same token, if two or more landing sites are close together and the same boats are just as likely to land fish at either site, the sampling unit should include a cluster of landing sites as a single data collection point.

Other important considerations are the duration and frequency of the landings survey. Sampling strategy depends to a large extent on whether or not total catch and effort can be reliably estimated for the entire fishery (and for individual gear types and unit stocks) from sales receipts. If sales receipts can not be relied upon to provide this information — either because a large percentage of the fish which is caught is not sold to primary dealers or because a significant proportion of the landed catch which is sold to dealers is not recorded — then landings surveys should be carried out on a continual basis in order to provide primary data for stock assessment purposes. One advantage of a continual survey is that sampling is spread out over a long period of time and need not be very frequent since short term precision of catch and effort estimates is not as important as long term trends. If sales receipts can be used, then landings surveys need to be conducted periodically in order to determine changes which may take place in the species composition of landings, the average number of hours or days spent fishing during each fishing trip and the characteristics of the gear which were used. Periodic surveys could be carried out, for example, by sampling frequently during short periods of time (such as fishing seasons) when patterns of fishing activity can be expected to remain more or less constant. These periods of intensive sampling should be repeated often enough and last long enough to detect changes in resource availability and harvesting activity which take place over time.

In either case (with or without sales receipts), it is important to know something about the temporal variability in resource abundance and availability in order to design random landings surveys which are not biased towards particular periods when catch rates for particular species may be above or below average. Important biotic factors which affect resource availability and the distribution of fishing effort include seasonal migratory patterns, spawning behavior, and the abundance and distribution of food organisms. Abiotic factors include seasonal changes in temperature, currents, and the amount of river runoff as well as short-term (monthly) changes in tidal currents.

Most of these events recur with a predictable frequency and can be factored into a random sampling strategy; many of them recur on an annual basis, but some recur over much shorter time periods (weeks or months). Changes in tidal amplitude and currents, for example, take place over a 28-day period and can exert a strong influence on the swimming and feeding behavior of fish (and therefore their susceptibility to capture with certain gear types), the performance of certain gear types and the distribution and amount of fishing effort. Given the importance of these short-term effects on landings, long-term (e.g. annual) sampling effort should ideally be distributed over different fishing seasons and short term (e.g. monthly) sampling effort should be distributed so as to reflect actual changes in the number and type of landings (as defined by gear and vessel type) in individual sites as a function of factors such as tidal amplitude. Even the time of day (or night) when fish are landed can be important if, for a given gear type and landing site, landings during one time of day represent a different set of activities (fishing locations, for example) than landings at another time of day.

There are a number of problems which often make it impossible to completely follow a randomized sampling procedure even when sufficient information is available to permit its design. The spatial distribution of sampling effort among individual landing sites requires either that interviewers remain stationary in a given site long enough to obtain the necessary samples or that a sampling schedule be devised which permits interviewers to move from one site to the next without completing all their samples in a given site during a particular time of year, time of month, or time of day. Since many small-scale fisheries are characterized by large numbers of remote landing sites which may be inaccessible at certain times of year, the design of random sampling procedures which can in fact be followed without considerable expenditures of time, manpower, and funds is a challenge (see Chapter VI). Another problem which must be confronted is the conflict between office working schedules and fishermen's schedules. It may be impossible to sample landings at night, early in the morning, or on the weekends unless non-government personnel are hired to do so.

5.2.2.1(c) Sea Sampling

Periodic observations made aboard small-scale fishing boats can provide some basis for estimating the types (species), sizes, and quantities of fish which are caught, but not landed.[10] These observations should include fish which are discarded at sea and fish which may be used for bait, consumed aboard the boat, spoiled, or sold before the catch is delivered to the primary dealer. If fish are gutted before they are landed, an estimate of the percent weight loss after gutting is necessary. If fish are discarded, some estimate of the proportion which do not survive should be made. If other fisheries (for example, trawl fisheries) are harvesting and discarding significant quantities of the same species which are captured by the small-scale fishery, some time should be spent aboard these vessels as well.

Sea sampling data can not be expected to provide very reliable estimates of how much fish is caught but not landed since catch rates are so variable and since the amount of fish caught during each trip is small. Sea sampling should only be carried out occasionally and the results should be complemented with landings survey data and data collected while conducting sociocultural surveys of fishermen.

5.2.2.2 Vital Statistics

5.2.2.2(a) Growth

A number of mathematical functions are used to express the growth history of fish. The most common is the von-Bertalanffy growth function (VBGF):

$$\ell_t = L_\infty(1-e^{-k(tc-to)})$$

This function may either be fitted directly to length (or weight) at age data or after mathematical transformations to various linear regression formulae (see Ricker, 1975 or Gulland 1969). Size at age data may be obtained from fish of known absolute or relative ages using a variety of techniques such as 1) tag and recapture studies, 2) analysis of growth rings on scales and other hard parts, and 3) the analysis of increments in size frequency data collected over a period of time. Some methods allow for the simultaneous estimation of maximum length (L_∞) based on length at age data. L_∞ may be converted to maximum weight (W_∞) if the length/weight relationship for the species in question is known. Maximum weight estimates rather than maximum length estimates are used in dynamic pool yield models.

5.2.2.2(a1) Tag and Recapture Studies

Growth increments during specified time periods can be calculated for individual fish which are measured at tagging and again at recapture after a known period at liberty. In this case, the growth coefficient (K) is estimated from the slope of the linear regression when Y equals the change in length during a given (constant) time interval and X equals length at tagging; the length at which the change in length is zero (the X-intercept) equals L_∞. When growth data from all fish returned during any number of short time intervals are used, K may be estimated from the slope and L_∞ from the X-intercept when the increment per unit time is plotted against initial length. For equal time periods, when Y equals the length at recapture and X equals initial length, K is estimated from the slope and L_∞ from the intersection of the linear regression with a 45° line representing no change in length during the time interval. The parameter t_o can be estimated from the VBGF for any known length at age once L_∞ and K have been estimated. For longer, unequal time intervals between tagging and recapture, other methods are necessary. For a complete description of analytical techniques used in tag and recapture studies see Jones (1976).

One of the most persistent problems associated with estimating growth from tagging data is measurement error. Errors as small as ± 5 mm or less can be significant when time intervals between tagging and recapture are short. When large numbers of returns are available, data obtained from fish recovered during an initial phase of minimum growth can be eliminated. This is also the period of time when the effects of tagging injury on growth will be most pronounced. Attempts should be made to actually recover all recaptured fish for precise measurement. Also, data obtained from fish which are iced or frozen should be corrected to account for shrinkage. Care should also be taken to use the same measurement (for length, standard length or total length) for each species. A complete description of materials and methods used in marking studies is given by Jones (1979).

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[10] See Gulland (1966) for a description of data collection techniques which apply to sea sampling.

5.2.2.2(a2) Analysis of Hard Parts

It is known that the growth of fish scales, fin rays, otoliths or vertebrae is proportional to the growth of the entire animal. If it can be confirmed that growth rings laid down by cyclical interruptions in the animal's growth are caused by natural events (such as low temperatures, low salinities or slowed growth during spawning) which recur with a known periodicity, the growth history of individual fish can be deduced from the length of the fish at capture, the distance from the focus of the scale (for example) to its edge and to each growth ring. This method requires that each ring correspond to an absolute age. Once an age-length key has been established by examining scales (or otoliths, etc.) from a number of fish, a growth function is fit to the data to estimate parameters. Graphical methods described in the previous section are applicable.

This methodology does not apply as well to tropical fish species since growth is not as predictably cyclical as it is for temperate zone species. Annular rings are sometimes produced, but may be caused by variable natural events such as strong wind and heavy rainfall as well as seasonal changes in temperature, salinity and spawning activity. For growth analysis, understanding the causes of cyclical growth are not as important as the fact that ring formation must correspond to some predictable, recurring natural event. In general, the analysis of hard parts for growth information is a time-consuming process which requires a great deal of judgement and practical experience. For an excellent review of age and growth studies as they apply to tropical fish species, the reader is referred to Brothers (1980).

The growth of invertebrate species is not quite so straightforward. Crustaceans, for example, only increase in size when they molt (shed their hard exoskelton); growth rates are a function of the number of molts and the increase in size at each molt. Growth proceeds in an interrupted, stepwise fashion. Mollusks which are subjected to seasonal changes in environmental factors such as temperature and salinity produce growth rings in their shells which may sometimes be used to estimate growth rates.

5.2.2.2(a3) Size Frequency Data

Size frequency data can be obtained by measuring individual fish either aboard fishing vessels or a research vessel or when fish are landed for delivery to buyers. When large quantities are available, sub-samples should be randomly drawn to avoid biasing the measurements toward either large or small fish (see Gulland, 1966). Lengths are more easily and precisely recorded than weights and may be converted to weights once empirical length-weight relationships are known. Length-weight relationships for individual species may be determined from length and weight data collected for several hundred fish selected randomly over the course of a year. Care must be taken to compile data separately for male and female fish, since growth rates may vary by sex, and to include fish with both ripe and spent gonadal tissue and full and empty stomachs.

Once primary size data have been collected, they should be compiled by equal length or weight intervals. Ten to fifteen intervals are normally sufficient to permit a visual interpretation of component size groups. All size data must be recorded by fishing locations, gear and time of year since all of these factors may affect the sizes of fish captured. There is, however, no need to randomly select certain landings. Instead, attention should focus on those landings which supply the greatest number of fish.

Growth rates can be estimated from the progression of modal or mean lengths of individual size groups which recur in size frequency distributions collected over time by plotting the natural logarithm of the quantity $L_\infty - lt$, (y), versus lt, (x), when lt equals the modal or mean length for a given size group at time t. The growth rate during the interval between samples is estimated from the slope of the regression; the "best" estimate of L_∞ is that which produces the most linear array of data points. Estimates of K and L_∞ are thus obtained by repeated trial-and-error attempts to fit the "best" regression to the data when L_∞ is allowed to vary. Once L_∞ is known, t_0 can be estimated from the y-intercept (which equals kt_0). Information on the absolute age of individual size groups is not required. Since the growth of individual size groups must be followed through time, it is easier to identify the same size group in successive data sets if the interval between samples is minimal. The best results are obtained from continuous monthly (or even weekly) size frequency data.

The use of size frequency data to estimate growth parameters is difficult when 1) there is excessive overlap between adjacent size groups, 2) sample sizes are small, and 3) recruitment of juvenile fish to the exploitable population is continuous or nearly so. When overlap is extreme, component size groups are not visually obvious and graphical and mathematical procedures for estimating the mean lengths of individual size groups produce unacceptable results even when sample sizes are large (Stevenson, 1980).

The number of size groups and the degree of overlap between them increases when there is more than one annual spawning season, when spawning is prolonged and when male and female fish grow at different rates. When recruitment is continuous, size increments in time series data can not be detected. These phenomena are common in tropical fish species. Also, the best results are obtained when fish are captured by gear which is not size selective (seines, traps) since selective gear (gill nets) severely restricts the range of sizes captured.

5.2.2.2(b) Mortality

Dynamic pool models require estimates of instantaneous natural morality (M) and fishing mortality (F).[11] Together, these two estimates are summed to estimate total instantaneous mortality (Z). The time interval of interest is usually one year in which case mortality is expressed as an annual instantaneous rate. The first step in estimating M and F is usually to estimate Z since total mortality is more easily determined. In the special case of an unexploited population, all mortality can be attributed to natural causes and Z = M. Three of the most common methods for estimating mortality are 1) tag and recapture studies, 2) the analysis of size frequency data and 3) changes in total mortality and fishing effort.

5.2.2.2(b1) Tag and Recapture Studies

If tag returns are grouped in equal time intervals, the plot of Y (the natural logarithm of numbers returned during each time interval) versus t time intervals is linear with slope equal to -Zt. Furthermore, knowing the total number of tagged fish and the numbers of tagged fish caught in successive intervals, F can be calculated for any interval or F can be calculated from the Y-intercept. Once Z and F are known, M is estimated by subtraction. Assuming that tag returns are being reported by fishermen and that fishing effort does not remain constant with time, more reliable estimates are obtained when the number of returns in successive time intervals is recorded on a per unit effort basis, especially if fishing effort varies significantly over the course of the year.

There are many sources of error inherent in this technique which can be grouped into three categories depending on whether they affect F only, Z only or both F and Z (see Gulland, 1969; Jones 1976). Natural mortality estimates may or may not be affected, depending on the degree to which F and M are affected. Some errors can be corrected during the experiment, others cannot. In warm tropical waters infections due to tagging are more likely to cause problems, and fish are more susceptible to injury during handling. Also, the non-random distribution of tagged fish which are returned to the population is a major problem which may be more significant for demersal tropical species with limited geographic ranges.

Tagging experiments conducted with species which are captured by small-scale fisheries often require the capture of large numbers of fish in locations which are not accessible to efficient harvesting techniques, for example, in mangroves and on coral reefs. Since only a 5 - 10% recovery rate can be expected it is necessary to tag and release several thousand fish for each species which is being studied. Furthermore, most tagging experiments rely on fishermen for returns. In small-scale fisheries, tagged fish are often landed in remote landing sites which frequently do not have any means of rapid communication with major population centers where fishery offices tend to be located. Moreover, fishermen may be suspicious of government research programs. Successful recovery efforts therefore require extensive publicity programs and efficient methods for recovering tagged fish and paying rewards. (It will, of course, not be necessary to recover the tagged fish themselves unless growth measurements are being made). If enough tagged fish are released the percentage of non-reported recoveries can sometimes be estimated by comparing the recovery rate from a group of cooperative fishermen (or boats) with the recovery rate for all fishermen (or boats).

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[11] Instantaneous rates of change equal the natural logarithm of the absolute finite rate. In the case of mortality rates, the absolute finite rate equals the percentage of fish which die during some time interval. Finite rates cannot be summed whereas instantaneous rates can.

5.2.2.2(b2) Size Frequency Data

Total mortality rates can be estimated directly from the decline in the relative abundance of successive age classes in size frequency data available from samples of commercial catches or landings if it can be assumed that the age structure of the population is stable. Stability implies that the relative abundance of successive age classes at the same point in time is the same as the relative abundance of a single age class if it were followed through time. To estimate Z during some time interval t, the absolute or relative ages of successive size groups must be known. Relative abundance is estimated as catch per unit effort (CPUE). The slope of the natural logarithm of CPUE versus age gives an estimate of annual total mortality when t equals one year for all age groups represented in the data. The same analysis can be performed for the relative decline in abundance of a single age group (year class) through time. In either case, it is important to only use age groups which have fully recruited to the fishery and are completely vulnerable to capture. Vulnerability to capture depends on the gear used and its size selective properties.

If estimates of the growth parameters K and L_∞ are available from other sources, total mortality can also be estimated from the equation derived by Beverton and Holt (1956)

$$Z = \frac{K(L_\infty - \bar{l})}{(\bar{l} - l_c)}$$

when lc equals the mean length at first capture and l = the mean length in the catch for lengths greater than lc. The parameter lc is best defined as the length of 50% retention for gears such as trawls or gill nets where mesh size is important and selection occurs over a range of sizes.

5.2.2.2(b3) Changes in Total Mortality and Effort

If a series of paired Z and effort estimates are available for a series of equal time periods, the Y-intercept of a linear regression of Z versus effort provides an estimate of M. For this analysis, Z and effort may vary with time, by location or even by age of fish in the exploited population (see Beverton and Holt, 1959). This method assumes that fish at any time, location, or age remain equally vulnerable to capture.

5.2.2(c) Recruitment

Yield per recruit assessments are of little value for predicting biomass yields unless annual changes in recruitment can be predicted, at least on a relative basis. One source of information which can be used to estimate the relative size of pre-recruit year classes is CPUE data obtained from research survey cruises which sample juvenile fish before they are recruited to the fishery. Similarly, size specific or age specific CPUE data collected from commercial landings for a fishery which routinely harvests younger fish can sometimes be used to predict recruitment to a fishery which harvests older fish.

5.2.2.2(d) Age (Size) Parameters

An estimate of the size at first capture (lc) can be obtained directly from samples of commercial catches and can be converted to age (t_c) if the growth history of the exploited species is known. Estimates of size (age) at first capture will correspond to size (age) at recruitment (l_r, t_r) as long as there is no delay between the time that fish first become available for harvest and when they are actually harvested. Delays occur when the fishing gear is size selective (i.e. when it only harvests fish within a specific size range). When t_r does not equal t_c estimates of t_r (or l_r) must be based on some knowledge of migratory behavior, i.e. the age (size) at which recruits can be expected to arrive on the fishing grounds.

5.3 SOCIOCULTURAL DATA COLLECTION METHODS

5.3.1 Introduction

Before any data collection scheme is implemented, the investigator should ask himself "why are we collecting these data?" It is especially important to ask this question when one begins to construct the interview form for a sample survey (Casley and Lury 1981), but it is also important when formulating questions to be posed to key informants. In preceding sections, justifications were provided for most of the sociocultural data needs, but it must be remembered that some were situationally dependent. For example, one need not obtain data on proposed innovations if no changes are projected. Furthermore, data concerning attitudes towards changes in income or occupation need not be collected if these changes are not expected to be part of the fishery development process. Obtaining and analyzing this attitudinal data is perhaps the most time consuming aspect of any survey and thus the question "why are we collecting these data" should be posed several times when collecting attitudinal data.

5.3.2 Examination of Available Records

Usually the information that can be found in written documents is limited to census material which, if sufficiently detailed, can be used to determine the numbers and locations of potential project participants (4.2.2.3), and aspects of the occupational structure (4.2.2.6). The investigator must be warned that in many cases census material does not include occupation; in such a case, if licensing records are available they can be used to estimate numbers of fishermen.

5.3.3 Interviews With Key Informants

A great deal of the sociocultural data discussed in the preceding chapter can be obtained from well selected key informants. For example, key informants can provide many of the necessary data such as group identification (4.2.2.1), degree of intergroup tension (4.2.2.2), locations of potential project participants and estimates concerning numbers (4.2.2.3) which should be verified by a review of written records or by conducting some sort of census. Key informants can also provide information concerning traditional communication channels (4.2.2.4), level of community development (4.2.2.5), occupational structure of the target community (4.2.2.6), temporal distribution of fishing effort (4.2.2.9), and local knowledge about fishing and fish (4.2.2.10).

Much of the information concerning the social structure of the occupation of fishing can also be obtained from key informant interviews. General information concerning fishing gear types and ownership patterns (4.2.3.1) can be obtained from knowledgeable local fishermen. Likewise, key informants selected from the local fishing population can be used to provide data concerning crew size and social composition (4.2.3.2), criteria for crew selection (4.2.3.3), degree of occupational mobility (4.2.3.4), patterns of interaction between owner and crew (4.2.3.5), degree of on and off vessel specialization (4.2.3.6), relationship of fishing groups with other groups (4.2.3.7), and the local distribution of wealth and power (4.2.3.8).

Finally, key informants also can provide data concerning innovations. Local fishing equipment suppliers and older fishermen can be used to supply data concerning a history of innovative behavior in the community (4.2.4.1). Preliminary assessments of attitudes towards risk, change, and investment (4.2.4.2) as well as perceptions of proposed innovations can also be obtained from key informant interviews (4.2.5.4 through 4.2.5.8). These preliminary assessments, however, must be confirmed by sample surveys of the attitudes and perceptions of fishermen.

5.3.4 Data from Sample Surveys

There are a number of simple, easy to ask questions which can provide quantitative estimates to support statements made by key informants. These questions can be included in a sample survey interview which is administered inexpensively during a short period of time. Surveys provide general background information as well as data which can be used, for example, to determine the social structure of the occupation. Fishermen can be asked if they are presently employed (4.2.2.7), when and for how long they go out fishing (4.2.2.9), the kinds of gear and vessels they use and who owns the equipment (4.2.3.1), whether or not they can realistically expect to own a vessel themselves some day (4.2.3.4), and what their position is in the crew (4.2.3.6).

Much of the attitudinal data listed in sections 4.2.4 and 4.2.5 (Innovation Data and Occupational Preference and Training Data) must be obtained with the use of sample surveys. This methodology is essential because we need to know which individuals or groups will be more likely to accept a proposed innovation. Such conclusions are based on the statistical properties of the sociocultural variables which are examined. For example, once we have determined the history of innovation in the community (4.2.4.1) through the use of key informants, a widely accepted innovation can be identified, and individual fishermen can be asked when they began to use this innovation, how long they have continued to use it and whether or not they still use it. These data, in combination with individual data such as age, years of formal education, degree of literacy and exposure to mass media, (see list under 4.2.5.9) can be used to determine individual attributes associated with innovativeness in the community (4.2.5.9).

Attitudes towards risk, change, and investment can also be determined through the use of sample surveys. Questions such as those listed under 4.2.4.2 could form part of a survey questionnaire. The distribution of perceptions of the attributes of a proposed innovation among individuals or groups must also be determined with the use of a survey (4.2.5.4 through 4.2.5.8). Individuals could be provided with a description of a proposed change and asked to comment on its complexity, compatibility, the advantage it provides over the old techniques, whether or not they feel they could actually experiment with it, and if they feel that they can adequately assess its potential by observing proposed demonstration techniques.

Finally, survey data is also necessary to obtain accurate indications of occupation preferences (4.2.5.1 and 4.2.5.2) as well as attitudes towards income changes (4.2.5.3). Several techniques can be used to obtain these data. First of all, potential fishermen can be requested to compare fishing with realistic alternative occupations. For example, the following questions could be posed: (a) Would you prefer to be a farmer (for example) or a fisherman? Why? (b) Would you like your son to become a fisherman? Why or why not? (c) Would you become a fisherman if you had the opportunity? Why or why not? Analysis of responses to direct questions such as these can be quite revealing.

A more sophisticated and time consuming technique would be to compare fishing with other realistic alternative occupations by examining a series of relevant dimensions which represent occupational likes and dislikes. Dimensions related to job preference must be culturally relevant, so they should be determined through preliminary interviews. Individuals could be requested to compare different occupations and tell what they like and dislike about them. The output of these interviews could be used to construct a list of relevant dimensions such a income, status, "goodness," intelligence, family life, or least preferred to most preferred occupation. A sample of individuals could then be presented with a ladder diagram and told that the bottom rung of the ladder represents the lowest possible income and the top rung the highest. They would then be requested to place each of the occupations on the appropriate rung. This would be done for each of the dimensions resulting in a comparison of occupations along all dimensions.

Some people (Casley and Lury 1981, for example) object to the use of open ended questions such as these in surveys because they are difficult to analyse. On the other hand, open ended questions can be preferable since it is extremely difficult to anticipate answers to these types of inquiries. Closed ended questions can sometimes elicit responses which are biased in the direction of the investigator's expectations — they suggest an easy response for the busy fisherman who is anxious to get rid of the interviewer.

Responses to most open ended questions can be categorized into ten or fewer categories with one residual category for idiosyncratic responses. For example, in a study of attitudes towards the occupation of fishing, Pollnac and Ruiz-Stout (1977) asked the question "what do you like about fishing in comparison with other occupations?" Responses were categorized into a total of seven categories, including a "don't know" and an "other" category. The open ended responses categorized as "sport-pleasure," "monetary reward," and "independence" accounted for 83 percent of the responses while only nine percent of the responses had to be classified in the catch-all "other" category. Evidence that analysis of open ended questions can be easy is found elsewhere in the cited work (Pollnac and Ruiz-Stout, 1977) and other papers by the same authors.

5.4 ECONOMIC DATA COLLECTION

5.4.1 Introduction

This section is not meant to be a comprehensive treatment of either applied fishery statistics nor of sampling theory. For a thorough discussion of the former the reader is referred to Bazigos (1974) and for a comprehensive set of lecture notes on the latter to Chakraborty and Wheeland (1979). The discussion which follows will examine some of the causes of variation in observed values of the many variables discussed in Chapter IV and, based on this, suggest how to aggregate the collected data. This will be followed by a very general discussion of sampling in order to highlight some advantages of using sales receipts as both a census of fishing activity and a sampling frame.

The advantages of having a census of fishing activity available are apparent to all concerned with fishery statistics. However, due to the problems associated with conducting such a census, little has been written about it. It is the authors' belief that sales receipts can be used to provide information on fishing activity in much the same way as a census.

5.4.2 Kinds of Variables and Sources of Variation

Section 4.3 lists a large number of variables useful in many different kinds of economic and bioeconomic analyses. The variables were put into two groups: those relating to a day's fishing by a single firm (called a unit of fishing activity) which are best measured at the end of a fishing trip, and those which are not related to fishing activity and are best measured in a community setting. One use of this data is in estimating annual amounts of the quantitative variables that describe the operation of the fishery. We will continue to use this as a framework in discussing the data because all other uses of the data will be served if one can obtain unbiased, properly grouped estimates of annual amounts of these variables. Interview data will be discussed first.

The total annual amount of any given quantitative, activity-related variable, such as the amount or value of ice used, the weight or the value of a particular species or the cost of fuel, can theoretically, either be determined directly or estimated. The total annual amount of variable X is equal to

$$\Sigma X \quad \text{or} \quad \bar{X} \cdot N.$$

The first case, which is a sum of all of the values, is only possible in a theoretical sense since all values will, in reality, never be known. The second case is an estimate of the total annual amount. The reliability of this estimate is determined by the bias of the estimate of the true population mean, i.e., $\bar{X}$, and the accuracy of the count or estimate of N, i.e., either N or $\hat{N}$. The degree of statistical confidence one can have in the annual estimate is related to the variance of the estimator $\bar{X}$. This, in turn, is related to variation in the observations on X. It will be seen below that if N is estimated as well, then the confidence limits on the estimated total annual amounts are affected by the variance of this estimator, $\hat{N}$ as well. The causes of variance in observations on X will be discussed first.

The variable X is either a biological, economic, sociocultural or physical quantitative variable. A very basic question is why two or more daily observations of X are different.[12] There are, of course, many reasons: some are the result of economic and technical decisions by fishermen, and others are the results of natural (biological and environmental) phenomena.

The nature of the variable itself determines to a great extent the number of factors which affect the values it assumes. For example, observations of a biological (or related) variable such as weight (or value) of a particular species caught on a given day result from economic factors (the boat/gear combination in use), physical factors (how frequently the net was hauled), and biological factors (e.g., the dispersion of the species in the area fished). Factors which produce variability can operate on a daily, monthly, or annual basis. Weather and pollution could also be added as additional sources of variation. It is clear that variations in observations of biological (and related) variables result from a very large number of factors.

In contrast, non-catch-related economic variables, such as the amount of ice used, and physical variables, such as the time actually fished, are affected by fewer sources of variation. They are, for example, exempt from the short run, direct impact of many biological factors.[13] The values they assume, of course, result from the various short-run and long-run decisions the fishermen make. Also, these economic and physical decisions are influenced by how the fishermen evaluate many of the biological factors.

5.4.3 Sampling and Aggregating

A sampling scheme designed to take into account some of these sources of variation can either reduce the total number of observations needed or, for the same number of observations increase the degree of confidence in $\bar{X}$, the sample mean of the variable X. An even more important reason for grouping (or stratifying) the observations according to the various sources of variation is that the groups or strata themselves are of interest. In particular, many of the groupings of the data will represent the results of decisions made by groups of fishermen who live in similar conditions, are organized similarly, use the same boat

[12] By daily observations we mean observations made between days on the same boat or between boats on the same or different days.

[13] They may be subject to some sources of variation from which biological variables are exempt. For example, unloading fees may differ over landing sites.

and gear types, and will be the target of departmental actions.[14]

Of all the sources of variation only a small number are important in producing large variation in several kinds of variables. Still fewer are also easily observable. Those which do satisfy the first condition are variables describing qualities of the unit of activity such as home port of boat, location fished, gear type, boat class, mesh size, method of propulsion, size of crew, etc. Many of these are referred to as identifiers above. Each of these qualitative variables affects the range of the observed values of a different but overlapping set of quantitative variables. Some of these qualities are not easily observable, they require much closer examination or responses to questions about them. Many of them have to do with aspects of nominal fishing effort.

The first basis for stratifying the samples to be taken (besides date and location) should be one which is a reasonable substitute for (is correlated with) as many of the sources of variation as possible. For common bioeconomic sampling purposes this factor should be one which affects the values of both biological *and* economic variables. In many small scale fisheries this will be the boat/gear combination used. Boats may be classified by type (e.g., canoes, sailing vessels, motorized vessels) and perhaps further by size (e.g., sailing vessels over 25 feet or motorized launches with sleeping quarters, etc.). More detailed gear distinctions may be more difficult to observe. In Costa Rica the boat/gear combination was a good indicator of days fished per trip, range (areas) of fishing activity, crew size, the general mix of fish caught and, in some instances, the home port and likely landing site.

How the data are aggregated (i.e., stored and summarized in strata) will reflect, first of all, the sampling strata. Data should be grouped for a given time period (e.g., a month) because of the time dependency of many of the sources of variation. It is also worthwhile storing data by location of sample because of the correlations that exist between some important variables depending on location. For example, landing sites may be a strong indicator of area fished, home port, gear type, etc.

The number of strata in which the data are aggregated and stored should be at least as great as the number of strata used for sampling.[15] There are several important sources of variation which are not easily observable and cannot be used to stratify the samples but which can be used to distinguish stored data. One of the most important of these is the area fished.[16] Interviews will produce data on areas fished but for any particular area this information will be obtained by chance. The probability of collecting data by fishing grounds can be increased as collected data are examined for correlations between areas fished and different landing sites or other factors.

Ideally, data should be aggregated in a way which: 1) allows for ease of generating summary material; 2) is sufficiently disaggregated so that many sources of variation can be examined; and 3) permits newer, more refined data to be added at a later date (for example, a species breakdown of the catch, market prices for labor services, adjustments to crew remuneration, etc.).

5.4.4 Variation in Numbers of Stratified Units of Activity

The problem of counting N or estimating it ($\hat{N}$), may be considerable. N is the total number of units of activity (days of fishing) by everyone who fishes over the entire year. Counting or estimating N within the same strata used for sampling is more difficult. Assuming that one dimension of stratification, say gear type, is in use for sampling and that there are three gear types, the annual total for variable X is now estimated by

$$\hat{X} = \sum_{j=1}^{J=3} \bar{X}_j N_j$$

Nj is the number of days of fishing over the year by gear type #1 (j=1), #2 (j=2) and #3 (j=3). The total number of units of activity for the entire fleet for the year, N, is equal to N_1 plus N_2 plus N_3.

[14] It is exactly these decisions and their aggregate impact on the resource that bioeconomic analyses attempt to capture.

[15] If computer facilities and programs for data manipulation are available, then the raw data can be stored by identifiers, and any necessary aggregations can be generated at will. If this capacity is not available, summaries can be stored by way of a filing or cataloging system. The raw data should be kept on hand as well since our "educated guesses" as to the appropriate summaries may not always be correct.

[16] Several more of these are aspects of fishing power such as mesh size, net area, hook size and number, etc.

There will be, of course, two additional subscripts reflecting the location (l) and the date (t) of the opportunity to sample. Hence, if we assume three landing sites,

$$N = \sum_{j=1}^{J=3} \sum_{t=1}^{T=365} \sum_{\ell=1}^{L=3} N_{jt\ell},$$

and the annual total of a variable such as X is estimated by

$$X = \sum_{j=1}^{J=3} \sum_{t=1}^{T=365} \sum_{\ell=1}^{L=3} \bar{X}_{jt\ell} \cdot N_{jt\ell}$$

There are many reasons why the number and composition of units of activity (Nj) vary from day to day, month to month, and landing site to landing site. Therefore, there are even more reasons why $\bar{X}_{jt\ell} \cdot N_{jt\ell}$ varies. As with X, these variations have daily, seasonal and annual aspects which are particularly important in small scale fisheries. For example, the amount of fishing activity taking place on a given day is influenced by the weather and the seaworthiness of small vessels. Seasonal influences include migrations of fishermen and seasonality of agricultural work. In the long run there is entry into and exit from the fishery as surrounding economic conditions change. In general, the list of sources of variation in the number and composition of units of activity (here differentiated by gear type) per unit time is almost as long as the one describing sources of variation in variable X. There are several ways to estimate N_{jtl}. For example, people could be placed at a few sites for the duration of the year or at all landing sites for a short period of time. They would first keep track of all landings and second try to record the number of days of fishing. More reasonably, they would estimate the number of days of fishing per-trip or landing. The number of estimated days of fishing per landing could then be used along with any other information (about relative number of landings at other sites or other times of the year) to extrapolate over all sites or all months respectively. The resulting estimate of N, however, is at least twice removed from the actual count. Other frequently used sampling techniques focus on boats or landing sites in trying to estimate annual amounts. Some of these techniques require that the number of fishing days per boat or per landing site per time period be estimated as an intermediate step. Still other estimates are three or more times removed from the true N.

In some fisheries, because of the logistics involved and the decentralized location of landing sites, the only reasonable data collection method relies on observations which are not taken in post-trip interviews. Consequently, much of the detailed amounts of fish, revenue and costs revealed in a post-trip interview setting are missed.

In spite of these drawbacks, many of these methods are, in fact, fairly sophisticated in dealing with many seasonal and locational variations in the amount of fishing activity. Correlations between time and/or locations and several other factors such as boat/gear combinations can be and are exploited, and many of the infrequently observed details can be estimated to yield accurate results (see Bazigos, 1974; Banerji, 1974). The estimates of total annual amounts are based on estimates of both the variables and the amount of fishing activity, however. The use of sales receipts can solve some of these estimation problems and provide valuable information for reducing costs associated with increased accuracy.

5.4.5 Sampling and Aggregating with Sales Receipts

The advantages of being able to use sales receipts, either simple or detailed, from all or even some landing sites, for all or some of the year, and on an indefinite or periodic basis (alternate or every fifth year, for example) will become evident from the following discussion. Statisticians will discern even more advantages than are described here. The purpose of this section is to encourage consideration of the benefits and costs of such a scheme. As long as the majority of the catch is landed within a reasonably centralized area and is sold (rather than bartered or consumed directly), the economics of supplying incentives to primary buyers to use sales receipts as opposed to supplying incentives to fishermen to provide data, should be obvious.[17]

An ideal simple sales receipt might contain data such as location of sale, value of the amount sold, date, a commercial classification of the amount sold (i.e., prices and weights), a receipt number, name of the buyer and name of the seller. This simple receipt supplies us with an estimate of N_{jtl}

[17] These two options are clearly not mutually exclusive.

i.e., an estimate of the number of units of activity by site by month for the purposes of calculating monthly totals. We are still required to estimate the landings by gear type and the number of days fished per landing. These can be estimated using the interview data *if* the interviews are not biased in favor of particular gear types.

For sampling purposes, the simple receipt supplies landings by site by day of the week and week of the month. This can be used to estimate the amount of fishing activity in the next period and the frequency of landings at different sites. For purposes of proportional sampling, the simple receipt allows one to determine how many post-trip interviews or species breakdowns should be attempted. But in addition, it supplies us with an enumeration of an important variable which appears on the interview form: amount (and value) sold to the primary buyer. There is, therefore, no need to estimate these annual amounts. But there are, of course, many reasons to continue to collect these pieces of data in interviews. The further uses of this variable will be discussed below. The sales receipt may also supply a commercial classification of the total amount sold — helpful information for determining species composition.

A detailed receipt might contain, in addition to the data mentioned above, items such as time of sale, boat type used, method of propulsion, obvious gear used, number of people fishing, number of days on the trip, boat name or registration number, home port of the boat and, perhaps, zone fished, i.e., many of the same variables which appear on the interview form. This kind of receipt will provide: 1) an exact count of the various Njtl and the count for several additional strata in which data might reasonably be stored; 2) a greater quantity of data, at an earlier date, with which to determine the number of samples required for whatever strata; 3) a greater quantity of data, at an earlier date, with which to establish the presence or lack of correlations between both sampling location and time (hour, day of week, week of month) and the various strata; 4) the possibility of reducing the number of interview questions about even the most changeable economic variables — catch related costs — asked in subsequent years of data collection, and 5) the possibility of having the receipt become the primary source of data in the future — thereby reducing data collection costs (but increasing the data processing costs).

The first advantage is clear; an exact enumeration is preferable to an estimation, and the cost of this enumeration is small relative to manpower costs. The second advantage is almost the same as that provided by simple receipts, except that the desired number of interviews for the next time period can be determined by more strata — most importantly by boat/gear combination. The ability to use this advantage can be determined by examining the relation between landing time and location in the various strata. Detailed receipts will supply the data for this analysis. These relationships almost certainly exist in the artisanal fishery, and it is possible to take advantage of them by adjusting the sampling procedures — even to the point of target sampling. An interesting relationship to be examined for efficient sampling is between landing times and tides. If relations such as these exist and are not recognized, the most inefficient (in terms of cost per sample) methods must be used to assure an unbiased sample, i.e., a completely random placement of personnel over location and time.

The number of samples to be taken in the next period (regardless of their specific time and location distribution) can be determined in several ways. The most efficient way uses the number of landings (and not days fished) as the basis. This is because the sampling unit, the landing, may contain data for several days of fishing. Sampling on the basis of the number of landings in the previous period will come closer to yielding a given percentage of the number of days of fishing than will a scheme based upon number of days of fishing in the last period. The difference is only one of efficiency, however.

The sample means estimated for any given period are multiplied by the N of that period even though the number of observations that were involved in these calculations were determined by the previous months landings. In other words, the number of interviews for a period is a percentage of an *estimate* of the number of landings that period. Various methods can be used to obtain this estimate. One might simply use the total of last month's landings. Trends in the amount of fishing activity from month to month can be accounted for by weighting the previous period's landings.

Better still, one might have available data on the number of landings for the period of interest from previous years. As time goes on, the accuracy with which we can predict the number of landings for the coming period(s) will increase. It is because of the difficulty in trying to predict the next period's activity that we suggested in 4.3 that a combination of methods be used to calculate maintenance and repair costs in the early years of data collection.

The fourth and fifth advantages are related to each other. Even in the case of sampling without receipts, the interview data can reveal relations between catch related variables and the value of the catch sold to primary buyers.[18] For example, labor costs may be based on several possible measures of the value of the catch. With enough interview data this cost can be related, with varying degrees of confidence, to the amount of fish sold to the primary buyer. If a relationship exists and is fairly strong, it might be possible to eliminate questions about labor costs from the interviews given that we have recorded the number of crew. This holds for several other variables as well. Of course, if the estimate of the total annual value sold to the primary buyer is biased, this bias will be transferred to annual catch related costs. A simple or detailed sales receipt system will eliminate the probability of such bias.

The logical extension of this elimination of variables is to be able to substantially reduce the dependence on interviews and, for a significant period of time (several years), rely on sales receipt data, a regular sampling program to determine the species composition of the catch, and occasional in-depth interviews to reveal changing relations.

It is inadvisable, however, to completely forego the regular collection of economic interview data on the basis of relations between a given variable and only one other variable (say a percentage relationship even within a grouping of interviews). The amount of statistical confidence which can be assigned to this relationship will probably not be very great. The conditions which permit the interruption of economic data interviews require a complete year of interview data and computer facilities for performing multiple regression analyses. Given these conditions it is possible to relate many of the variables compiled from the interview forms to each other and to then apply these relations to variables represented on the detailed receipts. For example, labor costs can be related to the value of the fish sold, the number of men fishing, and the boat/gear combination. These relationships can then be used to estimate values for the same variables (e.g., total labor costs) for all landings during some period of time from data provided on the receipts.[19] The interviews become, in essence, an occasionally applied instrument for revalidating the relations established in the first year's intensive interviewing and for discovering changes in those relations. The use of sales receipts is worthwhile regardless of a fishery department's ability to exploit this last advantage.

The sales receipts can be stored separately but in parallel with the stored interviews, i.e., within the same strata defined for interviews. Their number will be so great, however, that a system of summarizing the data they contain must be established.

It is suggested that the feasibility of using a receipt system be evaluated by examining the degree of expected compliance, the use of incentives, the ability to distribute and collect the receipts regularly, and the human and/or computer resources necessary to tabulate, store and interpret completed receipts.

5.4.6 Fixed Costs

Fixed costs are best measured by means of interviews conducted in fishing communities. Total annual estimates of fixed costs can be obtained by a proportional sample of the population of firms. The total number of firms, or better still, the total number in each stratum, can be derived from a census or from registration lists, or it can be estimated per village, per landing site or per geographical area. The proper strata for sampling the firms and storing the data are principally defined by economic *and* locational sources of variation. The sample number (a percentage of the estimated total number) in each strata should reflect defined amounts of capital investment and common sociocultural characteristics in each grouping. Again, a good indication of the amount of capital involved is the boat/gear combination in use. This is, furthermore, a stratum common with the variable costs. The timing of these interviews is discussed in Chapter IV.

[18] After a year's data collection, the frequency with which we need to collect catch-independent cost data is greatly reduced. We should know, for example, the mean quantity of ice used per days fishing by particular boat/gear type (within each stratum). This estimate should have a relatively small variance.

[19] There is a strong possibility that the annual economic quantities estimated from multiple regression relations will be more accurate than those estimated by sample means.

Chapter VI

DATA COLLECTION STRATEGIES

6.1 INTRODUCTION

A major objective of this guide is to demonstrate the importance of integrating biological, economic, and sociocultural data in order to generate information which is useful to fishery administrators in developing countries who are responsible for managing and developing small-scale fisheries. Previous chapters have described information and data needs as well as appropriate data collection methods for each discipline. In this chapter, we will outline two strategies for integrating data collection efforts which should be applicable in most situations which require multi-disciplinary information. Before examining these strategies in more detail let us first discuss the ways in which the data collection efforts of different investigators can be effectively combined to provide the greatest amount of information to policy makers at the least possible cost.

6.2 INTEGRATING DATA COLLECTION EFFORTS

Data collection efforts can be integrated at two levels. At the first level, the data collection activities which are planned and carried out independently by biologists, economists, and anthropologists/sociologists are coordinated in order to save time. In its simplest expression, an interviewer who is responsible for collecting, say, catch and effort data for resource assessment purposes may be asked to also obtain price information or compile lists of fishermen for later sociocultural interviews. Interviewers conducting economic or sociocultural surveys may also be able to provide valuable information for the biologist. On the other hand, some data which are routinely collected by one investigator may be useful to another. In either case, substantial savings can be realized, especially if data are being collected from a number of remote locations requiring large investments in time and vehicle (or boat) use. Coordination of data collection efforts at this level is not complicated, but does require that data be collected during the same period of time and that at least some of the survey locations be the same. It also requires that investigators working in each of the individual disciplines be familiar with each other's data collection procedures and schedules.

The second level of integration involves the design and implementation of common data collection procedures. At this level, coordinated data collection activities are not only useful, they are essential since investigators in different disciplines are following the same survey format to obtain a common data base.[1] Even greater savings are realized than at the first level since each discipline can make use of the same interviewers, sampling schedule and sampling locations and thus avoid a great deal of duplicated effort. Collaboration at this level requires that research and data needs be clearly defined before data collection begins. In addition, considerable time must be devoted to the design of procedures which will produce as much multi-disciplinary data as possible, but which are not so unwieldy that they are difficult to administer. For example, it is particularly important to avoid using lengthy survey questionnaires which take a long time to complete. In a statistical sense, the successful design of joint data collection procedures requires the identification of common sam-

[1] It is unrealistic to assume that *all* the data required for even the most compatible purposes (e.g. stock assessment and variable cost and earnings analysis) can ever be collected using common data collection strategies; there will always be some additional information which must be obtained independently.

pling units and a sampling scheme which produces estimates that are unbiased and reasonably precise. This is not always a simple matter when, for example, a biologist estimates mean catch per species and an economist estimates the mean cost of a day's fishing, even though both are equally interested in knowing how much fishing effort is associated with a given catch or a given cost of operation.

In seeking to attain a greater degree of cooperation between researchers who are studying the small-scale fishery system, it is obviously preferable to reach the second level of collaboration. Data collection procedures which are described in this chapter are designed to achieve that objective. This is, however, an ideal objective which isn't always attainable because 1) a strong commitment to cooperative research does not always exist, even when multi-disciplinary studies are undertaken, or 2) given the diversity of sampling objectives, each with its own associated statistical variability, data collection methods are not always compatible. Despite these problems, we believe that multi-disciplinary approaches to data collection are needed and should be promoted. Of the two strategies discussed in this chapter, one in particular is designed for achieving closer cooperation between the three disciplines which are represented in this guide. It is up to the reader to consider how other issues mentioned in Chapter I might be included in an even more comprehensive and unified data collection scheme.

6.3 TWO ALTERNATIVE DATA COLLECTION STRATEGIES

There are two recommended approaches to collecting catch, effort, revenue, and cost data which apply to small-scale fisheries. Neither one is better than the other, but one may be preferable over the other in a particular situation. Although the two approaches are similar in many respects, it is important to understand the differences between them so that the appropriate strategy can be selected when necessary. The first approach has been described in detail by Bazigos (1974) and Banerji (1974) and is widely followed in a number of countries; the second approach is not so common, but may be more applicable in certain circumstances which will be described below. It is our contention that the second approach, which is described in more detail in this guide, is more amenable to multi-disciplinary data collection needs.

6.3.1 Strategy Based on Static Frame Surveys

In the approach described by Bazigos and Banerji, total catch (and catch by species) is estimated from a "catch assessment survey" which is designed on the basis of a census of sampling units (usually boats and/or landing sites). This census or frame survey represents the number of sampling units which are counted at a particular point in time and must be repeated periodically as the number of units in the fishery or their distribution changes over time. Total catch can be estimated from the mean catch per boat or per landing as long as an estimate of the total number of boats or landings is available. Estimates of total fishing effort (hours fished, for example) can be obtained following the same procedure. Furthermore, the catch assessment survey can easily be extended to generate economic cost and earnings information. Gains in precision are possible if the information available from the frame survey is detailed enough to allow for the stratification of the sample survey by gear type and/or geographical region. Although it is not our purpose to describe this procedure in detail, we do offer the following brief summary of how it could be implemented along with an example:

Step 1: Define the sampling unit (e.g. individual boats at individual landing sites, preferably categorized according to gear type);

Step 2: Conduct a census survey of sampling units within a defined geographical region (or regions);

Step 3: Randomly select some proportion of all units for sampling during a defined period of time (e.g. a month), choosing an appropriate sample size (e.g. 10-20% of all boats) according to the desired level of precision and the amount of manpower, etc. available to conduct the survey;

Step 4: Either station someone at each selected landing site to obtain catch, effort, variable cost, and earnings data from randomly designated sampling units or devise a schedule for visiting individual sampling sites and collecting the same data randomly in each site;

Step 5: From mean catch, effort, revenue, and variable costs per boat per landing, estimate total catch, etc. by extrapolation.

As an example of how this data collection procedure could be applied in a real situation, consider the case in which three landing sites are randomly selected within a certain geographic sector every week. The sampling unit is defined as a landing by an individual boat in a given site and the frame survey consists of an enumeration of all landing sites within that sector and the number of boats actively involved in small-scale fishing at each site. The frame survey would have to be up-dated periodically by repeating the census in a portion of all the landing sites in the sector. Observations are made at each selected site for two consecutive days every week; the interviewer counts the total number of boats landing during those two days and determines the landed catch of a subsample of all boat-landings selected systematically (each landing, every other landing, every fourth landing, etc.) with a random start. The estimated monthly catch at each selected landing site is obtained by multiplying a weighted average catch for the three selected sites times the total number of landings at all sites as determined from the frame survey.

Sample surveys based on a static frame survey of boats and landing sites are probably the only alternative in situations where there is a large number of fishermen or boats in the fishery and/or when fish is landed in a large number of remote sites along the coast. This approach is also preferable in situations where buying and selling arrangements between fishermen and dealers are informal and where there is no tradition of recording catch and revenue data when fish are landed and/or no hope of promoting such a practice (see 5.4).

6.3.2 Strategy Based on Continuous Frame Surveys

This approach involves the use of sales receipts — which are filled out when fish is landed and sold to primary dealers — to estimate total catch, effort, and revenue and as a frame survey of fishing activity upon which to base a random landings survey which generates more detailed catch and effort data as well as data on the costs of harvesting. The major advantages of this approach are that 1) total catch, effort, and revenue are recorded directly as fish are landed and do not have to be estimated from a landings survey, 2) the frame survey is continuous in time, geographically complete and does not require periodic up-dating, and 3) the sampling unit for subsequent landings surveys can be defined in terms of the production activity of a firm (e.g. days fished by boats using a particular gear). Also, since total catch, effort, and revenue data are recorded by dealers, government fisheries agents have more time to devote to intensive landings surveys.

This approach has been described in previous chapters of this guide on the basis of its utility in multi-disciplinary evaluations of small-scale fisheries; it is preferable to the methodology described previously (section 6.3.1) in situations where the fishery is fairly small and restricted to a well-defined geographic area, when most of the catch is sold to dealers, and when there is an existing or potential practice of recording sales information.

The estimation of total catch, effort, and revenue from sales receipts and the use of intensive landings surveys to generate additional information such as the species composition of the catch, improved effort estimates, and variable cost estimates form a major part of a larger, more comprehensive multi-disciplinary data collection strategy which has been described in this guide and which will be summarized in the remainder of this chapter. This strategy consists of five basic steps.

Step 1: Compile General Background Information

In situations where little or nothing is known about the fishery, the collection of general backgound information ideally precedes the collection of more specific data. This information simply describes the fishery system and how it functions in very general terms. It is based on the observations and experiences of people who are familiar with the fishery and is fairly easy to obtain.

An extensive list of descriptive information needs is presented in Appendix A. This list is by no means complete and does not include all the types of information which might be required in any given situation, but it does indicate the extent and the variety of the information which is included in this category. The information needs presented in this list relate only to resources and their habitats, harvesting activities, and the contexts in which the fishery exists.

General background information can be used to identify the important activities and elements of the fishery which require more intensive data collection efforts. It also provides the basis for forming perceptions and hypotheses about the fishery and can therefore be used to design more intensive data collection methods. Failure to collect enough background information before implementing a data collection program can result in poor sampling designs, unreliable data, and the loss of considerable time and effort. Furthermore, the collection of background information provides an opportunity for fisheries staff to get out of the office and into the community where they will gain valuable experience which will facilitate subsequent data collection efforts. Background information can be obtained from written records, by simply observing what goes on when fish are caught, landed, and sold and by interviewing people who are familiar with the fishery. Methods for collecting background information are summarized in section 5.1, and additional information can be found in the introduction to Appendix A. The presence of a trained anthropologist is crucial at this stage in the data collection process since he is needed to train interviewers, identify key informants, and supervise the collection of sociocultural background information.

Step 2: Institute System to Estimate Total Catch, Effort, and Revenue From Sales Receipts

The estimation of total catch, effort, and revenue from sales receipts is a crucial step in the data collection process. Efforts must be made early to institute a system of collecting and compiling transaction data. The feasibility of using receipts to generate these data should be carefully evaluated. If most dealers are already using receipts to record the quantities and value of fish which they purchase from the fishermen, it may be a fairly simple matter to encourage other dealers to follow the same procedures. Existing procedures should be examined for possible improvements. In many cases, the receipt forms which are used may vary so much between dealers or be so crude that they will have to be replaced altogether. Improved data retrieval may result from 1) recording more data on each receipt, 2) recording more reliable data, 3) standardizing the receipt form which is used so all dealers record the same types of data, or 4) collecting more receipts from more dealers.

In any event, a distinction should be made between recording data — a job which is done by the dealers — and retrieving data. Data retrieval requires either that the dealers send copies of their records to government officials or that government agents collect copies of the receipts from the dealers. If there is no existing system of record keeping which can be relied upon to provide the necessary data then a small group of dealers should be randomly selected and asked to test a new procedure for recording transaction data. This trial period provides an opportunity to determine the feasibility of introducing a new receipt format throughout the entire fishery. If the use of a receipt system does not prove to be feasible, then this strategy should be abandoned in favor of the strategy outlined previously (see section 6.3.1).

The use of a standardized receipt which includes all the necessary information and the same units of measurement (see Appendix B) is essential and can be encouraged if government assumes the responsibility for printing, distributing, and collecting receipts. Approaches which rely on voluntary cooperation between government agents, dealers, and fishermen are preferable to approaches which require compliance.

A major problem which must be confronted when receipts are relied upon to provide estimates of total catch, effort, and revenue is that some transactions are not recorded. When this is the case, some estimate must be made of the percentage of total landings which are not recorded (or reported). Other problems which have already been discussed in greater detail in Chapter V include 1) the need to correct landings data in order to obtain catch data, and 2) the fact that fishing effort may be very crudely estimated. Unless fishing effort is recorded on the receipts as the number of days fished (or hours) per boat per landing, the only possible estimate of effort will be the number of transactions, which, in most cases, can be assumed to approximately equal the number of fishing trips made by individual boats. The recording of "days fished" on each receipt is crucial if information from the receipts is to be used to design a random landings survey for obtaining economic information based on the production activity of each firm type (see section 5.4).[2]

[2] A day's fishing is most easily defined in terms of a 24-hour period away from port or any fraction thereof and includes any activity during that period which incurs a cost (e.g. travelling to and from port, catching bait, buying ice or fuel). A boat, for example, which leaves port at 3 PM the first day and returns before 3 PM the second day was "fishing" one day even though it may have been underway, and not actually fishing, for four hours. If it returns at 8 PM, it would count as two days fishing. The system used must be simple enough that it will be readily understood by the dealers who are filling out the receipts.

Step 3. Other Sources of Resource Assessment Data

If catch and effort estimates are not available or can not be used to predict the maximum sustainable yields of exploited stocks, alternative procedures for collecting other types of resource assessment data should be considered at this stage. If assessment data of any kind are available, plans should probably be made to initiate a system for collecting catch and effort data as well as vital population statistics since it will take at least several years to accumulate enough data to permit an analysis and since there is no guarantee that once enough data are available, the analysis will produce reliable estimates of MSY for all of the principal exploited species or even any of them. Since many of the vital statistics needed for assessment purposes can be generated in a year's time and do not require expensive and sophisticated research techniques, it makes sense to proceed with techniques for estimating population parameters such as growth rates, total mortality rates, and size and age at recruitment and first capture at the same time that catch and effort data are being collected from receipts and landings surveys.

Some of the parameter estimation techniques which have been described in this guide are 1) size frequency analysis, 2) analysis of growth rings on scales or otoliths, 3) tag and recapture studies, and 4) exploratory fishing surveys (see sections 3.2.4.4 and 5.2.2.2 for more information). The first two methods should be considered first since fish can easily be measured and scales and otoliths collected when landings surveys are being conducted for other purposes. In fact, most — if not all — of the supplementary data needed when compiling size measurements (e.g. fishing location, gear type) are routinely collected as part of any landings survey (see Appendix C). Another good reason for combining size measurement activities with landings surveys is that landings do not have to be randomly selected in order to measure fish. Thus a randomly designed landings survey can proceed and incorporate measurement efforts as time permits and when there are enough fish to measure. In addition, since biologists are trained to quickly recognize individual species when performing size measurements, their participation as members of a survey team would facilitate the collection of reliable species-specific catch, effort, and cost data.

Step 4: Estimate Catch by Species, Effort and Variable Costs From a Landings Survey

Once a system for compiling total catch, effort, and revenue data from sales receipts has been implemented, a detailed landings survey is required in order to determine the species composition of landings within individual price categories, to improve effort estimates for individual gear types, and to obtain detailed variable cost data for different firm types and to use this data to determine relationships among the different cost variables. Totals for most variables can be extrapolated using sample means and the number of days fished. Receipts will provide the ability to actually count totals of some variables. Alternatively, multiple relations established from interview data can be applied to sales receipt data (see 5.4).

To obtain unbiased parameter estimates, any landings survey must be randomized to account for variations in the more important factors which affect the inputs and outputs of production. These factors have been described in detail in Chapter V. In reality, designing a completely random sampling scheme is an impossible task since there are more variables than can be included in a single sampling scheme and since it may be logistically impossible to follow a random sampling procedure when it is time to assign interviewers to particular sampling locations and times. Also, it is frequently difficult to identify which are the most important variables and to understand exactly how they interact with each other and how they affect production activity. Additional problems arise if different investigators pursue different objectives and design random landings surveys based on different variables. Conflicting objectives and designs can lead to differences in the units which are sampled, the sampling procedure which is followed, and the number of samples which are collected.

A good strategy for avoiding these conflicts is to define a common sampling unit and follow a common sampling procedure which will provide all the important data needed by the biologists and the economists in sufficient quantities to permit analysis. Researchers must also accept the fact that they can not exactly define the population which is being sampled, nor can they expect to obtain perfectly random samples or be very sure how good their random sampling scheme is. Therefore, they can only try and reduce sampling bias and error to a minimum by concentrating on those factors which can be quantified in the frame survey.

Following the strategy based on the use of sales receipts as a frame survey, the primary sampling unit can be defined as a landing by a single firm. In most cases, the firm will be a boat and crew which uses a particular type of gear. The secondary sampling unit is the aggregation of landings by firms (boats) in individual landing sites. Landing sites can be selected for sampling on the basis of the *number of landings within a given period of time* as determined from sales receipt data and then a pre-determined number of landings are sampled in each landing site during the sampling period.[3] A convenient sampling period is a month. Sampling locations can be selected on the basis of the distribution of landings in the preceding month or during the same month of the previous year or on some combination of the latter weeks of the previous month, etc. (see 5.4 for details).

Care must be taken to spread the sampling effort within each landing site and between landing sites out over the course of the entire sampling period in order to avoid taking too many samples during particular times of day, days of the week, or weeks of the month.[4] It is possible, given the nature of the information obtained from the receipts, to include the temporal distribution of landings (or days fished) in the sampling schedule. If this is done. considerations should be given to using lunar (28 days) months instead of calendar months.

In the absence of a sampling schedule, a reasonable method for allocating the necessary number of samples randomly through time is to divide the total sample quota for each landing site into four equal parts (for each week of the month), begin each week's sampling in a given site during a randomly selected day of the week and hour of the day, and decide ahead of time how frequently to sample, i.e. each successive landing, every other landing, every fifth landing, etc. Many of the practical decisions such as how frequently to sample will depend on factors such as how long it takes to complete an interview and how often boats are landing; these decisions can be made by the survey crew. The important thing is to begin the sampling effort with a randomly selected landing.

Sample size should be determined on the basis of the most variable factor, i.e. the factor which requires the largest number of samples. This is likely to be the landed weight (and revenue) per species; the variability in some costs per day fished data will probably be much smaller. Those data related to catch, of course, will vary as much as the catch does. Thus, sample size should be large enough to generate reasonably precise catch data by species.

The interview form and procedure which will be used should be tested during a brief pre-survey trial period of a week or two: inappropriate or ambiguous questions should be eliminated or rephrased and the interview should be shortened or divided into several parts if it takes longer than half an hour to complete (see section 5.1.5). A trial period is also important for determining how random the survey really is and how feasible it is to follow the prescribed sampling procedure. Poorly designed surveys are more likely in situations where important background information is either not available or has been ignored. In all cases the "ideal" sampling scheme will emerge gradually.

The duration of the sampling effort depends on the variability of the parameters which are being estimated over the course of a year, and, to a lesser extent, by their variability between years. Variability within years will be greater, in most cases, than variability between years. In most situations there is no existing information which documents, say, seasonal changes in species availability, operating costs incurred during fishing, or income. A good strategy, therefore, is to continue to sample landings for an entire year and to use that information to design a system of periodic sampling limited to particular times of year during subsequent years. Thus, a continuous landings survey in the first year should reveal variations between seasons, and periodic surveys in subsequent years would reveal

[3] Recall that the unit of analysis, the day's fishing by a firm, will be the basis upon which we calculate our sample means within the strata, while the occurrence of landings by firms will be used to determine the number, location, time, and type of samples we will collect.

[4] In the Gulf of Nicoya fishery the magnitude and distribution of landings varied little across the weeks in a month, but there were considerable differences in landing frequency and in the type of firm landing according to the day of the week and hour of the day.

variations between years for the same seasons or months.

Step 5: Conduct Sociocultural and Fixed Cost Surveys.

At this point preliminary analysis and interpretation of the data which have been collected will lead to the design of surveys of fishermen and their assets. While sociocultural and fixed cost surveys may be conducted independently, the population they seek to sample is the same. Some proportion of the population of fishermen which is representative of the population of fishermen in the nature of their fishing enterprise is the target for fixed cost interviews. Generally, the target sample for the anthropologist/sociologist will encompass this group. While the time distribution of these interviews is not important (except perhaps for maintenance and repair cost considerations), all geographical areas should be covered.

Questions about indebtedness and investments in gear, etc., are ideally asked after some rapport has been established with the respondents. Sociocultural interviews are well suited for establishing this rapport. Well conceived questions about fixed costs, in turn, convey the impression that the interviewer is familiar with fishing enterprises. Those competent enough to conduct sociocultural interviews should be able to ask a coherent set of questions about investments. The reverse does not hold for those trained only for economic data collection.

Responses to questions about investments, obviously, reveal something about the cultural context of those investments and of the future orientation of the fishermen and are therefore of value to the anthropologist. The economist can likewise benefit from the anthropologist's data since they relate to the organization and conduct of the fishing business and to its potential for change. Just as the bioeconomic value of catch, effort, revenue and variable cost data is increased by sampling the same units of activity, so too the mutual value of sociocultural and economic data is enhanced if the data relate to the same individuals.

As pointed out in Chapter III, an equally important function of the anthropologist-/sociologist is to provide insights into aspects of human behavior which will help the biologist and the economist obtain better data. Some of this information is descriptive and should be collected in the beginning of the data collection process. More specific sociocultural data can be used to improve biological and economic data collection efforts. In addition to facilitating the work of other investigators, interviews with fishermen may also provide long-term economic data such as the costs of repairs and maintenance of gear and vessels which are not obtained during short-term landings surveys.

APPENDIX A

Artisanal Fishery Background Information

Introduction: The following is a list of background information which should ideally, be at hand, albeit on a very general level, prior to planning a data collection scheme. The information listed simply describes the fishery system and how it functions in very general terms. As noted above, it is based on the observations and experiences of people who are familiar with the fishery and is fairly easy to obtain. It is the kind of information which can be obtained from written materials and key informant interviews as these techniques are described in Chapter V. As the data collection proceeds, however, the accuracy and level of specificity of information concerning the various elements listed below should and will increase. For example, the salinity tolerance of various species is listed as background information. Information on this item will probably be extremely general when the research begins. The background information may be as general as noting that the species of interest abandon the estuary after heavy rains. Further research, at a later date, will provide more specific information concerning salinity tolerance, but it is not essential as a preliminary bit of background information.

It should be made clear that much of this type of information can or should be able to be derived from a general meeting of fishery inspectors and other department personnel who are familiar with the fishery. The list of information types can be reviewed and filled in where possible. In areas where information is lacking, inspectors can be assigned five or ten bits of information to be collected from knowledgable key informants in the fishing communities. This could continue until all of the involved personnel are satisfied that they have a general, not necessarily a detailed, knowledge of all the listed information at the beginning of the data collection process.

1. Habitat Element

Physical description of habitats occupied by principal species

Sources of primary production

Rates of primary production in different habitats and at different times of year (high, low or moderate)

Sources, amounts and seasonality of nutrient input to coastal ecosystems

Principal coastal oceanic and tidal currents

Tidal amplitude and periodicity

2. Resource Element

Number of species exploited (approximate)

Most abundant species

Most valued species

Length and weight ranges of exploited species

Scientific and common names of exploited species

Ease of correct identification

Temperature and salinity tolerances of principal species (approx.)

Ecological niches occupied by principal species (feeding habits, modes of reproduction, migrations, etc.)

Spawning seasons and locations of principal species

History of changes in size and abundance of principal species

3. Harvesting Element

Inputs (Fixed)

Identification of all boat-types

Number of each (approx.) by location

Length, width, draft, superstructure configuration by type, capacity of holds

Useable life of boats

Cost of boat-type new and import duties

Common vessel improvement practices

Range of boat-type resale values

Boat building and repair sources

Hull materials used and their supply sources

Sources of training for repairs and construction

History of evolution of boat-types used

How number of boats has changed in recent past

Ownership patterns - owner operated (owner-captain), absentee owner, cooperative ownership

Identification of all methods of propulsion

Number of each (approx.) by location

Motor types used — horse power, fuel used, and other characteristics

Useable life of motors

Cost of new motor types and import duties

Range of motor resale values

Sources of motor purchases

Sources of spare parts

Sources of repairs

Sources of training for repairs

Ownership patterns of motors

Common combinations of boat/motor

Numbers of each combination (approx.)

Speeds of boat/motor combination

Average cruising range of each combination

Physical characteristics of other modes (sails, etc.)

Useful life of other modes

Cost of other modes new

Source of supplies and repairs for other modes

Source of training for repair and construction

Identification of all gear-types used

Numbers of each type used (approx.) by location

Physical characteristics of gear-types - length, width, mesh size, number of hooks, etc.

Useful life of gear-type

Cost of gear-type new and import duties

Range of gear-type resale value (if any)

Construction and repair sources

Materials used and their sources (and import duties)

Source of training for construction and repair

History of evolution of gear-types

Ownership patterns of gear-types

Patterns of gear-type use among different groups of fishermen

Common combination of gear with boat-type and boat-/motor, boat/sail, etc., combinations

Numbers (approx.) of these combinations by location

Multiple gear-types owned by a single fishermen or single boat

Use of insurance for boat, motor, gear, crew, other

Sources of insurance

Costs of insurance

Sources of credit for boat, motor, gear

Interests rates for equal loan life from different sources

Average repayment period

Registration fees

License fees

Association (e.g. Cooperative) fees

Existence of taxes on income, property, other

Mooring fees

Other fixed fees, e.g., accounting costs, legal fees

Process

Most frequent kinds of maintenance to the hull/motor/gear

Average (typical) cost of maintenance per year to hull/motor/gear

Timing of major and minor repairs by month

Who pays for maintenance and repair

Who supplies the labor for maintenance and repairs to hull/motor/gear

Average number of lost fishing days for all maintenance per year

Average number of lost fishing days for all repairs per year

Average number of men per boat/gear-types

Use of family relations as crew

Sources of training for fishing, navigation skills

Use of ice in various boat-types

Various forms of ice used

How quantity of ice is determined for a trip

Price per standard unit of ice

History of costs of ice

Number of sources of ice

Ownership of sources of ice

Fuel capacity of various boat/motor combinations

Sources of fuel

Price per gallon

History of price changes

Amount consumed per average trip

Oil sources

Oil prices and their history

Amount consumed per average trip

Typical baits per gear-type

Bait sources

Prices of different baits and history of changes

Standard food costs per average trip

Who supplies food for trips

Additional trip costs, e.g., unloading fees by location

Systems used to divide trip costs such as the cost of food, ice, fuel, oil, bait, etc. among owner, owner-captain, captain, crew members

Time of day/night fishing by gear-type

Frequency of trips by gear-type in a week, month

Average length of trip by boat/gear-type

Seasonal differences

Major fishing areas

Relation between home port and fishing area

Areas reserved for certain fishermen or certain gear-types by tradition

Time and distances to reach fishing sites

Usual time for fishermen to return to port

Specific methods of using gears

Several gears used on a single trip

Gears directed at particular species

Differences in catch among gear-type (species, sizes)

Competition for fish with industrial fleets

Supplies of inputs or prices affected by industrial fleet purchases.

Number (approx.) of days fishing lost per month or year due to bad weather

Is this seasonal

Recent history of catches for major species — falling, increasing, etc.

Output

Fish preparation methods

Number of primary buyers, locations

Reasons fishermen select a particular primary buyer

Do some fishermen transport the catch of others to sale

Commercial classes of fish

Determinants of commercial class

Rules buyers use to determine if a fish is acceptable

Fish sales at sea or to other than primary buyer

Existence of underutilized species

Reasons for underutilization

Tax on catch - percentage of fish caught actually taxed

Existence of support prices for fish

Current prices of the various species/classes

Price changes (approx.) through time

Large seasonal changes in prices

Competition between artisanal and industrial catch or by-catch

Relative magnitude of industrial vs. artisanal landings of same species

Point of entry in delivery system of industrial catches or by-catch

General quality differences in artisanal and independent catch of same species

Systems used to divide revenues between the owner, owner-captain, captain, and crew

Differences in systems by home port and boat/gear combination

Fish used to pay the captain and crew, other costs

Revenue for services other than fishing, e.g., towing, transport, etc.

Are the costs of food, fuel, ice etc. paid before the trip or deducted from the revenue afterward

Who pays for losses, e.g., gear lost during a trip

Fish withheld from sales so that it can be smoked/dried/salted for later sale by season

Species saved for curing

How is the fish that is sold used - sold fresh, frozen, processed (canned, meal), exported

Other services the primary buyer provides

Are fishermen required by these services to sell to a particular buyer

Do primary buyers or transporters give preference to industrial fleet catch or by-catch

Other

Fishermen's perceptions of primary buyers and their profit margins

Fisherman's perceptions of reasons for large differences in the prices they receive and retail prices

Existence of and services performed by cooperatives or fishermens organizations

Number of members and number of active members

What do the cooperatives own

Sources of training for cooperative officers

Alternate employment opportunities for fishermen

Barriers, e.g., physical, cultural, to entry into the fishery

Seasonality of fishing and relation to agricultural seasons

System of laws pertaining to fishery, e.g., licenses, registrations, inspections, trip reports, insurance requirements, inspection of landed fish, pollution restrictions, season or area closures, industrial fleet interaction, gear use restrictions

Number of landing sites - location, clusters, remoteness from buyers

Pier construction and locations

Ability of landing sites to handle larger, deeper draft boats

Are mooring and shelter sufficient

Infrastructure serving landing sites - roads, communications, centralized markets, public transport, etc.

The fishermen's perception of his job

The fishermen's perception of what others (non-fishermen) think of his work

Attitudes (general) among groups of fishermen to adoption of different gear-types and boat-types

Traditional areas for fishing by certain groups

Traditional barriers to extended fishing trips

Traditional barriers to more frequent trips

The role of the family in the fishery enterprise

APPENDIX B

Detailed Sales Report

SALES RECEIPT

(1) No. ____________

(2) Date ____________

(3) ____________________________
Company or Buyer's Name

(4) MR. ____________________________
Sellers Name

(5) Hour ____________ (6) Place of Sale ____________

(7) Name of Boat ____________________________

(8) ☐ Type 1 ☐ Type 2 ☐ Type 3 ☐ Canoe ☐ Other ____________

(9) ☐ Gillnet ☐ Handline ☐ Longline ☐ Other ____________

(10) Number Fishing ____________ (11) Days Fishing ____________

WEIGHT	CLASS/SPECIES	PRICE	VALUE
	1st CLASS		
(12) ______	(13) Species 1 ______		
______	Species 2 ______		
______	Species 3 ______		
(14) ______	Other ______		
	Total	(15) ______	(16) ______
	2nd Class		
______	Species 1 ______		
______	Species 2 ______		
______	Species 3 ______		
______	Other ______		
	Total	______	______
	3rd CLASS		
______	Species 1 ______		
______	Species 2 ______		
______	Species 3 ______		
	Total	______	______
(17) ______	All Classes		(18) ______

This version of the detailed sales receipt contains: (1) the preassigned number of the receipt - all of the color coded copies of the receipt have the same number and the number series given to the primary buyer is on record at the fisheries office;
(2) The date of sale;
(3) The name of the buyer or the company;
(4) The name of the ranking fisherman;
(5) Hour of the sale;
(6) Place of sale;
(7) Name or registration number of the boat;
(8) Spaces for indicating the type of boat - size ranges could be substituted;
(9) The apparent gear used, i.e., what the recorder sees;
(10) The number of people on the boat;
(11) The number of days of the trip;
(12) Weights of identified predominant species in each class;
(13) Names of identified predominant species in each class;
(14) The total class weight;
(15) The class price;
(16) The value (price x weight) of that class;
(17) The total weight of the catch sold;
(18) The total value of the catch sold;
Depending on the degree of cooperation expected, additional items could be added, (location fished, for example,) or deleted. Receipts used in Costa Rica measured 10½" by 5½" and were produced in triplicate.

APPENDIX C

Combined Post-Trip Interview and Catch/Effort Survey

I. GENERAL

Date: ________ Hour: ________ AM ________ PM Location of Sale: ________

Primary Buyer: ________

Name of Interviewer: ________ Name of the boat: ________

Type: ________ Kind of Propulsion ________

Who is the owner of the boat? ________

What is the boat's home port? ________

Who is the owner of the motor and/or gear? ________

II. EFFORT

What date and hour did you leave to go fishing? Date: ________ Hour: ________ AM ________ PM

Total number of days fished? ________ How many people worked on the boat? ________

What types of gear did you use? A ________ B ________

On the first day of fishing: Where did you fish with gear A? (be specific as possible) ________

How many hours? ________ When? from ________ until ________

Where with B? ________ How many hours? ________ from ________ until ________

Day 2: Where with A? ________ How many hours? ________ from ________ until ________

Where with B? ________ How many hours? ________ from ________ until ________

Day 3: Where with A? ________ How many hours? ________ from ________ until ________

Where with B? ________ How many hours? ________ from ________ until ________

Day 4: Where with A? ________ How many hours? ________ from ________ until ________

Where with B? ________ How many hours? ________ from ________ until ________

Day 5: Where with A? ________ How many hours? ________ from ________ until ________

Where with B? ________ How many hours? ________ from ________ until ________

If a gill net was used:

How was it used? At the surface? ________ At the bottom? ________ Drifting? ________ Anchored? ________

What is the stretched mesh size? ________

How long is it? ________ How high is it? ________

What kind of twine? ________

If a hand line was used:

Number of hooks per line? ________ Number of lines? ________ What size of hook? ________

Kind of bait used? ________

If a long line was used:

How many long lines? ________ Total length of long lines? ________

Total number of hooks used? ________ Kind of bait? ________

How was it (were they) used? Surface? ________ Mid-water? ________ Bottom? ________

Other kind of gear:

Barrier net: Size? ________

Beach Seine: Size? ________

Other: ________ Physical Dimensions ________

III. CATCH AND REVENUE

Sale to Primary Buyer

Commercial Class Species	Weight (kg or lbs)	Price	Value	Rejected from sale (kg or lbs)
First Class				
Species 1 (Name)	________	________	________	________
Species 2 "	________	________	________	________
Species 3 "	________	________	________	________
Class Total	____	____	____	____
Second Class				
Species 1 (Name)	________	________	________	________
Species 2 "	________	________	________	________
Species 3 "	________	________	________	________
Class Total	____	____	____	____
Third Class				
Species 1 (Name)	________	________	________	________
Species 2 "	________	________	________	________
Species 3 "	________	________	________	________
Class Total	____	____	____	____
Other				
Species 1 (Name)	________	________	________	________
Species 2 "	________	________	________	________
Species 3 "	________	________	________	________
Class Total	____	____	____	____

Total weight sold (all classes) ____________ Total value sale ____________

Are you selling anyone else's catch? How much of this is yours: Wt. __________ Value __________

Value of other catch

1. Did you sell any part of your catch before coming here? ____________________
(If no go to #2; if yes, ask the following questions):
What species or commercial classes did you sell and what was their weight and price?
Species or class __________ ; Weight __________ ; Price ________________
Species or class __________ ; Weight __________ ; Price ________________
Species or class __________ ; Weight __________ ; Price ________________
How much money (total) did you get for that sale? ____________________
Whom did you sell it to? ____________________________

2. Are you selling now or did you sell earlier any seafood besides fresh fish? ____________
(If no, go to #3; if yes, ask the following questions):
Dried or smoked fish? ________________
What class or species? ________________ ; Weight? ____________ ;
Total value ____________________
What other food (e.g. turtles, clams, lobster, etc.)
Class or kind? __________ ; Weight? ________ ; Value ________ .

3. What is the *total* amount of fish from this trip not being sold? ________________

4. What do you intend to do with this seafood?
(i) Dry or smoke it to sell later? ________________ Weight? ____________
What species or class? ________________ Weight? ____________
What species or class? ________________ Weight? ____________
What species or class? ________________ Weight? ____________

(ii) Are you going to sell it later today? ________________________
Species or class ________________ Weight ____________
Species or class ________________ Weight ____________

(iii) To give to the crew as part of their pay?
Class ______ Weight ______

(iv) To eat in your house?
Class ______ Weight ______

(v) To be thrown away?
Class ______ Weight ______

(vi) To pay for things or services?
What ______ Class ______ Weight ______
What ______ Class ______ Weight ______

(vii) To give away?
Class? ______ Weight? ______

5. What other income did you receive on this trip (e.g. from cargo, passengers)? ______

For what? ______ How much money did you receive? ______

6. What is the system for dividing the revenue of this trip? ______

IV. COSTS OF THIS TRIP

Costs Independent of Catch

Is the captain also the owner of the boat? ______
How many people went on the fishing trip? ______
What costs are shared costs? ______

Fuel

How much fuel was actually *used* on this trip? ______
Price per gallon or liter? ______
Therefore, the total value of fuel used was ______
Of this amount, the boat's share is ______
The crew's share is ______
Others are responsible for ______

Oil

What amount of oil was actually used? ______
Price per quart or litre? ______
Therefore, total value of oil used is ______
Of this sum, the boat is responsible for ______
The crew for ______
Others for ______

Ice

What amount of ice was used (bought)? ______
Price per unit? ______
Total value of ice used was ______
Of this amount, the boat is responsible for ______
The crew for ______
Others for ______

Food

What was the value of the food you ate on the trip? ______
Are food costs shared? ______ How? ______

Other Costs

What other costs were there for this trip or for unloading and selling the catch?

Unloading? Cost ________

Sorting? Cost ________

Cleaning? Cost ________

Other? What? ________ Cost ________

Are there any costs that you still have to pay? What? ________

Are any of these cost shared? How? ________

Are any of these costs related to the amount or value of the catch? How? ________

What is the system for dividing costs of a trip on this boat? ________

How many times have you landed fish in the last 7 days? ________

In the last 30 days? ________

Maintenance & Repairs

What maintenance and repairs were necessary since your last trip?

(i) On the hull (e.g. paint, caulking, etc.)? ________

How much (total) did the materials cost? ________

How much did the labor cost? ________

How much of these costs was paid by the boats owner? ________

How much was paid by the crew? ________

By others? ________

Who supplied the labor? Owner? ________ Crew? ________ Family? ________

How many hours or days were involved? ________

(ii) Repairs on motor (filters, spark plugs, etc.)? ________

How much did the materials cost? ________

How much did the labor cost? ________

How much did the owner of the motor pay? ________

How much was paid by the crew? ________

How much was paid by others? ________

Who supplied the labor? Owner? ________ Crew? ________ Family? ________

How many hours or days were involved? ________

(iii) Repairs on the gear (like mending, replacing hooks, floats etc.)? ________

How much did the materials cost? ________

How much did the labor cost? ________

How much was paid by the owner of the gear? ________

How much was paid by the crew? ________ Others? ________

Who supplied the labor? Owner? ________ Crew? ________ Family? ________

How many hours were involved? ________

(iv) Because of these repairs were any days of fishing lost since the preceding trip? ________

How many days? ________

(v) Did you lose any equipment this trip? ________

What? ________

What is the present value? ________

What will it cost to replace it? ________

How much of this replacement cost will be paid by the owner? ________

How much will be paid by the crew? ________ Others? ________

(vi) Have you bought any new equipment since the last trip? ________

What? ________

How much did it cost? ________

How much was paid by the owner? ________

How much was paid by the crew? ________ Others? ________

(vii) Was any of your equipment damaged this trip? What? ________

What will it cost to repair? Materials ____________
Labor ____________
Who will pay for it? ____________
Who will supply the labor? ____________

APPENDIX D

Village Based Interview: Fixed Cost Questions

I. Service Costs

What annual or monthly expenses do you have for the following:

Mooring Fee	Monthly ______	Annual ______
Guard/Protection	Monthly ______	Annual ______
Membership	Monthly ______	Annual ______
Accounting	Monthly ______	Annual ______
Legal (Insurance)	Monthly ______	Annual ______
Other	Monthly ______	Annual ______
Other	Monthly ______	Annual ______
Other	Monthly ______	Annual ______

II. Crew Costs

Do you provide housing, food, education fees etc., to your crew or their families? If so what?

______	Monthly ______	Annual ______
______	Monthly ______	Annual ______
______	Monthly ______	Annual ______
______	Monthly ______	Annual ______

III. Investment Costs

Hull

Type: ______ Length: ______ Width: ______
What is the capacity (maximum) of fish that the boat (hull) can carry? ______
How old is the hull? ______ How much did it cost you? ______
When did you buy it? ______
What would be its value if you sold it now? ______
How much did it cost (hull) when it was new? ______
How much would it cost to buy a new hull equal to this one? ______
How much longer will the hull last — working as it is? ______
Have you made any major improvements or repairs in the hull in the recent past? (1-2 years) When?
What? ______
How much did it cost? ______
Did you get a loan to buy the hull? (If he says yes, continue): (If he says no, go to motor).
How much was the loan for? ______
When did you receive it? month ______ year ______
How much did you *actually* receive? ______
Who is the creditor? Bank? ______ Which bank? ______
Family? ______ Friend? ______ Money Lender? ______ Financer? ______
Other? ______
How much do you pay monthly against this debt? Interest ______ Principal ______
Is this monthly payment decreasing? ______ Remaining Constant? ______
or increasing? ______ What rate of interest are your paying? ______
How many payments do you still have to make? ______
Did you have to put up any collateral as insurance on the loan? ______
What did you use as collateral? ______ What is its value? ______

Motor

What brand is the motor? ____________ Horse Power? ____________
What does it use? Gasoline or diesel fuel? ____________
How old is the motor? ____________
When did you buy it? ____________
How much did you pay for it? ____________
How much would you get if you sold it today? ____________
What did it cost when it was new? ____________
How much would it cost to buy the same new motor today? ____________
How much longer will this motor last? ____________
Have you made any major improvements or repairs in the motor in the recent past? (1-2 years) When? ____________
What? ____________
How much did it cost? ____________
Did you get a loan for this motor?
How much was the loan for? ____________
When did you receive it? Month ______ Year ______ How much did you actually receive? ____________
Who is the creditor? Bank? ______ Which Bank? ____________
Family? ______ Friend? ______ Money lender? ______ Financier? ______
Other? ____________
What is the monthly payment on this loan? Interest ______ Principal ______ Total ______
Is the monthly payment getting smaller? ______ Staying constant? ______ Increasing? ______
What interest rate are you paying? ______ How many more payments remain? ______
Did you put up any collateral for the loan? ____________
What did you offer? ____________ For what value? ____________

Gear

What kinds of gear do you have?

Gear Type	What kind?	How many?	What size?
A	______	______	______
B	______	______	______
B	______	______	______

How old is each gear
A ______ B ______ C ______

What is its value if you sold it today?
A ______ B ______ C ______

How much did it cost you?
A ______ B ______ C ______

When did you buy it?
A ______ B ______ C ______

What did it cost when it was new?
A ______ B ______ C ______

How much would it cost to replace it with new gear of the same type(s)?
A ______ B ______ C ______

How much longer will it last?
A ______ B ______ C ______

Did you get a loan to buy the gear?
A ______ B ______ C ______

How much was the loan for?
A ______ B ______ C ______

When? Month & Year?
A ______ B ______ C ______

How much did you actually receive for each piece of gear?

A __________ B __________ C __________

Who is the creditor?

A __________ B __________ C __________

How much in total do you pay on these loans monthly? __________

How much of this is interest? __________ Principal? __________

Are these payments going down? ______ Staying constant? ______ Getting larger? ______

What interest rate are you paying on these loans? __________

How many more monthly payments must you make? __________

Did you put up any collateral for these loans? __________

What was the collateral and its value? __________

Other

Do you have (own) other equipment: for example, vehicles, buildings, docks, i.e. any equipment related to fishing activity?

Do you have any other major debts? For what? __________

What is the size of the debt? __________

Owed to whom? __________

How much do you pay monthly? __________

Are these payments going down? ______ Staying constant? ______

What interest rate are you paying? __________

How many more payments must you make? __________

Did you put up any collateral for these loans? __________

For what value? __________

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