Summary and Importance of the GCFI Sessions on Spiny Lobster[1]

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I have been asked in this presentation to summarize and review the papers presented at the session yesterday (12 November 1980), and to point out their relevance to the Spiny Lobster Workshop that is under way today. I have arranged my contribution under the six headings which you will use in the course of your deliberations during the next 2 days: (1) Management Objectives, (2) Biological Research, (3) Economics, (4) Administration, (5) Regulations and (6) Cooperative Programs.

The papers presented, which will serve as the basis of my summary, do not include information on all of the spiny lobster fisheries of the Caribbean area; in fact most are missing, but the papers available do provide excellent examples of research and management problems and solutions – an array sufficient for useful discussion.

1. MANAGEMENT OBJECTIVES

In some ways the development of management objectives is the most important of all steps in the preparation of a fishery management plan. If the objectives are not appropriate to the fishery involved, or if they are not stated clearly, the rest of the work may fail and an unworkable or faulty management plan may result. Time will therefore be well spent by careful and thoughtful attention to the specific objectives appropriate to the particular fishery involved.

Management objectives may be classified into three categories: (1) Biological, (2) Economic and (3) Social.

Biological objectives relate to the conservation of the resource, including the important matter of preventing biological overfishing. Economic and social objectives are sometimes difficult to separate one from the other, relating as they do to the individual and corporate profitability of the fishery and the impact of management on the status and life style of participants in the fishing industry at various levels. In developing fishery management objectives it will quickly become apparent that some desirable biological objectives may be incompatible with certain economic or social objectives, or that there may be incompatibilities even within a single category.

The objectives will differ according to: (1) the nature and the stage of the fishery, (2) the local economic and social system and its values, (3) the size and nature of the markets for the products and (4) other special local needs.

In developing management objectives for the lobster fisheries of the Caribbean there are particular complications that may make the development of a management plan more difficult than in some other areas. One of the significant special difficulties is that in many parts of the Caribbean the spiny lobster fishery is tied to and in many cases subsidiary to a trap fishery for fish. Secondly, in many of the countries of the region the information required to implement a management system is missing. In that case, objectives may have to be modified, and certain desirable objectives delayed until it is realistically possible to put them into practice.

[1] Also published by the WECAF Project, Panama, as the introduction to the Spiny Lobster Workshop.

Biological Management Objectives

In the papers presented at yesterday's session the following biological management objectives were set out as desirable, or as ones that were already being used as the basis for existing management schemes: (a) to ensure the conservation of stocks (Cato and Prochaska); (b) to achieve maximum sustainable yield (MSY) (Vega and Dammon for the Puerto Rico and Virgin Island fisheries; Hancock for the Western Australian fishery); (c) to provide recruitment (Richards and Potthof) and to prevent recruitment overfishing (Waugh for the Bahamas fishery; Hancock); (d) to maintain spawning populations (Richards and Potthof); and (e) to avoid growth overfishing (Hancock).

Economic and Social Management Objectives

The Chairman of the Spiny Lobster Session, Dr. Albert Jones, reminded us that management of fisheries involves the control of people, with the manipulation of the fish (or the lobsters) being incidental to the management of the fishermen and the others making use of the resource. Chitty made the same important point in his lead paper. This is a fundamental economic and social fact that underlies the whole of the exercise of developing fishery management goals.

The papers of the session stated the following economic/social management goals, either explicitly or implicitly:

a) to provide equitable allocation of the harvest,
   (i) income distribution (Cato and Prochaska),
   (ii) allocation between the commercial and recreational segments (Davis for the Florida fishery);
b) to provide maximum benefits from the utilization of the resource,
   (i) for society as a whole,
      (1) maximum economic yield (Cato and Prochaska),
      (2) economic efficiency (Vega and Dammon for the Puerto Rico and Virgin Islands fisheries),
      (3) social and cultural needs (Vega and Dammon),
   (ii) for the individual,
      (1) to improve the economic condition of the fishermen (Hancock);
c) to maintain or increase employment (Hancock).

The significance of the papers reviewed in terms of the management objectives may be summarized as follows:

Objectives should be tailored to local needs. It may be important to maintain or increase employment in the fishery, even at the expense of some economic or biological maximization of the returns from the fishery. Or there may be local specialized needs to provide strong protection for the stock that is being exploited; to protect the income of the fishermen and other workers in the fishery; to provide equitable or some sort of special distribution of the catch or the profits. Or there may be some special requirements of the local or the export markets that require modified or unusual management objectives.

Objectives should be realistic in terms of what is possible to achieve with existing administrative machinery. If research, marketing or other information is not available; if law enforcement machinery is not good enough to enforce the regulations necessary to implement certain objectives; if central and field

administrative staffs are not capable of performing the backup tasks that will emerge from certain objectives, then these objectives should be scaled down to realistic levels.

Objectives should be realistic in terms of what is possible politically. The general philosophic basis of a set of management regulations and the regulations themselves must have the approval of the people affected. That is not to say that the fishermen or others being regulated must like the proposed regulations, but they must be persuaded that they are generally necessary, rational and fair.

Objectives must be capable of translation into regulations that are enforceable. Hancock cautions against such regulations as those that depend on boundaries drawn on water.

Objectives should allow for change, and for periodic review.

2. BIOLOGICAL RESEARCH

In years past nearly all the regulations that formed the framework for fishery management were based (at least in theory) on the results of biological research. That is no longer the case, with the realization of the need for consideration of economic and social considerations in designing management programs. Nonetheless, biological research is still the largest single source of the information used in this kind of activity.

Fishery managers and other adminstrators are never supplied with all biological information they could use for the optimum set of regulations. Yet, regardless of the paucity of information, if a fishery requires protection, a managament plan must be conceived and put into operation with whatever data are available.

In most fisheries the amount and kind of biological information needed is substantial and complex. Often its collection takes years of work, and is costly. Chitty pointed out in his paper that adminstrators should estimate these costs, measure them against the expected returns to the community from implementation of a management plan, and decide from this analysis whether the cost of the research is warranted.

Two of yesterday's papers are especially valuable in setting out guides to the biological kinds of research necessary to supply information required for rational and workable fishery management plans. Waugh, in discussing his work on the Bahamas lobster fishery, provides a useful checklist of information needed, and the kinds of research that should be performed to accumulate this. Hancock suggested that there were different kinds of research programs required at four stages of a fishery: (1) The developing fishery, (2) The regulated fishery, (3) The fully exploited fishery and (4) The fully controlled fishery.

He points out that the kind and amount of research becomes increasingly complex, and therefore increasingly expensive as a fishery advances from one stage to the next. This classification is also useful in reminding scientists and administrators that some kinds of research are not needed in the first stages of a fishery, thus saving effort and money.

In this review I have arranged the biological research needs in the following categories: (1) Larvae and larval recruitment, (2) Production and population models, (3) Recruitment overfishing and (4) Bait.

Research on larvae is related to both stock recruitment and the question of the possible foreign origin of larvae. Considerable attention was paid in the session yesterday on these two problems and on research relating to them.

There is convincing evidence that spiny lobster larvae are carried into near-shore areas throughout the Caribbean and south Florida regions from distant waters. Drift bottle and other evidence reveal that current patterns and velocities are such that larvae can be carried in a generally east to west direction, and that the long life of the phyllosoma larvae, which have a pelagic existence for about 8 months (a range of 6 to 12 months), allows ample time for transport by these currents over very long distances. Moreover, in some areas, including Florida, the presence of larvae over the whole year strongly suggests that at least some of them are of foreign origin because the seasonal spawning pattern of the Florida stocks could presumably not supply larvae during every month.

If this evidence is taken at face value, and it is assumed (as some observers have done) that each stock of spiny lobster depends for its supply of larvae on another spawning stock downtream, the management implications are critical. This is a comfortable theory in the sense that administrators in a particular area are not required to provide regulations to protect the spawning population. And if the theory turns out to be correct, it could lead to a dangerous situation unless an unusual amount of cooperation were to be exhibited by the many countries sharing intermingling lobster populations.

Despite the substantial evidence that spiny lobster larvae from foreign sources are recruited to the inshore waters of Florida and other lobster habitats, Menzies reports that there are apparent genetic differences among the adults of populations from different parts of the Caribbean, instead of the genetic homogeneity that would be expected if widespread mixing of phyllosoma larvae occurred. These apparently contradictory results could be explained if larvae carried to a distant area fail to survive because of inability to adapt to an environment different from the one where they were spawned. This point, so vital to the development of a rational pan-Caribbean management scheme, has not yet been settled. Research required on a number of points relating to the problem was identified by the authors of yesterday's panels:

a) The Need to Develop Taxonomic Criteria for the Specific Identification of Specimens of Larvae Captured in Plankton Hauls. The location of the capture of larvae and their stages of development are critical to the larval recruitment problem, but at present it is not possible to distinguish among the several closely related species (Richards and Potthof).

b) Data on the Rates of Growth of Spiny Lobster Phyllosoma Larvae and the Length of the Total Larval Life. On the latter point estimates range from 6 to 12 months, with some of the best data suggesting that 8 months may be correct. This has very important implications for spiny lobster management since the length of larval life (combined with the direction and strength of the ocean currents) controls the distance larvae can travel from point of hatching to point of settling as puerulus larvae (Richards and Potthof; Lyons; Menzies).

c) The Absence as well as the Presence of Phyllosoma Larvae in the Plankton Hauls. When hauls are sorted, the presence of spiny lobster larvae may be

recorded if this is requested, but unless special instructions are given the absence of larvae will not be noted. Information on the periods of the year when no lobster larvae are present will assist substantially in understanding the relationship between spawning and recruitment, and the origin of larval recruitment in a particular area (Richards and Potthof).

d) Genetic Differences Among Adult Populations. Early results from biochemical research show that spiny lobsters are genetically separate in most areas of the Caribbean where tests have been conducted; there are some exceptions, which may be explained by sampling inadequacies. But the question is still unsettled, and further research is essential (Menzies; Lyons).

e) Water Current Patterns. The large-scale current patterns of the Caribbean have been delineated well enough to indicate that their direction and strength are such that larvae could be transported long distances. But limited studies of small-scale local current patterns suggest that locally spawned larvae could be recruited back to the parent population, and more of this kind of study is required in many areas.

f) Genetic Structure of Larvae. If the genetic structure of larvae entering an area (e.g., Elliott Bay in south Florida) is not the same as that of the adult population, it would suggest that larvae from downstream are not surviving, and that local adults are the product of local recruitment, even though this may be small (Menzies).

Production/Population Models

Intelligent management of lobster fisheries requires that certain data be collectd from the fishery and that additional information be obtained by special sampling programs. Management decisions can usually be improved with the addition of more information, but Lyons lists the following data as the minimum required to construct usable production models for spiny lobsters: (a) Quantity of lobsters captured, (b) Species composition and (c) Amount of fishing effort, by gear.

In addition, Cato and Prochaska suggest that length frequencies of the animals caught should be obtained.

Clearly many other kinds of information would be useful to the fishery manager engaged in the conservation of spiny lobster stocks, but in many parts of the Caribbean the collection of even the minimum kinds of information listed above presents a challenge. Lobster fisheries in many parts of the area are parts of multi-species fisheries, with fish being the major targets. Further, the social structure of the fisheries are often such that data are biased. In addition, manpower and money resources are often inadequate to collect even the minimum information (Cato and Prochaska). Regardless of the abundance or paucity of resources, expenditures for research should be scrutinized against the value of the resource before they are committed (Chitty).

Recruitment Overfishing

For animals with high fecundity, including most invertebrates, there is usually no demonstrable correlation between fishing pressure and recruitment. This pattern holds for most spiny lobster populations where data have been available to test it, but there is evidence that in some highly exploited stocks fishing pressure, breeding stock and recruitment levels are related (Hancock). It is essential that such a relationship be identified and measured, if it exists. The research should be designed to determine not only the minimum size of animals allowed to be caught but also the

maximum fishing pressure to avoid recruitment overfishing (Waugh; Hancock): (a) Measurements of the size, weight, age composition, growth rate, mortality rate, size at first maturity and migrations of the lobsters (Hancock); (b) The spawning season, longevity and rate of exploitation (Hancock); (c) Fecundity; definition of unit stocks, (d) The relationship between annual catch and fishing effort - stock production models (Hancock); and (e) The relationship between recruitments and breeding stock (Hancock).

Bait

The fishery in the Florida Keys uses undersized lobsters ("shorts", those less than 76mm carapace length) to attract larger lobsters into traps. Shorts are highly effective as bait: in one experiment traps using cowhide as bait caught significantly fewer lobsters per week than traps using cowhide plus three small lobsters (Lyons). Fishermen maintain that there is no adequate substitute for undersized lobsters as bait.

But there is ample evidence that the use of small lobsters as bait is highly detrimental to the population. Fishermen bait their traps with from two to eight (and sometimes as many as 15) sublegal lobsters; if the average is taken as three, more than one million shorts are confined in traps at a given time during the height of the season. The damage to the lobsters from handling and confinement in traps causes high mortality and reduced growth from starvation. Studies conclude that "enormous losses (up to 93%, discounting recreational harvest) of lobsters to the legal fishery are attributable either to illegal harvest of shorts or to heavy, fishery-related mortality." Despite these detrimental effects, the effectiveness of using undersized lobsters as bait has persuaded authorities in Florida to legalize this practice.

But if an effective substitute bait could be developed far more legal-sized lobsters would enter the fishery. Lyons states that "Curtailment of this practice, together with cessation of illegal harvest, should produce approximately twice as many lobsters as are presently available for legal harvest."

It is obvious that the development of an effective bait to substitute for the use of undersized lobsters is a high priority research subject.

3. ECONOMICS

In the end, solutions to management and development problems in the fisheries must be economic solutions: fishermen, wholesalers and others involved must operate at a profit. All biological regulations aimed at the objective of conserving the resources must be qualified and modified by the economic realities, and in some cases optimization of yield must be foregone for the sake of economic values. The sequence of events in designing fishery regulations is, first, that solutions are proposed for biological problems, which would hopefully result in the maintenance of an adequate fishable stock. These solutions may then have to be modified and adjusted to take into account the economic conditions in the fishery, a principal one being to provide for a catch per unit of effort which would permit reasonable individual profits. An example among lobster fisheries is the Florida industry. Apparently biological management has resulted in the stabilization of the stocks at close to biological optimum levels, yet the fishery is troubled, and requires control for economic problems.

The usual economic forces of the market place do not operate fully in common property fisheries. As a result, vessels continue to enter the fishery long after the average individual profit levels are unsatisfactory, and economic inefficiencies multiply. Hence, fishery management that exhibits any kind of sophistication, and which meets with the approval of those effected, has been shown to require economic considerations. Obviously, no successful fishery management scheme can operate by economic criteria alone, but the biological controls must be combined with and modified by economic controls.

If biological data are scarce in the lobster fisheries of the Gulf and Caribbean region, economic information is even more inadequate. This is both because the need for these data has become apparent only in relatively recent years, and because economic data are difficult to collect.

Three of the papers presented yesterday focus strongly on economic considerations in developing management strategies for spiny lobsters. That by Cato and Prochaska provides a valuable theoretical background, and discusses some of the problems associated with implementing economic/social regulatory controls. Their paper also contains an extensive table of economic data requirements. Austin focuses on one of the more difficult and controversial kinds of such control, that being the institution of limited entry, and points out the difficulties that face the implementation of such controls in the Florida fishery. Hancock provides valuable accounts of experience in Western Australia in management by limited entry, and the difficulties and successes experienced there are illuminating. These three papers, and some of the others that were presented, provide suggestions for the kinds of economic research necessary or useful as background for the management of spiny lobster fisheries. I have categorized these research needs as follows: (a) Demand analysis, (b) Social/cultural data and (c) Overcapacity in the fisheries: Effects of overcapacity and Control of overcapacity.

Demand Analysis

Detailed examination of markets for fishery products, especially in developing countries, has been neglected. The need for this has often not been realized, and even where it has been the data are commonly not available. But the variations that always take place in supply, demand and price functions in fisheries industries, and the shifts that occur in economic targets, require examination and analysis if management is to be fully effective. Hence, to the extend that resources for the collection and handling of data are available, information on prices, consumption, demand and related functions should be collected (Cato and Prochaska).

Social/Cultural Data

Cato and Prochaska point out that decisions reached solely on economic efficiciency or biological information may not be the best decisions for a particular fishery. To avoid mistakes, certain social and cultural data are useful, including "profiles" of the fishermen describing their education, amount of fishing employment, incomes earned by fishing and otherwise, job opportunities outside fishing, personal goals, and related matters.

In addition, social/cultural data are required before decisions can rationally be made about the distribution of the profits of managed fisheries, especially if limited entry is involved.

Effects of Overcapacity. The most profound change that has taken place in fishery management in the past 20 years has been the development of the theory that advantages gained from successful control of biological parameters can be dissipated because of the loss of economic efficiency that results from the influx of too many vessels or fishermen in relation to profits available. Overcapacity results in a loss to the economy of capital and manpower for alternative activities. In order to detect and measure this loss, it is essential to consider related segments of the economy and not study the fisheries in economic isolation. The additional competition which follows overcapitalization has a direct and immediate effect on the catch per unit of fishing effort, and on the profits of individual fishermen. But both the analysis and the cure for this condition (including the improvement of economic efficiency) are complicated. In the Caribbean, lobster fisheries are commonly only adjuncts to trap fisheries for fish (Austin; Cato and Prochaska.)

Control of Overcapacity. The most direct way of controlling overcapacity is to limit the number of participants in a fishery–the number of fishermen, vessels or gear. This is by no means universally accepted as a satisfactory procedure, although it is in operation in many fisheries throughout the world (for example, Japan, Canada) and is in place in some fisheries in the United States (Alaska). The spiny lobster fishery of Australia has been under limited entry for a number of years, and despite imperfections it has the support of the industry and the government (Hancock).

Imposition of a limited entry system in an established fishery is complicated by a number of problems. One is the common lack of data sufficient to make satisfactory calculations of the models to be used in designing the system (Cato and Prochaska). Secondly, with fewer vessels engaged in the industry, the value of licenses increases, sometimes to very substantial levels. Difficulties often arise in making the political decisions as to who receives the economic advantages of these increases, and of the larger catches that follow decreased competition. Cato and Prochaska assert that to be equitable the system must extract the "rent" that is produced by limited entry; this can be done through taxation. Hancock disagrees, on the basis of experience in Australia, and believes that limited entry will not be approved by fishermen in the first place unless they are the beneficiaries economically. A third problem is that the effective level of fishing effort is not reduced by limited entry alone, since the survivors are the most efficient fishermen, and fishing operations gradually improve in efficiency. Both these factors erode the amount of reduction originally achieved by reducing the number of vessels (Cato and Prochaska; Hancock).

Fishing effort can also be controlled by the imposition of quotas that limit the amount of landings. Hancock states that this has not been favored in Western Australia on the grounds of dampening of incentive, problems of policing and difficulty of forecasting quota levels.

Effort can also be limited through the imposition of taxes and fees. This encourages more fishermen to leave, and extracts part of the economic rent. It is the least palatable politically of the various methods of reducing fishing effort (Cato and Prochaska).

Austin, in his analysis of the possibility of applying limited entry to the Florida lobster fishery, concludes that social and economic problems are too great for this to

be feasible there at present. The common property heritage in the fishery is too strong to allow fishermen to accept the new concept yet, especially since the condition of overfishing which might be overcome in some degree by limited entry is a relatively new phenomenon. Further, it has been difficult to devise a satisfactory system for distributing the economic advantage of limited entry among the various possible recipients–the fishermen, others in industry, and the consumers.

4. ADMINISTRATION

Among the papers presented yesterday, the important matter of establishing and operating an adminstrative system for the management of lobster fisheries was treated specifically only by Hancock. His description of the Australian system provides valuable guidance for other countries on this matter.

In Australia, administrative authority for the fisheries is shared by the Federal and State governments, with the Federal authority being generally applied to activities outside 3 miles. This division of authority resembles that in the United States, and its effect on lobster management in Puerto Rico and the Virgin Islands is evident in the paper by Vega and Damman. That paper describes the spiny lobster Fishery Management Plan prepared by the Caribbean Fishery Management Council, a group consisting of Federal and State officials, and other interested persons.

The division of authority in Australia includes the assignment to the State governments of responsibility for the day-to-day management of the fishery, including the issuance of licenses, law enforcement patrol and inspection, and certain kinds of biological research. Federal responsibility includes the conduct of biological and economic research, and the imposition and enforcement of export quality controls. Research is also conducted by some universities in the region.

Stress was placed by Hancock on the importance of the industry advisory committee which has been established to review proposed regulations, or other matters that would affect the operation and profits of the industry. Substantial decisions are not made without being discussed beforehand with this committee, and without gaining the agreement or at least the understanding of the committee members.

Hancock supplied figures for the cost to the government of administering and developing the Australian lobster fisheries, which recently have amounted to about 2.5% of the gross local value of the catch. These costs breakdown as follows: administration 18%, inspection 61%, research 21%. A small amount of this cost is recovered by the State from the industry, in the form of limited entry license fees and licenses for fishermen and vessels.

The costs of administration (including enforcement and research) are rising rapidly, and Hancock cautioned authorities that a fully regulated fishery may impose such high costs that the monetary returns to society are not sufficient to justify them. In their paper on economic research, Cato and Prochaska make this same point in reminding administrators of the high cost of research (biological and economic/social). The message is clear that there may be some fisheries where the value of the product does not justify an elaborate admistrative/research establishment.

5. REGULATIONS

Regulations applied to a fishery are the methods used to implement management objectives. Jones, in his opening remarks as chairman of the session, and Chitty, in his lead-off paper, both reminded us that fishery management controls the activities of people and not of the fish. In line with this, Waugh stated that the design of fishery regulations should involve an understanding of the beliefs, values and attitudes of those who are regulated directly or are otherwise affected by the regulations. And Hancock warned against instituting regulations that are not easily enforceable.

In the discussions of the countries covered, the following regulations were included: (a) Minimum size, (b) Closed areas, (c) Retention of females bearing eggs, (d) Closed seasons, (e) Size and design of traps, (f) License limitation, (g) Requirements to supply data, (h) Gear regulations and (i) Sport fishermen.

a) Minimum Size. Puerto Rico and the Virgin Islands impose a minimum size below which lobsters cannot be legally retained (89 mm carapace length). The purpose was stated to be to prevent growth overfishing (Vega and Damman). Castillo reported on an extensive examination of the length frequencies of lobsters landed in the commercial catch in those islands in order to determine the effect of this regulation on trends in average sizes of lobsters. Florida imposes a minimum size (76 mm carapace length), also for the stated purpose of preventing growth overfishing (Lyons). But in this case the regulation "does little to protect spawning stocks." The fishery is so intense that it leaves only small newly mature females (whose fecundity is smaller than that of large individuals) in the stock to spawn. The reproductive potential of the Florida Keys population has been reduced approximately 88% from that of a natural population, and it appears that the minimum size should be raised from the prevailing 76 mm carapace length to 90 mm to ensure most lobsters an opportunity to spawn at least once.

Furthermore, the existing minimum size limit of 76 mm in Florida does not result in the highest total yield in weight (Davis), providing only between 84 and 88% of maximum possible weight yield.

Despite these deficiencies, the present minimum size in Florida is proposed to be maintained, since the monetary gains would be small and the social losses substantial from an increase in the legal minimum size. An increase to 90 mm would result in a decrease in the price per pound by an estimated 7%, and an increase in the total yield by 12 to 17%–a net gain of 5 to 10% in gross revenue. This is not regarded by the Fishery Management Council (which is designing regulations for this fishery) as enough to justify the disruption of fishery practices and the costs to fishermen of an increase in the legal size.

The minimum size in the Bahamas (86 mm) is larger than that in Florida; this is believed to give greater biological protection to the stock, but raises problems when the catch is exported to the United States, where the market is geared to smaller animals (Waugh).

In Western Australia the legal minimum size (76 mm carapace length) is also below the size that would prevent growth overfishing, but for economic reasons the adjustment in size would not be worthwhile because of the extra costs that would be imposed on the fishermen.

b) Closed Areas. Closed area regulations are imposed in the Virgin Islands and Puerto Rico to prevent growth overfishing (Vega and Damman); in the Bahamas to

assist growth of juveniles, to promote recruitment, and to reduce juvenile recruitment (Waugh); and in Australia seasonally to reduce juvenile mortality through handling and mortality of adults through transport (that is, the most distant grounds are closed because mortality increases with the length of time in transport) (Hancock).

c) Retention of Females Bearing Eggs. It is illegal to retain and sell berried females in Puerto Rico and Virgin Islands, in order to maintain the spawning population and to provide recruitment (Vega and Damman; Castillo). Hancock expresses doubt that this regulation has any usefulness in a developing fishery, but states that it may be necessary in an intense fishery. In Florida the regulation is in force but its biological validity is in doubt.

d) Closed Seasons. Florida imposes a closed season for the purpose of protecting spawning females and promoting a more efficient harvest (Austin; Lyons). In Australia this regulation is imposed in order to maintain the spawning population and to reduce fishing effort. Hancock states that a closed season is not effective by itself for the latter purpose. Further, it appears that lobster populations can be fished to levels where recruitment is significantly reduced, and a closed season may be effective in protecting such stocks. Hancock says that this apparently has not occurred in Australia, but he suggests that managers must be alert to the possibility.

e) Size and Design of Traps. Most of the reports on western hemisphere lobster fisheries did not include regulations on gear, but in Australia these are important; the traps must have minimum sized escape panels. Further, the sizes of traps are being regulated in Western Australia, to standardize and control fishing, and this incidentally will assist in the analysis of catch per unit of effort in population dynamic studies (Hancock). In the Bahamas the new regulations include requirements to have self-destructing panels on traps and door fastenings. Because of the use of undersized lobsters as bait, no "escape" regulations exist in Florida, despite the demonstrated high losses due to the captures and retention of small animals.

f) License Limitation. The limitation of licenses is believed by some economists to be the only effective way of avoiding or overcoming overcapacity in a fishery (Austin). Hancock believes that limitation of the number of licenses has been a key to the successful management of the Australian fishery.

Limited entry in the Florida fishery, which has been determined to suffer from overcapacity, has been considered and rejected (Cato and Prochaska; Austin). Studies have shown that by reducing the fleet by 186 vessels maximum profits would be possible, saving 14% in costs and raising the annual profits per boat from $6,677 to $18,350. A reduction from the current 300,000 traps to 100,000 would result in a 211% increase in the catch per trap. Predictably, the fishermen approved of this aspect of limited entry program; but perhaps almost equally predictably, a majority of fishermen rejected any of the proposals of how to accomplish this end: choosing the surviving license holders by lottery, by auction, or by past performance. But if patience can be exercised by the manager, so that the reduction is by attrition after current operators are allowed to have licenses, reduction can be achieved equitably.

g) Requirements to Supply Data. Regulations in Puerto Rico and Virgin Islands include the requirement that fishermen must supply data on catch and effort (Vega and Damman). Waugh believes that such a regulation is the single most important

to be imposed on the Bahamas fishery. In Australia a substantial quantity of information is required of fishermen and dealers as one price of their participation in the industry (Hancock): a) from the fishermen, details of weight of lobsters caught, by area; average number of pots pulled per day; number of fishing days for each depth; b) from the processors, details concerning the fishermen who supply them (including home anchorage); registered boat number; live weight supplied to them; sales, by size of box and in seven lobster size categories; amounts held in cold storage. In addition, 20-25% of the fishermen voluntarily keep logbooks in which they record fishing effort and catches in 10-mile transects, by four depth categories, plus data on weather and other variables.

h) Gear Regulations. Puerto Rico and the Virgin Islands impose regulations prohibiting the use of poisons, spears, hooks, or explosives for catching lobsters (Vega and Damman). Hancock reports that in Australia pots must include a rectangular escape gap to allow the escape of under-sized lobsters; that the pot may have only one entrance, on the top; and that a pot may not be larger than one meter in any dimension. Spearfishing is prohibited.

i) Sport Fishermen. Lobster sport fishermen in Western Australia must have licenses, and may not use more than two pots nor catch more than eight lobsters in a day and are prohibited from spearfishing (Hancock). In Florida, sport fishermen in pursuit of lobsters may not use hooks, spears, or gigs. These fishermen are allocated a special 2 day exclusive fishing season (Austin).

Modification of Regulations for Local Needs

The papers presented yesterday include several examples of how regulations based originally on biological data are modified to accommodate to special local conditions, and to economic, social, or political realities:

1. The minimum legal size of lobsters in Florida is smaller than the size that would yield the greatest catch, and this is permitted because the restaurant market prefers the smaller sizes and will pay more per pound for them. This results in a larger total value to the industry, and reminds us that in the end the fishermen are fishing for dollars and not for fish. The minimum size limit regulation in Western Australia originated for a similar reason.

2. A nearly universal regulation against the retention of egg-bearing females prevails in the face of acknowledgment by biologists that in most cases there is no convincing evidence that this regulation is required to maintain the spawning population at a satisfactory level. This is literally a "motherhood" ethic, and its translation into a fishing regulation may impose an unnecessary and costly rule on the industry.

3. The use of undersized lobsters as bait in Florida is patently a destructive and wasteful practice. It is nonetheless permitted because it has become deeply embedded in the fishing practice, and authorities in the state believe that the economic and political costs of prohibiting the practice would be too great.

4. The design and size of traps is regulated in Western Australia, even though this may impose some inefficiencies on fishermen. The justification is to control fishing effort, with the added bonus of making population parameters more reliable.

5. License limitation works well in Western Australia, and may be desirable in the Florida and perhaps other lobster fisheries, but social and political difficulties have made it impossible so far to put such regulations into force in the latter fisheries. The

problem in Florida revolves around the question of whether to allow the economic advantages that will result from limiting entry into the fishery to accrue to individual fishermen or to society as a whole.

6. COOPERATIVE PROGRAMS

The necessity for cooperative lobster research and development programs in the Caribbean is unusually great. On the one hand, there exists a possibility that there is an "open system" lobster population in the region, with widespread larval dispersement and recruitment of populations from downstream sources. If this turns out to be a fact, to whatever degree, then cooperative management and the research that supports such management are required if the lobster stocks are to be maintained. Whatever the truth turns out to be about the way that the Caribbean lobster populations are recruited, there are enough common biological and other features concerning the stocks and their fisheries that the results of all research done in the region will have relevance to each of the countries possessing lobster populations.

It is always (or nearly always) advantageous to cooperate in research and development work where similar fisheries are involved. This permits the pooling of resources, knowledge, and experience, which usually leads to increased efficiency and more useful results. Cooperation is actually essential, rather than merely desirable, where shared stocks/fisheries are involved, if fully effective management is to be achieved. There are ample examples of the truth of this: the international fishery research performed in the North Sea, in the Northwest Atlantic, by the salmon commissions. In the Caribbean and the southern United States lobster fisheries there seems to be an unusually good opportunity, even a strong necessity, for active well planned cooperative programs.

The following cooperative lobster programs were proposed in the various papers presented:

a) Origin of Recruitment. Both Menzies and Lyons pointed out that even if there proves not to be Caribbean-wide recruitment of young lobsters from spawning areas downstream, there may be some local areas where one political unit receives recruitment from spawning stocks in another unit. As long as the jury is still out on this question, continued research is essential, and this can most effectively be done through cooperation among research units.

b) Relationship between Larval, Postlarval, Juvenile and Adult Populations. (Waugh).

c) Abundance of Juveniles. (Waugh).

d) Coordination of Management Systems. Cato and Prochaska point out that ineffective or ill-advised management practices may have adverse affects not only on the stocks and the fisheries to which they are applied indirectly, but possibly on those of other areas where there is some sharing of the populations.

e) Data Standardization. If data are collected and analyzed in a manner agreed upon cooperatively and in a way that helps achieve common biological and economic management goals, considerable efficiency will be promoted.

VITAL ISSUES REQUIRING RESOLUTION

In summary, there appear to be three especially important issues in the spiny lobster fisheries which should be the focus of most management plans in this

hemisphere:

1) The Stock/Recruitment Relationship. If a relationship is demonstrated between the size of the spawning stock and the size of the recruited stock, regulations should be designed to take this into account. Such regulations include the minimum size at capture, the release of berried females, closed seasons and areas. If a relationship does not exist, modifications to such regulations should be considered to avoid waste.

2) Optimum Allocation of Harvest and Profits. This is the area of economic and social control of the fishery, where decisions are often very difficult. The alternatives available to the managers include: (a) Control the fishery only as necessary for biological conservation. Some fisheries are managed at this level; in most cases this kind of management is not adequate. (b) Impose some kinds of economic regulations. If this includes limiting the number of participants, a further decision is required, whether to tax away the economic rent from the fishermen and distribute it to the general treasury or to some other recipient, or to allow the rent to be kept by the fishermen. The former course of action may be politically unacceptable, while the latter may reduce economic efficiency.

3) Interdependence of Lobster Stocks. Management cannot be fully effective until it is known whether the Caribbean and the adjacent lobster stocks are all interconnected, all separate, or somewhere between these extremes.

The priorities of effort which should be applied to these problems depend on the local management needs which are expressed as the management objectives. Thus we have come back full circle in our discussion of information required to conduct lobster management plans: from objectives, through the research needs, administration, regulations, and cooperative programs, back to objectives. This emphasizes the importance of considering local differences and requirements, and reminds us that there is no single "right" solution to any of the problems of controlling or developing spiny lobster fisheries. It is worth noting again that even a demonstrably right solution to either a biological or economic problem may have to be modified because of special local conditions — the lobster fishery is often only one part of a mixed fishery; market pressures and trade agreements; tradition; entrenched catching systems; and political acceptance.

Yet despite all of the complexities and roadblocks to management of the spiny lobster fisheries, the papers presented yesterday must encourage all of us that substantial progress is being made, and that continued effort will result in more countries attaining a measure of useful control over this resource.