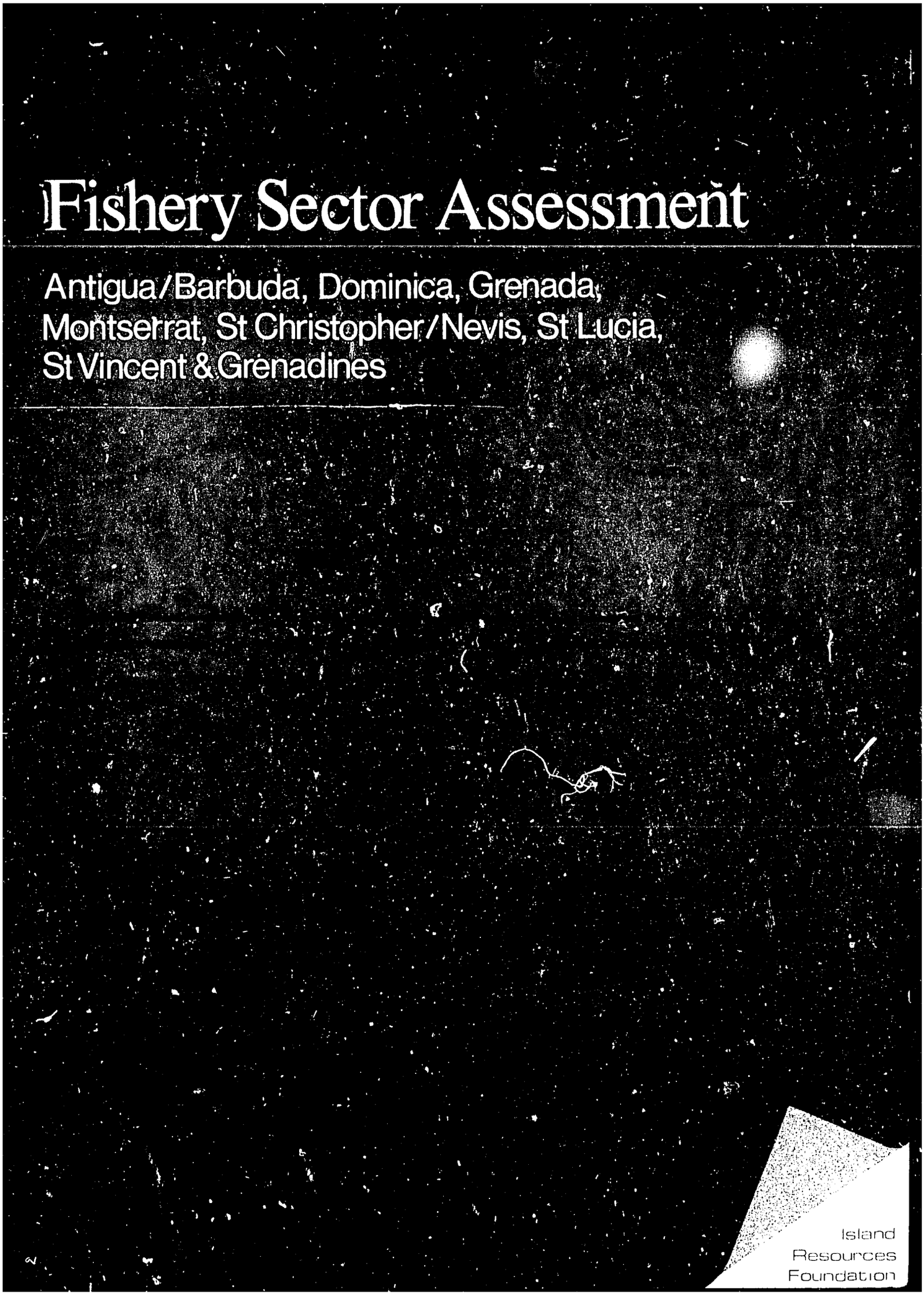
Fishery Sector Assessment

Antigua/Barbuda, Dominica, Grenada, Montserrat, St Christopher/Nevis, St Lucia, St Vincent & Grenadines



Island Resources Foundation

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FISHERY SECTOR ASSESSMENT FOR THE EASTERN CARIBBEAN:

Antigua/Barbuda, Dominica, Grenada, Montserrat, St. Christopher/Nevis, St. Lucia, St. Vincent & Grenadines

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Island Resources Foundation was established in 1970 as a research and technical assistance organization dedicated to the improvement of human and natural resource management in offshore oceanic island areas. Since that time, the Foundation has sought to develop research, planning, and technical assistance programs which both protect and enhance the development options of small islands. It has been a major contributor to worldwide efforts to confront the extraordinary problems and pressures facing tropical island communities and to develop sound ecological principles and management practices which insure that the special qualitities of island life are preserved.

Incorporated and based since its inception in the U.S. Virgin Islands, the Island Resources Foundation has a 501(c)(3) tax exempt status under the U.S. Internal Revenue Code and has received grant and contract support from a wide variety of public and private sector funding sources. With headquarters facilities in St. Thomas (and a support office in Washington, D.C.), the Foundation has carried out over 100 projects totaling in excess of three million dollars in primary funding support for island areas. Most have focussed on the Caribbean region, but several have extended to various island countries in the South Pacific Basin.

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I. EXECUTIVE SUMMARY

1. The fisheries sector of the Eastern Caribbean has been historically perceived as having relatively minor importance. There is, however, increasing recognition of its potential significance to such problems as balance of payments, unemployment, stimulation of local economies, and nutrition. Due to a variety of limitations, the scale of development that is possible in Eastern Caribbean fisheries is modest in global terms yet significant on the small island scale. The issue of scale and applicability to local circumstances is critical to effective development of the fisheries sector in the RDO/C region.

2. Fisheries development typically places greater emphasis upon technological innovations to the harvest component of the sector than upon processes of biological production. As a result, such development typically leads to at least temporary collapse of target fisheries. The consequences of overcapitalization and unrestricted access are much more severe in developing countries than elsewhere, and it is doubtful that the RDO/C countries have sufficient "buffer capacity" to tolerate massive collapse of local fisheries. For this reason, management and innovation are considered complementary and inseparable elements of the fisheries development process for the Eastern Caribbean.

3. Information on the fisheries resource base in the RDO/C countries is reviewed. Some resources - especially nearshore species - are widely acknowledged to be overexploited and seriously in need of management. There is no indication that underexploited resources exist on a scale suitable for large-scale commercial development, but there is potential for constructive development on the small-island scale, particularly of deepwater and migratory pelagic resources.

4. The current harvest is based upon techniques which have been essentially unchanged for centuries. This is not primarily because fishermen arbitrarily resist change, but rather that traditional methods are well-adapted to local resources. Fishermen require clear demonstration of the superiority of new techniques before abandoning proven approaches. Fishing is generally a marginal enterprise, and many fishermen engage in several other occupations. Fishermen tend to be independent, and attempts to encourage development of fishing cooperatives in some islands are often unsuccessful. Local demand exceeds supply throughout the region, a situation which is at least partially due to inadequate marketing, processing, and distribution systems, and in some cases inappropriate government price controls.

5. No mariculture system has been shown to be sufficiently reliable to permit recommendation for its widespread introduction in the Eastern Caribbean. There are, however, a number of promising techniques being developed for culture of various species, and these should be developed further and tested on a site-by-site basis.

6. Previous experience with fisheries development in the RDO/C region is reviewed. For more than 20 years, capital-intensive commercial fisheries have provided the model for fisheries development in the region. Overly optimistic projections of potential yield, inappropriate technology, and inadequate understanding of social and economic components of fishery systems have contributed to the failure of many projects.

In contrast to the tourism and manufacturing sectors, which have required considerable restructuring of the domestic economy, fisheries projects can benefit from the base of long-term viability already present in many local fisheries. Five lessons are extracted from prior experiences:

- The high-capitalization fisheries model is not appropriate to the Eastern Caribbean
- Development projects must be based upon realistic estimates of probable yield
- Innovations in technology should be viewed as technology development or adaptation, rather than technology transfer
- Local fishermen must be intimately involved with fishery development projects
- Innovations to Eastern Caribbean fisheries should be undertaken in stages

7. Analysis of previous experience and available information suggests that there are policy, institutional, technical, and financial constraints to fisheries development in the RDO/C region. These constraints include:

- Lack of an appropriate development model
- Limited resource base
- Inadequate equipment and technology
- Inadequate understanding of fishery systems
- Lack of financial resources
- Shortage of trained indigenous personnel

General approaches to amelioration of these constraints are discussed.

8. A Fisheries Development Program is proposed which would provide a realistic model for achieving the development potential of Eastern Caribbean fishery resources. Review of current fisheries development activity suggests that the activities of other agencies are not targeted primarily to this task and will not fully meet this need. Without such effort, conventional approaches may jeopardize the stability of the RDO/C countries. The proposed Program includes:

- Development of locally appropriate mechanisms for improved management of fishery resources
- Strengthening of local capabilities for fisheries development
- Increased fisheries production and reduced overexploitaiton
- Technological innovations resulting from development and adaptation in the local context
- Maintenance of effective social and economic systems
- Rapid, visible, and ongoing attention to current problems of local fishermen

The Program addresses certain problems on a regional basis, but also recognizes that there are island-specific constraints which demand special solutions. Three major categories of activity are proposed:

- Adaptation and implementation of technical innovations, including mariculture
- Resource management
- Support services

For the proposed program to be effective, certain activities must be undertaken in each category. Key projects are suggested which include:

- Program development and monitoring
- Preparation of fishery resource baselines and management systems
- Training and local capacity building in all activities
- Development of underutilized resources
- Infrastructure improvement
- Mariculture development
- Habitat enhancement
- Coastal resource inventory
- Development of extension services
- Development of a fisheries management information system

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II. BACKGROUND

A. Overview of the Fishery Sector

The small island nations of the Eastern Caribbean face problems of unemployment, inadequate nutrition, and economic imbalances which threaten their social and political stability. World Bank (1979) estimates indicate that the labor force in Latin America and the Caribbean is growing at a more rapid rate than in any other region, while unemployment continues to rise. Eastern Caribbean islands are net importers of food. For example, recent figures indicate that the value of imported fish to Antigua exceeds 14 million EC dollars; Dominica's imports are valued at 2.5 million; those of St. Kitts 8.1 million. Coupled with increasing costs of all imported foods, fish imports exacerbate chronic problems with balance of payments. Political stability is endangered, because government leaders (correctly or not) can readily be considered responsible for such circumstances and are expected to provide instant remedies which simply do not exist.

Among the changes brought about by the fairly recent independence of these nations from their former colonial rulers has been a growing recognition of the need to maximize local food production. Some agricultural reforms are possible in pursuit of this goal; but arable land is in short supply, and agriculture often must compete with tourism, housing and light industry for available land. In addition, agriculture in most RDO/C islands traditionally is based on a few export crops. Little commitment or will has been evidenced for agricultural diversification which would provide the necessary produce for local consumption. The same problems are apparent in the fishery sector, where only a small portion of available resources are used. Intensified fishing effort increases the probability of overexploitation of some stocks while others continue to be underutilized.

Colonial and post-war development strategies almost exclusively stressed exploitation of land-based resources. But though historically undervalued, the fisheries sector has growing significance to a number of Eastern Caribbean problems:

Balance of Payments -- Substitution of domestic products for imported foods (especially fish) can help alleviate foreign exchange imbalances.

Employment -- Despite their anticipated growth, it is not likely that light industry and service labor sectors will absorb the projected labor force. For example, crude birth and death rates for the small islands of the Eastern Caribbean have been estimated to be roughly 32 and 6 per 1000 population, yielding a rate of natural increase exceeding 2.5% (United Nations Dept. of Economic and Social Affairs, 1982). Additional employment opportunities related to development of living marine resources will be of increasing importance, particularly considering the limited opportunities for expanding agriculture (which historically has employed roughly three-fourths of the labor force in low income countries) in small islands.

Stimulation of Local Economies -- The potential effects of increased local fisheries production are analogous to those of agriculture: resultant income increases generate new demands for other commodities, and create a demand for non-agricultural labor through expenditure linkages.

Nutrition -- The most effective long-term policies for improving nutrition are those that raise the incomes of the poor, that raise food production per person, and that produce foods typically consumed by the poor. Development of small-scale fisheries meets all of these criteria (World Bank, 1979, 1980).

Existing natural resource bases, current infrastructure, and marketing constraints limit the degree of fisheries development that is possible in the Eastern Caribbean. But though modest in global terms, such development can be significant on the small-island scale. Most of the circumstances which have led to the development of highly capitalized, high-volume, technologically sophisticated fisheries in other parts of the world are not present in the Eastern Caribbean. For this reason, activities to develop Eastern Caribbean fishery resources should be of a type and scale appropriate to local societies and economies.

Exploitation of fishery resources results in a system of three interrelated components which comprise the "Fisheries Sector":

The Physical Component (habitat and weather)

The Biological Component (the species being exploited as well as other organisms upon which survival of these species depends)

The Human Component (which effects exploitation)

These components interact in four major Fishery Sector processes:

Biological Production of living marine species which have current or potential value to the production of human food

Harvest of these species

Processing the harvest into forms useful to humans

Transfer of the product to consumers (marketing and distribution)

This report is primarily concerned with human manipulation of this system. It is important to recognize, however, that human activities are also subject to manipulation by the other components. For example:

- All fisheries are susceptible to the influence of weather and climate; the suspected link between the El Nino phenomenon and the collapse of the Peruvian anchovy fishery is well-known
- Eastern Caribbean fishermen report local declines of conch and sea urchin populations following hurricane destruction of seagrass habitats.
- Physical processes in areas far from the Caribbean may have significant effects on migratory stocks.
- Natural fluctuations in the populations of predator or prey species can drastically alter the abundance of harvested species.
- The appearance of disease organisms can rapidly destroy an aquaculture operation.

Despite the interrelation of these components, development programs typically place relatively little emphasis upon biological production, despite its obvious importance to the other processes. As a result, fisheries development is usually characterized by six phases: predevelopment,growth, full exploitation, over-exploitation, collapse, and (sometimes) recovery (Csirke, 1984). To date, fisheries development in the Eastern Caribbean has followed a similar course. There is an urgent need to reverse this trend, because the impacts of overcapitalization and resource depletion may be especially severe in small islands:

> Temporary declines in fish catches can lead to bankruptcies of marginal producers and of those in the fishery who are heavily in debt. . . . In a developing country the impacts of a sharp decline in fish catches can have catastrophic long-lasting societal effects, whereas in developed countries the societal impacts of stock declines may be more easily absorbed by other sectors of the economy. (Glantz, 1984)

Collapse of a fishery obviously may be caused by factors other than human activity. Many marine stocks are subject to fluctuations in abundance which can drastically affect the viability of associated fisheries. But it is significant to note that

> ...there is no instance as yet of the collapse of a fishery under conditions described as light exploitation. In addition, each of the fisheries that has witnessed sharp declines in landings ... has been advised to reduce fishing effort before its respective collapse. (Glantz, 1984).

Panayotou (1982) comments that fishery management is generally thought to be required once a fishery is overexploited, while fishery development applies while a fishery is still underexploited. But Eastern Caribbean fisheries include substantial underutilized

resources as well as others which are definitely overexploited. It is clearly desirable that development of underutilized resources not lead to overexploitation -- this can best be avoided by judicious management along with development. Conversely, management of overexploited fisheries may be impossible unless alternative opportunities are provided as an integral part of development projects.

There is little doubt that ANY fishery can be overexploited. Overexploitation clearly is not a desirable product of development and increasing attention is (rightly) being directed toward the issue of sustainable yields. Several concepts of sustainable yield have been articulated, three of which are particularly important to this report.

Maximum sustainable yield (MSY) is the maximum catch that can be obtained on a sustained basis. Panayotou (1982) points out that actual yield may be less than MSY because of OVERexploitation as well as UNDERexploitation. If MSY is to be obtained it is necessary to know quantitatively the fishing effort which corresponds to MSY and to compare this with harvest effort currently being expended. It is not sufficient or meaningful to simply compare current harvest to MSY.

In the Eastern Caribbean, economic benefits from fishing often are more important than the absolute quantity of fish landed. In this case, an appropriate goal is to maximize the amount of income over costs. The corresponding harvest is termed maximum economic yield (MEY). MEY is often less than MSY because the costs of fishing operations typically increase as MSY is approached (e.g., due to forays to more distant fishing grounds, or because greater effort must be expended to maintain catch rates when fewer fish are available for capture).

Even in developed countries, maximum economic yield may not be the most desirable goal. An analysis of spiny lobster fisheries in Monroe County, Florida, indicated that maximum economic yield would be achieved by eliminating 186 vessels (47% of the total fleet) from the fishery. The benefits from such action would have amounted to about $0.37 million, compared to the social cost of displacing 186 firms from the industry. Moreover, the dollar savings would accrue to fewer individuals than benefit from the current industry unless some new form of taxation were employed. Management decisions for this fishery would have to weigh advantages of increasing net revenues to the fishery as a whole against disadvantages of displacing fishermen and consolidating benefits from the fishery.

Development goals may also reflect the desire to improve social standing, distribution of income, employment, or other factors which are not reflected in absolute dollar terms (MEY, for example might be achieved by a few highly capitalized individuals; this would have a considerable adverse impact on the majority of local fishermen). The yield corresponding to maximization of social goals is termed maximum social yield, or simply optimum yield (OY). Panayotou points out that this concept is most applicable to small-scale fisheries, and that maximum social yield in any case cannot exceed MSY.

It should be noted that data alone are not sufficient to guarantee optimum development and management. A recent review of fishery resources monitoring (MacCall, 1984) suggests that "the preponderance of errors in fishery science are conducive to overexploitation." This is due not only to the imprecision of the estimates, but equally to a

tendency on the part of fishery scientists and managers as well as fishermen to adopt the most optimistic view of resource potentials. Gulland (1982) points out that development decisions based on MSY alone may be seriously flawed because of the changes which are certain to occur within stocks as fisheries expand. Much of the information needed to evaluate various fishery development options is simply not available. Determination of MSY, however, sets the upper limit for harvests, whether the goal is MSY, maximum economic yield, or maximum social yield. Unfortunately, for most fisheries MSY is very poorly known.

This report contains recommendations for increased fisheries exploitation capacity, but these innovations will not produce long-term benefits without simultaneous implementation of recommendations for improvements to biological production and resource management. Because of the unique properties of small-scale developing country fisheries, management and development will be treated as complementary and inseparable processes in this report.

B. The Natural Resource Base

1. General Comments

a. Yield Estimates

Rational fishery development plans require specific information on target species; stock abundance and sustainable yield are frequently of most direct interest. Estimates of MSY for Eastern Caribbean fisheries are not only hampered by a paucity of information, but also by the fragility and small size of the resource base whose productivity can vary substantially from year to year depending upon fishing pressure and natural disasters (e.g., hurricanes). A variety of techniques have been used with varying degrees of success to estimate the absolute or relative abundance and yield potentials of fishery stocks, including

- estimates based on catch-effort statistics
- analysis of age composition data for several years' catch (virtual population analysis)
- acoustic surveys
- aerial surveys
- experimental fishing
- estimates based on tag-recapture studies
- estimates based on visual census

A number of mathematical models exist for predicting sustainable yield, but can be difficult to apply because of uncertainty in estimating the various required parameters (this is a particular constraint for Caribbean fisheries). At present, the simple Alverson-Pereyra-Gulland formulation (Gulland, 1983) is popular (MacCall, 1984):

$$Y_{max} = 0.5\ MB$$

where Y_{max} is sustainable yield, M is natural mortality, and B is biomass of the *unfished* stock. For fished stocks, the appropriate version is

$$Y_{max} = 0.5\ (Y + MB)$$

where Y is the catch, and other terms are as above. This procedure is not intended to substitute for more detailed assessments, but provides a useful "ballpark" figure for preliminary planning. Unfortunately this formulation tends to overestimate realizable sustainable yield (Gulland, 1983) suggests that a factor of 0.3 instead of 0.5 would be better), and is often adhered to long after improved information becomes available (MacCall, 1984).

Two, more elaborate, models are widely used. Surplus Yield models require data on catch and effort over several years, and at several levels of effort. Yield per Recruit models require that estimates of growth and mortality as input parameters, but do not provide ications of overfishing which affects recruitment.

Management plans and fisheries development proposals for Caribbean fisheries often rely on abundance or yield estimates determined by extrapolating the results of experimental fishing or visual census in selected sites to larger areas. Depending upon the reliability of the yield factors, these procedures may provide a useful starting point, but there are several caveats. First, such estimates depend upon knowledge of the extent of productive habitat in the area for which predictions are being made. For example, maximum harvests of 10 - 20 metric tons/sq km/yr (of all edible species) are probably sustainable from coralline shelf ecosystems (Munro, 1984); but if these systems cover only one-third the total shelf, yield from the shelf will be 3.3 - 6.6 metric tons/sq km/yr.

Thus, 1982 estimates of sustainable yield of some reef fisheries in Jamaica (Hartsuijker, 1982) were 60% lower than earlier estimates (Munro, 1977) based on less complete data. Similarly, the Saba Bank is the largest offshore bank in the Leeward Islands, with an area of 2125 sq km, and a perimeter of 193 km along the 200 m contour. The commercially operable ground is only 18 km long, with an area of about 3.4 sq km (Kawaguchi, 1970).

Second, potential yield estimates based on shelf area are easily subject to misinterpretation. In a recent report, for example, the authors calculate sustainable fisheries yield in the Eastern Caribbean by multiplying shelf area of the individual islands by a productivity factor calculated for reef fisheries in Puerto Rico and the U.S. Virgin Islands by the Caribbean Fishery Management Council (CFMC) in 1981. The resulting yield estimates are then compared with current fisheries landings to show that these landings generally exceed sustainable yields. But this comparison is not valid: the majority of landings in many islands are from pelagic (mid-water) fisheries; not reef fisheries (in Grenada, for example, reef fisheries account for less than 10% of annual landings).

Finally, yield estimates vary widely (this may well be due to real variations within stocks and among islands). Munro (1974) estimated that the maximum sustainable yield of neritic fish species ranged from 1286 - 6141 kg/sq km of shelf around Jamaica, depending upon the bottom type. Assuming an average of 4000 kg/sq km, Klima (1976) estimated that 25% of this would be demersal (bottom-dwelling) species. WECAF (1978) concluded

that Munro's estimates were realistic and that Klima was conservative. Stevenson (1981) concluded that 4000 kg/sq km might not be sustainable in coral reef systems, but that an average yield of 1000 kg/sq km seemed reasonable for demersal species. More recently, Munro (1984) states that 4000 - 6000 kg/sq km/yr is a valid generalization of neritic fish production on coralline shelves.

Despite this variability, there is often a tendency to report a single figure for potential yield. The magnitude of the problem is illustrated by recent reports of fisheries potential in St. Kitts/Nevis. One estimate places the sustainable yield of all coastal shelf resources at 2381 metric tons; the other estimated sustainable yield of the same resources to be 674 metric tons. The report which specifically addressed shallow reef fisheries potential estimated sustainable yield to be 1229 metric tons. Draft management plans for similar fisheries have recently been prepared for Puerto Rico and the U.S. Virgin Islands. If the estimates derived for the latter plans are applied to St. Kitts/Nevis, the sustainable yield prediction is 278 metric tons.

Discrepancies of this magnitude do not provide a secure basis for long-range investment decisions. The fundamental problem with yield estimates for Eastern Caribbean fisheries is simply that available information on fishing effort and exploited stocks is inadequate. In the following discussion, yield estimates are provided primarily to illustrate that large-scale investment is inappropriate. As discussed above, these estimates cannot be compared with current landings to identify underutilized resources, because fishing effort cannot be reliably estimated. Some resources are almost certainly underutilized (sharks, deepwater species, etc.), but history suggests that fishery resources of the region are easily overexploited. Rational fisheries development absolutely requires reliable indications of stock condition to determine desirable levels of investment and to provide for long-range management of fishery resources. Yield estimates which are presently possible are totally inadequate for this purpose, and provisions for ameliorating this condition must be an integral part of any fisheries development activity planned for the Eastern Caribbean.

b. Underexploited Species

Munro (1984) points out that in the Pacific, invertebrates (particularly bivalve and gastropod molluscs, echinoderms, and crustaceans) account for 40% of total landings from some reef fisheries. This may be indicative of untapped, though certainly limited, potential in Eastern Caribbean reef fisheries. Octopi, for example, are seldom fished specifically (though several thousand pounds are landed annually in Puerto Rico). Holothurians (sea cucumbers) are similarly unexploited. Bivalve molluscs are harvested and marketed only in the French Antilles, though they have been found in several of the RDO/C countries. The actual potential of un- or under-exploited stocks cannot be determined without specific evaluation in terms of sustainable yield as well as market demand, but such evaluation *must* be done prior to promoting anything more than an experimental harvest of these species.

c. Nursery and Breeding Areas

Coral reefs, seagrass beds, and mangroves have widely acknowledged importance to neritic (coastal shelf) fisheries. These habitats are sites of high biological productivity,

and provide shelter for larvae and juveniles of many species, including spiny lobsters. In the Eastern Caribbean, these habitats are being exposed to increasing impacts:

- increased use of agrochemicals and pesticides
- sediment loading from road and building construction, dredging, and soil loss due to desertification caused by sheep and goats
- land clearing for development of tourist beaches
- sewage outfall from hotels
- thermal effluents from energy projects
- various chemicals from light industry and petroleum terminals

The importance of these habitats is not commonly considered when such projects are developed, and basic marine resource inventories needed to support such considerations are not available. Unless this situation is reversed, human impact on nearshore habitats can be expected to significantly degrade associated fishery resources.

d. Ciguatera

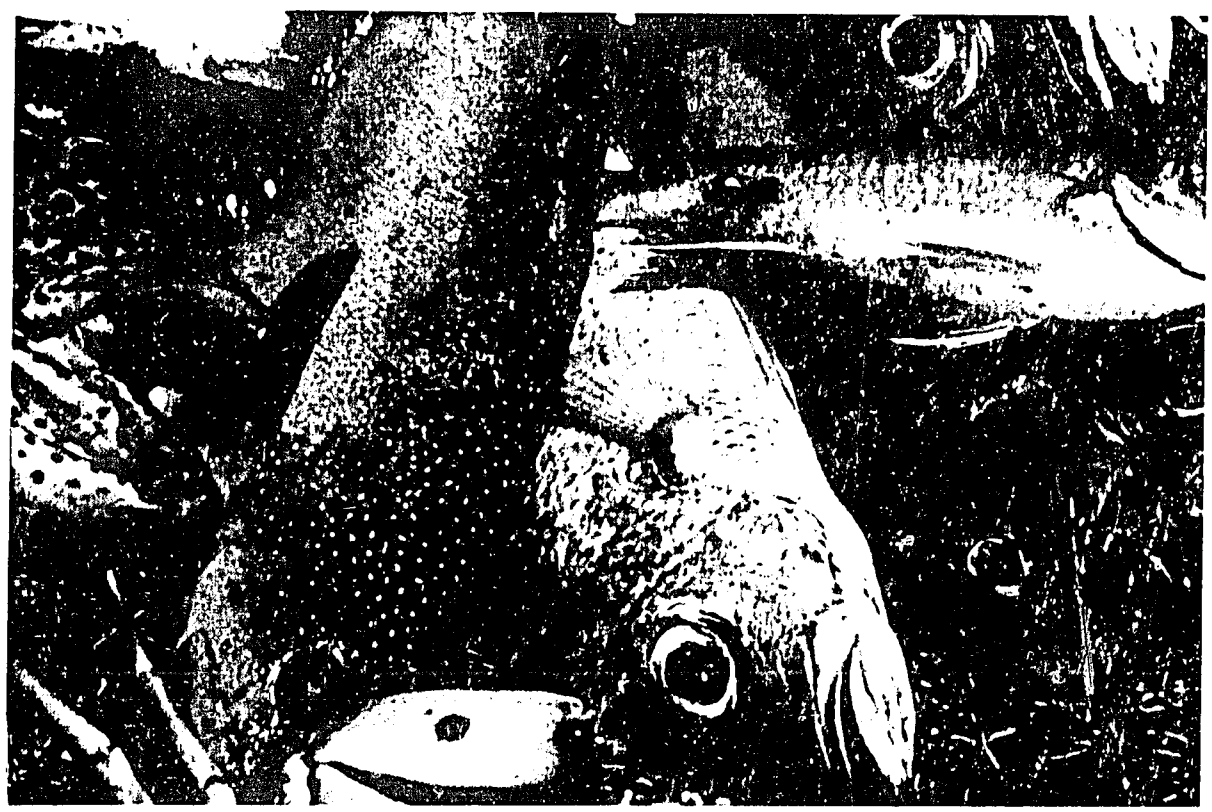
At present, ciguatera (tropical fish poisoning which is not related to spoilage), poses a major obstacle to marketing fish particularly in the northern islands. In the U.S. Virgin Islands, 50% of the fish species (comprising 56% of the landings by weight) have been implicated in fish poisoning (Olsen and Wood, 1982). Large reef fishes caught in depths of 30 fathoms or less are more likely to be toxic than other fishes. A particularly high incidence of ciguatoxic fishes is found in areas south of the British Virgin Islands, the eastern portion of the Saba Bank, the southern end of the Anguilla Bank, and the area surrounding Redondo (Olsen, et al., 1984). Snappers, groupers, kingfish, and jacks are most often implicated in ciguatera poisoning. Some species (e.g., barracuda) are generally shunned in the northern islands though they are commonly eaten without ill effect in the southern Antilles. These species frequently constitute a significant portion of the fisheries potential in coastal areas, but cannot be sold due to the risk of poisoning.

Olsen *et al.* (1984) report an occurrence of ciguatera- like symptoms following "several consecutive meals" of *Cittarium (=Livona) pica* (West Indian top shell). Experimental work is needed to evaluate the potentially disturbing implications of this observation for conch fisheries and mariculture of other animals which graze on benthic algae.

2. Nearshore Demersal/Reef Fishes

By far the majority of bottom-dwelling fish in shallow water around the Eastern Caribbean islands are associated with coral reefs (in this case the term "coral reef" is understood to include reefs formed by corals, as well as coral veneers on other surfaces), and nearshore demersal fisheries are concentrated around these habitats. More than 300 fish species are associated with Eastern Caribbean coral reefs, approximately 180 of which are landed for human consumption. In most cases a much smaller number of species constitutes the bulk of the catch.

Overfishing of nearshore stocks has not been documented, but has been reported by fishermen in all of the RDO/C islands (W. Hunte, personal communication). Juvenile fish are often landed from nearshore habitats, both in fish traps and beach seines. This has probably contributed in some measure to reported catch declines As these stocks are depleted there is a tendency to reduce the size of wire mesh used in trap construction, increasing the liklihood of capturing juveniles. Some species aggregate during spawning seasons, and are easily captured in considerable numbers (and consequently, easily depleted). This circumstance has resulted in the virtual annihilation of a breeding grouper population in the U.S. Virgin Islands. Munro (1974) pointed out that in heavily exploited Jamaican fisheries, "negligible numbers of fishes survive long enough to spawn." This means that recruitment is dependent upon production in other areas, and that increased fishing effort is likely to lead to collapse of the fishery.



Typically mixed catch of nearshore demersal species.
St. Kitts. Photo by Sandy Goodwin

The multispecies nature of reef fisheries makes it difficult to estimate sustainable yield. Based on reports cited above, a range of estimates of sustainable yield of these fisheries in the RDO/C countries are provided in Table 1. It is emphasized that:

> **These are only the most provisional estimates,** and the applicability of estimates from other parts of the Caribbean to the RDO/C region has not been established.
>
> **Traditional reef fisheries are probably overexploited,** and areas other than nearshore reef habitats will have to be developed to achieve sustainable increased landings from demersal fisheries.

Management plans for reef fisheries in Puerto Rico and the U.S. Virgin Islands reflect a similar situation in these territories, and are indicative of the sorts of action which may be necessary in the Eastern Caribbean: Fish traps must have a minimum mesh size of 1 1/4 inches, and must be constructed with a self-destruct panel to prevent "ghost fishing". A minimum size of 12 inches total length is to be enforced for yellowtail snapper, based on reports by fishermen in the U.S. Virgin Islands of a decline in the average size of landed snappers. Even more stringent regulations are to be applied to Nassau grouper which have virtually disappeared from catches in the USVI; an initial minimum size of 12 inches is to be observed, with an annual increase of one inch to an eventual minimum of 24 inches. In addition, a closed season (January - March) is established for the latter species to protect spawning aggregations.

3. Deepwater Demersal Fishes

The distinction between deep and shallow-water stocks of bottom fishes is somewhat arbitrary, though species differences do occur. Often the distinction is made on characteristics of harvest techniques, such as the transition from primarily trap fishing (nearshore) to primarily handline fishing, or the maximum depth habitually fished by artisanal fishermen. In the Eastern Caribbean, current bottom fishing effort in depths greater than about 60 m is considerably less than in shallower waters because the difficulty of hauling gear by hand increases with depth. Between 145 and 270m snapper and grouper are often found in areas where the slope is rocky or steeper than 30 degrees (Peacock, 1976). Groupers often require crevasses or holes in which to hide, while snappers frequently congregate around outcrops. Such areas can be difficult to fish.

The potential yield of deepwater demersal fisheries in the Eastern Caribbean is not known with any precision, but is of interest because these fisheries are probably underexploited at present in the RDO/C countries. Rathjen and Kawaguchi (1969) reported high catch rates (more than 34 kg/hr fished) of snapper and other demersals east of Honduras, south of Jamaica, north of Hispaniola, and on the Anguilla Bank. In the Eastern Caribbean, moderately high catches (51-75 lb/hr) were recorded on the Antigua Bank, and in the vicinity of the U.S. and British Virgin Islands. Fifty-one percent of the species captured were snappers.

Table 1

Examples of Variability in Maximum Sustainable Yield Estimates Applied to Some Neritic Fishery Resources in the RDO/C Countries

Resource	Method	Estimated MSY (metric tons per year)						
		ANU	DOM	GND	MNI	SKB	SLU	SVD
All Neritic Fishes	1	4372	919	3987	139	765	671	2315
	2	20879	4391	19037	663	3654	3206	11054
	3	12624	2655	11510	401	2209	1938	6683
Shallow Water Reef Fishes	4	1571	330	1432	50	275	241	832
All Deepwater Fishes	4	588	124	536	19	103	90	311
All Demersal Fishes	5	3400	715	3100	108	595	522	1800
Snappers	5	680	143	620	22	119	104	360

ANU = Antigua and Barbuda; DOM = Dominica; GND = Grenada and Grenada Grenadines; MNI = Montserrat; SKB = St. Kitts and Nevis; SLU = St. Lucia; SVD = St. Vincent and St. Vincent Grenadines

Methods
1 -- Munro (1974) lowest estimate
2 -- Munro (1974) highest estimate
3 -- Munro (1974) average
4 -- CFMC (1984)
5 -- Stevenson (1981)

NOTE: These figures are intended to illustrate the uncertainty of available yield estimates, and the precarious basis for rational development which exists because of poor understanding of fishery resources. These estimates should NOT be used for planning purposes, and clearly do not indicate that adequate information is available. On the contrary, the discrepancies (for example, between the first group of estimates and the second) underscore the need for reliable estimates of yield potentials as an inseparable component of fishery development.

Table 1 summarizes estimates of potential yield of deepwater demersals in the RDO/C countries. It is emphasized that these are highly approximate and preliminary estimates, and have not been verified in the RDO/C region. Development of these resources should be undertaken gradually with continuous assessment of impact, because previous experience suggests that deepwater stocks can be readily overfished (A. Dammann, personal communication), and because increased development of demersal fisheries in Jamaica coincided with an increase of less valuable species in the catch (Vidaeus, 1970).

4. Pelagic Fishes

Pelagic species account for the majority of fish landings in most Eastern Caribbean islands (e.g., Table 2), but estimates of abundance and sustainable yield are lacking. Landing records suggest that the relative importance of different species varies from island to island and possibly year to year, but recent work (W. Hunte, personal communication) indicates that this is probably an artifact of record-keeping procedures and differences in fishing techniques. The migratory nature of many important species makes regional management practically obligatory.

The International Commission for the Conservation of Atlantic Tuna (ICCAT) provides an annual review of the state of some of these stocks.

Yellowfin tuna are most abundant in the worldwide catch. Fishing activity directed toward this species in the Eastern Atlantic has increased markedly since 1969 and now exceeds estimates of effort required to maintain maximum sustainable yield; the stock has declined continuously during the same period. Though the impact of this circumstance on the Caribbean is uncertain, reasonably good time-series catch data exist for yellowfin tuna from the U.S. Virgin Islands and Barbados, and in neither case is there an indication of decline in abundance.

According to ICCAT, albacore comprise two stocks separated at the 50th parallel. The catch and effort in the southern stock have increased progressively since 1975, and it is estimated that this stock is now exploited at maximum sustainable yield, though some Eastern Caribbean countries record yellowfin tuna and true albacore jointly as "albacore", making it difficult to assess the importance of true albacore in this region (W. Hunte, personal communication). Bigeye tuna are exploited close to estimated maximum sustainable yield, and increased fishing effort would produce marginal returns. Little tunas are important in Eastern Caribbean artisanal fisheries, and worldwide yields have been relatively high in recent years.There are insufficient data to evaluate the status of little tuna stocks.

Catches of skipjack tuna in the western Atlantic have risen steadily in the past seven years. The development of Brazilian fisheries has been significant to this trend. These fisheries appear to be underexploited. Since skipjacks are often found in mixed schools with juvenile yellowfin and bigeye tunas, management of the latter species could be adversely affected by an increased harvest of skipjacks.

Table 2

Comparison of Fishery Landings In Four RDO/C Countries

	SKB (4), 1983		GND (1), 1983		SLU (2), 1981		DOM (3), 1984	
	lb	% of Total	lb	% of Total	lb	% of Total	lb	% of Total
Group A								
Yellowfin Tuna			106,434	8				
Blackfin Tuna			-					
Skipjack Tuna			14,025	1				
TOTAL TUNA			120,459	9	474,000	24	38,168	8
Dolphin Fish			119,819	9	481,000	24	55,378	12
Flying Fish			76,025	6	295,000	15	185,607	40
Kingfish			88,371	7	207,000	10	17,259	4
Shark			18,449	1	45,000*	2	4,825	1
Group B								
Jacks			180,713	14			43,510	9
Robin			151,449	11				
Other Pelagics			371,250	28			74,656	16
Demersal Fishes	1,572,000	84	168,521	13			39,521	9
Others			29,853	2				
ALL PELAGICS	307,000	16						
TOTAL	1,879,000		1,324,959		1,998,000		458,924	

SKB = St. Kitts; GND = Grenada; SLU = St. Lucia; DOM = Dominica

Sources:
(1) Grenada Fisheries Division (based on throughput of official fish markets)
(2) Agricultural Statistical Digest, January-December 1981
(3) 1984 Statistical Report, Dominica Fisheries Division
(4) Olsen, D., 1984. Fishery Assessment, St. Kitts/Nevis. Caribbean Development Bank, Wildey, Barbados
* – includes porpoise ("blackfish")

Recent work by Oxenford and Hunte (1984) suggests that dolphin are essentially an annual fishery, which implies that stocks would be subject to precipitous changes from year to year in response to fishing pressure. Once fishing pressure has forced parental stock size into the range where recruitment strength is affected, there would be little warning of imminent declines (this also implies that regeneration of stocks from an overfished state could be fairly rapid). From available data it appears that Barbados, St. Vincent, St. Lucia, and possibly Grenada are exploiting the same stock whose northern limit is the U.S. Virgin Islands (W. Hunte, personal communication).

Yield estimates and management data for other significant pelagic species (e.g. flying fish, wahoo, king mackeral, various jacks) are not available.

Current management plans for swordfish in the United States Caribbean are aimed toward reducing the capture of small fish by closing the fishery during the time of year when these are most abundant (October 20 - December 23).

A workshop on assessment of fish stocks of concern to the southeastern United States (which include some Caribbean pelagics) is planned for early 1986 under the auspices of the National Marine Fisheries Service.

5. Conch

Queen conch (*Strombus gigas*) is the most important edible mollusc in the Eastern Caribbean. It is second only to spiny lobster in pound-for-pound value, and to fin-fish as a component of local diets. Conch are seldom found in depths exceeding 30 m, a circumstance which makes these stocks highly vulnerable to fishing. In most islands with extensive habitat suitable for conch, this species is considered to be overfished. Conch are also susceptible to effects of storms which cause habitat modifications. In 1983, *S. gigas* was declared to be an "economically endangered resource" by the International Union for the Conservation of Nature and Natural Resources.

As with other fishery stocks in the Eastern Caribbean, realistic development and management policies require evaluation of sustainable yields of conch on a site-specific basis. Wood and Olsen (1983) estimated that the maximum sustainable yield of conch in the U.S. Virgin Islands is 80 - 101 kg/sq km. This estimate must be interpreted with caution, however, as it is based upon visual surveys extrapolated to the entire shelf area, some of which is too deep to be visible to divers and which is probably not suitable conch habitat. If the proportion of suitable habitat to total shelf area in other islands is significantly greater or lower than around the USVI, MSY will be correspondingly higher or lower. An average of 90 kg/sq km has been used to estimate potential conch yield for the RDO/C islands in Table 3.

The value and precarious status of natural conch resources has stimulated efforts to develop techniques for conch mariculture. After a larval life of 3 - 4 weeks, conch require about three years to reach maturity. This makes the grow-out phase a serious problem for would-be culturists. "Ranching" conch on natural habitats is an alternative, but the carrying capacity of such habitats has not been established, and data on percentage recovery are not

Table 3

Maximum Sustainable Yield Estimates for Conch Resources in the RDO/C Countries

Estimated MSY (metric tons per year)

ANU	DOM	GND	MNI	SKB	SLU	SVD
306	65	279	10	54	47	162

ANU = Antigua and Barbuda; DOM = Dominica; GND = Grenada and Grenada Grenadines; MNI = Montserrat; SKB = St. Kitts and Nevis; SLU = St. Lucia; SVD = St. Vincent and St. Vincent Grenadines

Method

Based on Wood and Olsen (1982); see text for reservations which are applied to these figures. It is stressed that such generalized estimates should NOT be used for planning purposes. Reliable and site-specific estimates of yield potentials must be an inseparable component of conch fishery development.

encouraging. Given these circumstances, a 1982 review of progress on conch mariculture (Berg, 1983) concluded that "commercialization of conch aquaculture does not seem economically feasible at this time." In some cases, the intention is to provide juveniles for "re-seeding" depleted areas. This interesting prospect requires pilot scale evaluation before widespread adoption, as natural mortality, habitat capacity, and differences between conch populations are likely to affect anticipated results.

6. Spiny Lobster

Panulirus argus is the most highly valued fishery species in the Eastern Caribbean. Spotted (*P. guttatus*) and smooth-tailed (*P. laevicauda*), and slipper (*Scyllarus sp.*) lobsters are occasionally landed, but not in commercially significant quantities. *P. argus* has a long (6 months or more) larval life which makes it difficult to determine the origin of adult populations. Thus, stocks in one island may depend upon stocks in other locales for recruitment, necessitating regional management of the species. At the same time, it is known that important population characteristics vary from place to place. Minimum reproductive size not only varies with location, but may also have decreased over the past 30 years possibly in response to fishing pressure (Davis and Dodrill, 1980). Growth rate almost certainly varies with locale, but is thought to average 20 - 30 mm/yr in the Eastern Caribbean. This circumstance necessitates site specific evaluation of these characteristics for rational development and management. Post-larval juveniles are typically found in shallow (1 - 5 m) water in the vicinity of mangroves or grass beds. Older juveniles migrate to reef and rubble habitats, and as adults are found in depths ranging from a few meters to over 200 m.

Abundance and sustainable yield of spiny lobster stocks in the Eastern Caribbean have not been generally established, and estimates in neighboring areas are varied (Table 4). The effect of these variation on estimates of spiny lobster MSY for the RDO/C islands is illustrated in Table 5. Because much of the catch is exported, existing landing data for most islands are even less reliable than for fin fish, and almost certainly underestimate the actual catch.

7. Sharks

There are no established shark fisheries in the Eastern Caribbean, nor any specific assessments of resource potential. Stevenson (1981) states that shark resources in the western central Atlantic region as a whole are underutilized on the basis of estimated average shark densities of 36 kg/sq km offshore and 270 kg/sq km inshore by (Bullis *et al.*, 1971). The factor derived for the ratio of sustainable yield to biomass was 0.075 for sharks and 0.10 for skates and rays. These factors have been applied in Table 6 to provide preliminary estimates of sustainable yield of shark resources in the RDO/C islands.

Sharks have a relatively low reproductive potential, slow growth rates, and greater age-at-maturity than other fishery stocks. As a result, sharks are particularly vulnerable to overexploitation. This is less true for skates and rays. One of the most complete reviews of shark fisheries potential has been provided by Smithline (1980).

TABLE 4

Estimates of Spiny Lobster Yield and Abundance

Location	Type of Estimate	Quantity	Source
Barbuda (lagoon)	abundance	390 - 700 **	Peacock, 1974
Florida (unfished reef)	abundance	5800 *, *** 8000 - 9000 **	Davis, 1977
Florida	annual yield	371 *	Gulf Mex. & S. Atlantic F.M.C., 1982
Grand Bahama	abundance	8400 - 123000 **	Waugh, 1980
Jamaica	potential yield	469 *	Aiken, 1980
Puerto Rico	sustainable yield	256 *	Caribbean F.M.C, 1980
U.S.V.I.	abundance (coral patches) (hard reef bottom)	 71 ** 1940 **	Hermkind et al, 1975
U.S.V.I. (St. Thomas - St. John) (St. Croix)	MSY	 339 * 564 *	Caribbean F.M.C., 1980

* -- kg/sq km

** -- lobsters/sq km

*** -- based on area of effective lobster habitat, not total shelf; about 19% of the total shelf offers suitable habitat in Puerto Rico/U.S.V.I.

Table 5

Maximum Sustainable Yield Estimates for Spiny Lobster Resources in the RDO/C Countries

Method	Estimated MSY (metric tons per year)						
	ANU	DOM	GND	MNI	SKB	SLU	SVD
1	870	183	794	28	152	134	461
2	1153	242	1051	37	202	177	610
3	1918	403	1748	61	336	294	1015

ANU = Antigua and Barbuda; DOM = Dominica; GND = Grenada and Grenada Grenadines; MNI = Montserrat; SKB = St. Kitts and Nevis; SLU = St. Lucia; SVD = St. Vincent and St. Vincent Grenadines

Methods

1 -- Based on estimates for Puerto Rico (CFMC, 1980)
2 -- Based on estimates for St. Thomas/St. John (CFMC, 1980)
3 -- Based on estimates for St. Croix (CFMC, 1980)

The variability in these estimates clearly indicates the need for site-specific estimates of spiny lobster sustainable yield. In addition, fishing effort must be estimated in rational development and management decisions are to be taken. It is stressed that these estimates extrapolated from other locales should NOT be used for planning purposes.

Table 6

Maximum Sustainable Yield Estimates for Neritic Shark Resources in the RDO/C Countries

Estimated MSY (metric tons per year)						
ANU	DOM	GND	MNI	SKB	SLU	SVD
69	14	63	2	12	11	36

ANU = Antigua and Barbuda; DOM = Dominica; GND = Grenada and Grenada Grenadines; MNI = Montserrat; SKB = St. Kitts and Nevis; SLU = St. Lucia; SVD = St. Vincent and St. Vincent Grenadines

Method

Based on Bullis et al. (1971). It is stressed that these estimates extrapolated from other locales may well be too high, and should NOT be used for planning purposes. As with any other fishery resource, site-specific estimates of MSY are needed for rational development.

8. Miscellaneous Stocks

a. Algae

Several species of edible algae occur in the region. "Sea moss" (*Gracilaria* sp.) has been harvested traditionally in most islands for consumption in a local beverage. There is an international market for algal gels (carrageenin and agar), but the Eastern Caribbean algae apparently have not participated in this trade. Grenada has established a formal processing and marketing system for sea moss, and local harvests are increasing. *Gracilaria* recently has been cultured successfully in an experimental system in St. Lucia (Smith, 1984), and this technology appears promising and appropriate for small-scale application in other parts of the region.

b. Bivalves

There are no established bivalve fisheries in the English-speaking Eastern Caribbean. Mangrove oysters (*Crassostrea rhizophorae*) are occasionally harvested for individual consumption or local sale, and the lucine clams *Lucina* (=*Phacoides*) *pectinatus* and *Codakia orbicularis* are harvested in Martinique and Guadeloupe. These species may have small-scale potential in other Eastern Caribbean islands.

Abundance and sustainable yield have not been estimated for any of these species in the RDO/C islands.

c. Cephalopods

Octopus and squid are not regularly harvested in the English-speaking Eastern Caribbean. Squid are caught only incidentally in other parts of the Caribbean (Stevenson, 1981).

These unexploited stocks may have considerable potential for local use as bait, for regional sale to French territories, and possibly as specialty items in tourist restaurants. Octopi are captured occasionally by divers in the Eastern Caribbean, and stocks are thought to be quite large though no numerical estimates have been made. Octopus fishing is extremely simple, and easily employed under artisanal fishing conditions. Potential regional markets for octopus are similar to those for squid.

d. Coral

Various true and pseudo corals, as well as black coral, are collected in many islands as souvenirs for the tourist trade. Extensive harvest of reef building corals can damage the reef habitat upon which many fisheries depend. Precious corals (which are not reef builders) can probably be regularly harvested with proper management. Matthes (1984) reports that harvesting pressure on these species in the Grenadines has decreased since the market for precious black coral in Barbados collapsed due to introduction of a plastic substitute.

e. Crabs

Crabs are not heavily exploited in the region, and are only occasionally captured in fish traps. Olsen, *et al* (1978) reported on a preliminary investigation of the resource potential of *Portunus spinimanus*.. Catch rates were low and variability was high, at least partially because the exploratory nature of the project dictated that effort be spread over a wide area, rather than concentrating on particularly productive sites.

In Bermuda, at least one fisherman has successfully used arrow traps to capture commercial quantities of deep-water crab *Geryon* sp. (W. Rathjen and R. Manning, personal communication). *Geryon* crabs are taken commercially in the Gulf of Mexico, and there may be potential resources in deep waters of the Caribbean.

f. Echinoderms

White sea urchins (*Trypneustes esculentus*) are locally harvested as "sea eggs" in most of the RDO/C islands. These stocks have been subject to periodic declines, probably due to a combination of overexploitation and natural causes (e.g., hurricanes; disease, though not reported in this species, may also be a threat considering that numbers of black sea urchins *Diadema antillarum* were greatly reduced throughout the Caribbean in 1983-84, apparently by a water-borne virus). White sea urchins have been severely depleted in Barbados, but no abundance estimates have been made. This species is clearly vulnerable to overexploitation, but appears to be capable of fairly rapid recovery. With management, a small-scale sea urchin fishery could probably be supported in most islands, though it is not clear that sustained production could be sufficient to supply a significant export market.

Sea cucumbers (beche de mer; trepang) are not harvested in the Eastern Caribbean, though edible genera (*Actinopyga*, *Holothuria*, and *Astichopus*) have been reported in the Grenadines (Mathes, 1984).

g. Turtles

All marine turtles are acknowledged to be endangered species. Green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), and leatherback (*Dermochelys coriacea*) turtles are commonly found and captured throughout the Eastern Caribbean despite local legislation and conservation efforts to the contrary. A Caribbean-wide sea turtle recovery program is underway as followup to the Western Atlantic Turtle Symposium held in 1983. Some (unestablished) level of artisanal harvest is probably permissible, but the current practice of ringing nesting beaches with nets and destroying eggs is clearly unacceptable. Until workable management strategies are implemented, sea turtles should not be considered as an exploitable fishery resource. Recent workshops to harmonize fisheries legislation among the members of the Organization of Eastern Caribbean States recommended a moratorium on turtles and turtle products which is likely to be approved by all of the RDO/C countries.

h. Whelks

The West Indian top shell (*Livona* (=*Cittarium*) *pica*) is found on rocky surf-washed habitats, and is prized as a local delicacy throughout the region. The species is heavily exploited locally, but has no recognized commercial potential. Cage culture of whelks may be possible.

The natural resource base of Eastern Caribbean fisheries is limited, but there are a variety of underexploited resources which collectively offer potential for local benefit. Development of these potentials must be at a scale appropriate to the size of the specific resources. Improved estimates of abundance and sustainable yield are absolute prerequisites to such development, because the overexploited state of many traditional fisheries demonstrates the relatiely low level of technology and investment needed to exceed natural productive capacity.

C. Overview of the Current Harvest

Four types of boats are used for the majority of fishing in the RDO/C islands:

Traditional canoes built from shaped and hollowed logs to which side planks are attached to provide increased freeboard; historically these were rowing boats, but are now propelled almost exclusively by outboard engines; the majority of these vessels are found in Dominica and St. Lucia

Carvel-built dinghies, length 12 - 15 ft, apparently modelled after traditional small sailing vessels; sail is often used for primary or auxiliary propulsion in St. Vincent, Grenada, and the Grenadines; outboard engines are used elsewhere

Doubled-ended "whalers", carvel-built, length 20 - 35 ft; until recently, these were powered primarily with inboard gas engines or sail, but outboard engines are now the dominant means of propulsion

Small decked sloops, length 30 - 50 ft; usually equipped with diesel engines

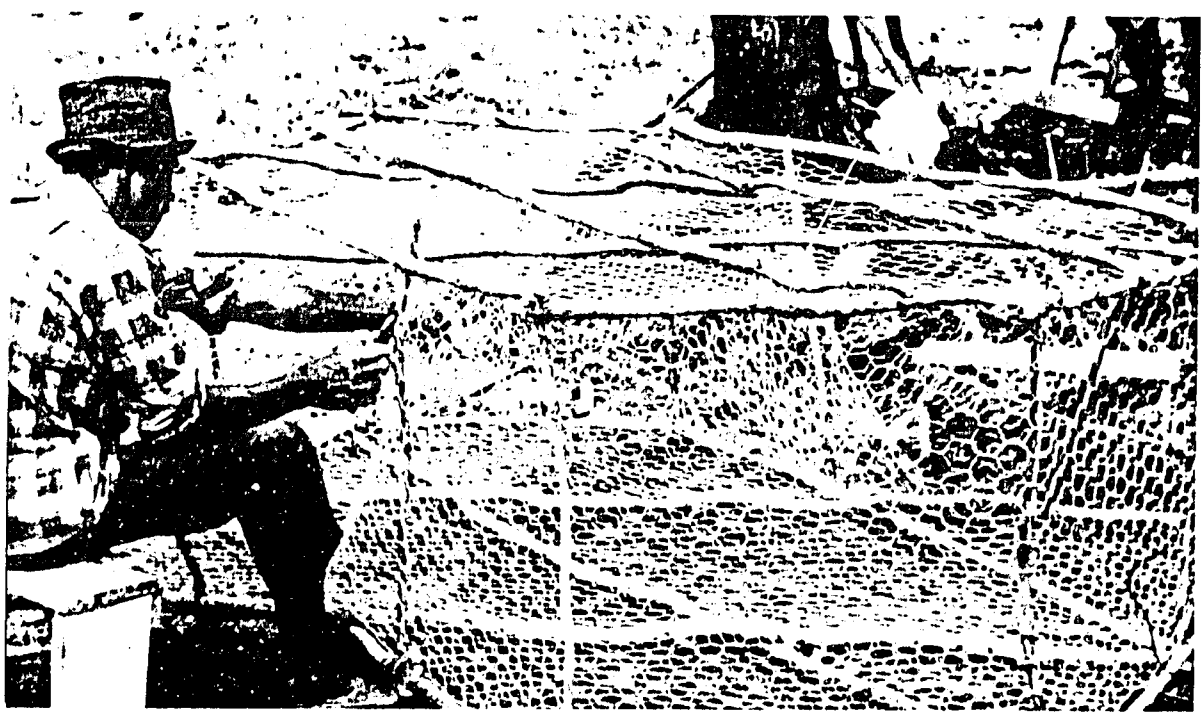
All of these designs are constructed in wood; various attempts have been made to introduce fiberglass vessels, but while extensively used in Martinique and Guadeloupe, these have not been adopted to a significant extent in any of the English-speaking islands.

Seven types of fishing gear are in common use:

Trolling Lines are deployed while the boat is underway or drifting; in the former case lines are typically fished at the surface, often using bamboo outriggers. Deep-set (100 m or more) lines are used in some islands when drift fishing for pelagic species. Artificial feather lures or baited hooks (ballyhoo, sprat, and flying fish are commonly used) are used with monofilament, monel or galvanized wire, or cotton lines, often in combination.

Bottom Hand Lines, in depths ranging from 20 m to 200 m, usually with monofilament lines attached to one or more baited hooks. Mechanical devices are not normally used to haul the lines. Only one or two lines are set at a time, because many fishermen believe that catches are best when one can feel the fish on the line.

Traps are usually Z-shaped with one or two funnels, made from chicken wire reinforced with wooden stakes and weighted with stones. Sizes range from 0.5 m x 0.6 m x 1.2 m to over 1.2 m x 1.2 m x 1.8 m. Smaller wicker traps are used occasionally, especially in Grenada and Dominica. Trap theft is a common and growing problem throughout the region, but timed float releases (which would make theft more difficult) and zinc anodes (which would double life of the wire mesh) are not in general use.



West Indian Fish Trap. St. Lucia. Photo by Sandy Goodwin

Gill Nets are the primary gear employed for capturing flying fish, and are occasionally used for both demersal and other pelagic species. Bottom set gillnets are hampered by the general lack of suitable bottom for this gear, while sharks frequently interfere with pelagic operations.

Trammel Nets consist of three panels of netting attached to common float and lead lines. The inner panel hangs loosely between the larger-meshed outer panels. This highly efficient and non-selective gear is typically set in relatively shallow reef areas where lobster, conch, and a wide variety of fish may be captured. Since juveniles and undesirable species are caught, the potential for resource depletion is substantial.

Beach Seines are probably the most traditional gear for organized fishing, and are used throughout the region, though the practice has declined in recent years. The net is normally set from a rowing boat to enclose schooling fish, and then hauled from shore. In islands with narrow coastal shelves (e.g., Dominica and the lee coast of St. Vincent) large pelagics may be captured with this technique. There has been a tendency to reduce the mesh size of seines, so that large numbers of juvenile fishes are now captured and often wasted.

Diving, often with SCUBA equipment, is commonly used for harvesting conch and spiny lobster and occasionally for spearfishing. This technique carries considerable potential for resource depletion, since protection of juvenile or reproductively active individuals depends upon the diver's discretion (which typically is lacking). The majority of conch populations are found in water depths less than 30 m, and are thus readily accessible to divers. Spiny lobsters can live at greater depths than can be attained with air-supplied diving, and deep-water "reserves" have probably helped forestall severe depletion of these stocks. As shallow populations are exhausted, however, there is a tendency for fishermen to dive into deeper waters. This practice coupled with lack of training is responsble for increasing reports of health problems among diver fishermen.

Gill nets are increasingly used throughout the Eastern Caribbean. Anguilla. Photo by Sandy Goodwin

Interestingly, all of these techniques were in use prior to 1776 (Price, 1966). This would appear to support the view that artisanal fishermen are reluctant to accept change. Yet, some innovations have clearly been readily accepted: metal fish hooks, synthetic lines, outboard engines, SCUBA apparatus. The reality seems to be that traditional techniques are well-adapted to local resources; artisanal fishermen do not resist change *per se*, so much as they require clear demonstration of the superiority of new approaches before abandoning proven techniques. Also, simple technology has been more than adequate to overexploit some stocks (e.g., conch, spiny lobster, sea urchins), and to saturate local markets during peak fishing periods. A case in point is the newly-opened fish landing complex in St. Lucia: encouraged by promises of guaranteed sale, fishermen flooded the facility with much more fish than could be stored or sold -- without any change in current technology (J. Harrison, personal communication).

In recent years there has been growing interest in the use of fish aggregating devices (FADs) and "artificial reefs" as a means of increasing local landings. Long-used in the Pacific, these devices appear to have substantial promise for Eastern Caribbean fisheries. Prototype artificial reef projects in Montserrat, British Virgin Islands, and U.S. Virgin Islands suggest that increased production of shallow-water fishes is possible using scrap automobiles and tires. Another approach which deserves investigation in the Eastern Caribbean involves the use of custom-designed structures to maximize the production of useful species. Reports of a recent study in Florida indicate that fish biomass on Japanese designed reefs was 2 - 6 times greater than on scrap metal "reefs" (Schmied, 1985). These particular units were quite expensive, and the actual differences in cost-benefits between the two designs are not clear. Designed reefs similar to those in the Florida study can, however, be constructed on site at a much lower cost.

A variety of mid-water fish aggregating devices (FADs) is being used experimentally in the region. Studies by the U.S. Virgin Islands Division of Fish and Wildlife have shown that catch rates are significantly increased by deployment of FADs. Units installed close to the edge of the coastal shelf are reported to attract many migratory pelagic species, particularly dolphin; an estimated 30 - 40 large dolphin may be caught each day around a single FAD (J. LaPlace and R. Gomez, personal communication). A project to evaluate the suitability of FADs for artisanal fisheries is now underway in St. Kitts. Grenadian fishermen have traditionally used similar techniques in the pelagic fishery. Flying fish are attracted to palm fronds tossed onto the surface of the water. The flying fish often leap onto the fronds to spawn, and are scooped into the boat. In addition to being an important human foodstuff, flying fish are used as bait on handlines to capture larger target fishes attracted by the activity at the surface.

While the current marine harvest is concentrated largely upon fin-fish, it is important to consider the development potential of other resources as well. In the Pacific, fish account for about 57% of the total harvest from shallow coral systems; the remainder consists of plants and invertebrates (Munro, 1984). Some of the Eastern Caribbean analogs of the latter resources are discussed above, but there has apparently been no effort directed toward comprehensive identification of such underutilized stocks.

D. Social, Cultural, and Economic Issues

1. Economic Context

Though the practice of fishing has changed relatively little in the past 20 years, major alterations have been taking place in the economies of the RDO/C countries which directly affect the fisheries sector. Along with independence has come a desire for greater self-determination and change from colonial practices. These aspirations along with declining world prices for many products of island agriculture have stimulated development of other sectors, particularly tourism and light manufacturing. Assured wages for more prestigious work in these sectors, as well as opportunities provided by emigration and the

local civil service, have constituted a disincentive to enter more traditional occupations such as farming and fishing.

A recent example from St. Kitts serves to illustrate the impact of economic change on traditional fisheries. Like most of the RDO/C countries, St. Kitts has experienced a variety of fisheries development efforts during the past 25 years. One local fisherman has been a particularly enthusiastic participant in these activities, has capitalized several small boats and fishing equipment on the basis of fishing profits alone, has attended several international conferences on fisheries development, and has been a strong advocate for fisheries management (often in direct conflict with other fishermen). Eager to explore innovations, he worked closely with an expatriot investor who ill-advisedly attempted to transfer New England fishing technology to a commercial fishing operation in St. Kitts. This enterprise recently failed.

Perhaps this raised questions as to whether there really was any development potential at all. In any case, the fisherman has virtually abandoned his former occupation and is now engaged in SCUBA diving excursions for tourists. This change has been encouraged by several expatriots who have since become involved in the new diving enterprise. In the absence of tangible examples and workable means for effective fisheries development, St. Kitts has gained a dive tour operator and lost one of its most productive fishermen.

On the whole, fishing in the Eastern Caribbean continues to be a marginal enterprise. Small-scale fishermen tend to have less disposable cash income than others, and in some cases only during certain seasons. This is particularly true where

- there are no price floors
- prices fluctuate with the level of the catch
- marketing facilities cannot handle a glut
- an increase in fishing effort has been instituted through investment in new equipment and gear

All of these situations are common in the Eastern Caribbean.

The marginality of many fishing communities in the RDO/C region is indicated by:

- physical isolation
- lack of physical infrastructure in coastal areas
- membership in minority or perpetual opposition political parties
- language differences and low rates of literacy and numeracy
- with the exception of St. Lucia, small proportion of fisheries support to total agriculture budget

The World Bank has identified several factors which contribute to fishermen's low incomes (Sfeir-Younis and Donaldson, 1982):

- As fishing activities expand, the free entry (particularly of part-time fishermen) and difficult exit (Panayotou, 1982) from the sector tend to exhaust the resource, leaving fishermen with nothing to sell.
- The special skills of fishermen are for the most part not readily transferred to other sectors.
- Limited availability of capital, and frequently unreasonable repayment terms (i.e., regular monthly payments instead of a schedule matched to periods of peak fisheries production) ensure a low rate of growth in productivity, locking the fishermen into low-level subsistence as the only adaptive option.
- Family ownership, or non-ownership, of the means of production limit the fishermen's opportunities, as boats cannot be subdivided to accommodate additional family members. World-wide data indicate that incomes earned by boat and gear owners are almost twice that of boatless fishermen and many fishermen neither own boats nor become involved in ancillary activities.

In addition, the fisherman's characteristic independence makes it difficult to form cooperatives, pool savings, and engage in similar activities which would reduce costs and improve the availability of capital.

2. Infrastructure and Product Flows

Lack of infrastructure development and uncertainty of product flows are principal sources of concern in regard to marketing. From the point of view of the fisherman, such problems appear in the form of a lack of responsiveness of the system itself. For example, fishermen in the Northern Mariana Islands of the Western Pacific (in an artisanal fisherysituation similar to those in the Eastern Caribbean) do not receive a price differential for iced fish (Orbach and Randall, 1980). The reason was basically that iced fish were locally perceived to be of generally poor quality (a similar perception has been common in many smaller islands of the Eastern Caribbean). Without a price differential and with inadequate storage facilities for their larger catches, there is little incentive for fishermen to increase the quantity or quality of their catch.

Fish is the preferred food in local diets throughout the region. Although fish are commonly graded as "class A" (e.g, tuna) or "class B" (e.g., parrotfish) local buyers do not always have the option of choice. During the latter part of the year, virtually all fish caught can be sold, and fishermen frequently sell directly from their boats as soon as they reach shore. Conversely, during periods of glut in the season for migratory pelagic fishes, fishermen often find it difficult to dispose of their catch and in some cases catches are below harvest capacity because of marketing difficulties.

Throughout the RDO/C region, the trend is toward a continuing shortfall in local landings compared to overall demand for fish. Despite periods of glut, fish imports to the region are valued in the vicinity of EC$ 50 million each year. A 1980 survey of marine resource management needs in selected Eastern Caribbean islands (Goodwin and Taylor, 1980) identified shortage of fish in local markets as one of the most frequently encountered problems. This situation continues (and in some areas is more acute) in 1984. In Dominica and St. Kitts-Nevis, local demand exceeds supply by a factor of 2.6 (Darroux, 1983; Wilkins, 1983). The majority of the smaller islands continue to import substantial quantities of fish from outside the region. Annual imports of fish to St. Lucia were valued at EC$ 2 million in 1982; approximately 60% of this was salt cod (Walters, 1982). St. Kitts-Nevis imports more than 240 metric tons of fish and fish products valued between one and two million EC dollars (Wilkins, 1983). With the exception of Anguilla, demand exceeds supply throughout the Lesser Antilles (Olsen and Wood, 1982).

A number of factors have contributed to this situation. Regional increases in resident and tourist population, greater local affluence in some islands, and a growing extra-regional market for fish have caused overall demand to rise. Increased fishing pressure on traditional stocks and fishing grounds have resulted in overfishing in many areas with consequent decline in landings. Habitat destruction has played a relatively minor role to date, but is likely to become increasingly significant with continued coastal construction associated with tourism and industrial activity. In fact, current trends in all factors suggest that the situation will worsen. But in every case, there appear to be underutilized stocks which, with relatively simple innovations, could significantly reduce the gap between local supply and demand.

Local demand for "luxury" fishery products is also high; some (such as shrimp) are almost totally imported. The potential for marketing underutilized "exotic" fishery products appears high; bivalves, squid and octopus, for example, are not harvested to any extent in the RDO/C countries but are conspicuous local products in Martinique and Guadeloupe. In the U.S. Virgin Islands, smoked marlin sells for US$ 7.50 per lb. Hotel and restaurant managers frequently complain of shortages of spiny lobster and conch (in addition to prime fin fish such as red snapper). In some cases these complaints are based on an unwillingness to match export prices (which have risen steadily in the last eight years), rather than an actual shortage of supply. In other areas, though, the shortage is genuine, usually resulting from fisheries which are largely controlled by a few entrepreneurs who export virtually all animals landed.

Lobster and conch fisheries illustrate the sensitivity of harvest pressure to demand. Commercial markets for these animals were rare prior to 1950, but increased consumer sophistication and development of alternative markets have led to the current regional trend toward export of spiny lobster and conch to Guadeloupe, Martinique, St. Maartin, Puerto Rico, and the U.S. Virgin Islands (DuBois, 1984). Lobster and conch stocks are now in urgent need of management throughout the RDO/C region.

Mariculture (in the broad sense of any manipulation to the natural productive process) offers some promise for stabilizing or improving yields of these species through use of protected nursery areas, habitat enhancement, or re-stocking; but none of these manipulations have demonstrated efficacy at this time.

The fishing production-to-consumption cycle is distinct from many other kinds of productive activities because the highly perishable nature of fish necessitates close coupling between components of the cycle. The domestic market cycle (in which harvests typically go directly to market) is different from the export market cycle (in which some processing or storage takes place between harvest and market). The typical domestic cycle resulting from high local demand for fish often appears to hamper the introduction of simple forms of intermediate processing (gutting, icing, etc.) which are only necessary during occasional gluts in supply.

Local marketing of fish is primarily handled directly by the fisherman, members of his family, or occasionally hawkers. There are few "middlemen" engaged in the local fish trade. This marketing style contributes to the underutilization of certain fishery resources during the fishing season for migratory pelagics. When fishing is good, a fishermen cannot afford to stay at sea and make most of the opportunity. He must hurry to shore before other fishermen arrive and create a glut which will drive prices down and may leave him with fish he cannot sell. It is often difficult to sell large fishes -- the individual buyer does not have sufficient cash or the means to store such a purchase, and many people know that larger fishes are more apt to be poisonous.

The same marketing patterns have (at least partially) resulted in a widespread prejudice against frozen or iced fish. Fish are landed whole (uncleaned) and have often been lying in the sun for several hours by the time the boats reach shore. If sale is difficult,

Marketing the artesanal catch. St. Kitts. Photo by Sandy Goodwin

a fisherman may occasionally try to freeze his surplus catch. By this time, significant decomposition has occurred; hence the belief that all frozen fish are spoiled. Gutting fish at sea and use of ice during the trip to shore would lessen the problem -- but would also increase prices because gutted fish weigh less and ice would add to the fisherman's operating costs. Governments are reluctant to encourage such increases, and price controls have been established in some islands in an effort to keep fish within the financial grasp of local consumers. This tends to inhibit the development of higher product quality, and is not generally effective because price controls do not reflect the reality of economics within the fishery.

The dual price structure resulting from government price controls and affluent purchasers abroad tends to favor export markets and contributes to domestic shortages and possibly a poorer quality product in local markets (which may justify lower prices). Under these circumstances, little increase in domestic fish consumption can be expected as long as fishermen continue to concentrate upon traditional stocks which are exploited close to MSY. It might be argued that income derived from export sales can be used to purchase other, less costly, foods; but this income is not uniformly distributed among the local population, while fish shortages in domestic markets have a more uniform effect. In order to resolve these issues in a rational fisheries development policy, local decision-makers require analyses of the impact of export trade and domestic pricing along with improved information on available fishery resources.

Recent experience with a centrallized fish landing complex in St. Lucia illustrates the need for an incremental approach to innovation. When the complex opened, fishermen were offered what they understood to be a guaranteed price for all the fish they could supply. The complex was quickly oversupplied by fishermen who had previously limited their effort because of marketing difficulties. Storage facilities were inadequate, and markets had not been identified to handle the surplus. Neither fishermen nor local consumers were enthusiastic about accepting price changes needed to cover the cost of additional processing. When the complex was unable to meet fishermen's expectations, a general boycott resulted, and customary marketing patterns were resumed.

In situations where domestic markets are a major part of the local fishery production cycle, innovations in processing should be expected to require changes in the local marketing pattern. Adjustments to such changes are considerably easier to make if the initial scale of implementation is small, and long-term impacts are likely to be less severe. It should also be noted that processing requirements for export markets may be different from those appropriate to domestic markets. Innovations resulting in greater supply of fish should therefore have their markets clearly identified in advance, or (more realistically) should be initiated on pilot scale with options to target either type of market.

At present, the most significant market for exported fishery products from the RDO/C countries is located in Guadeloupe and Martinique. Sixty percent of the fish landed in Antigua during 1982 were exported to Martinique; in the Grenadines the figure was estimated at close to 90% (cf Section VII). The French market has become so lucrative that vessels which formerly carried general cargo between islands now carry iced fish to Martinique. Many fishermen do not even land their catch; purchases are made at sea.

Particularly in the Grenadines, the local effect has been to exacerbate chronic shortages of fish, and to increase pressure on traditional fishing grounds. In an effort to improve their catch, fishermen are adopting (with encouragement from the French islands) bottom gill- and trammel nets which harvest indiscriminantly. This gear is frequently worked close to coral reefs, and poses a serious threat in terms of species depletion as well as mechanical damage to reefs. But local market and demand situations can change rapidly. In late 1983 and early 1984, Venezuelan fishing vessels operating in the Grenadines largely pre-empted the French market from the local fleet. As a result, local fishermen again restricted their efforts to traditional fishing grounds close to shore, despite poor catches resulting from severe overexploitation.

There are also examples of spontaneous local development. Historically, the majority of conch landed in St. Lucia were exported to Martinique. In February, 1984, what seems to have been an impromptu street party in one of the smaller communities developed into a weekly event at which conch and fresh fish are cooked and sold from street-side charcoal grills along with beer and various other local specialties. Tourists as well as local residents have been attracted, and conch exports to Martinique ceased. The new demand for conch has caused the local price to triple, and although the impact of this development on local conch stocks has not been determined, it appears that a fairly resilient local market (and another means for retaining tourist dollars) has been created. Significantly, this spontaneous development could not have occurred in the presence of government price controls.

3. Socio-cultural Characteristics of Fishing

Around the world, fishing as a way of life is oriented toward the sea and away from land, and thus away from land-oriented people, institutions, and processes. In addition, successful fishing requires very special skills, equipment, and a high tolerance for risk, both physical and financial (Pollnac and Poggie, 1978). In the Caribbean, fishermen are further distinguished from peasants and wage-earners by the legacy of slavery and the plantation system. Under this system, fishing slaves had, by virtue of their occupation, greater freedom of action and respect than those who worked on sugar, spices or other crops (Price, 1966). After slavery was abolished, wage labor for plantation owners continued, while fishermen maintained their independence. However, farmers have always outnumbered fishermen, and it is non-fishermen who now hold political power in the islands.

The separation of fishing communities is illustrated by the fact that (in contrast to other Caribbean islands) fish in the RDO/C countries are not generally marketed through the women-run marketing channels in use for other agricultural products. While the particularly perishable nature of fish and direct boat/beach sales may contribute to this exclusion, it is interesting that when processing or storage innovations are made or middlemen are involved, the women's network of higglers is seldom used (B. Richardson, personal communication). The literature on fishing communities and peasantries in the Caribbean documents the strong historical distinction between fishing and other economic and cultural adaptations (Price, 1966; Krasnow, 1983; Griffith, Johnson, and Orbach,

1985). This strong identification with fishing contributes to a system whose participants will only accept change when it offers significantly advantageous alternatives which can be fitted into the current mix of activities (Bennett, 1976; Vayda, 1969; McCay, 1981).

Fishermen value, and are admired for, their initiative and independence (Aronoff, 1967). Yet, this same independence coupled with the seasonal and risky nature of fishing has led to the poverty and marginality of many fishing communities. The poor conditions under which fishermen and their families often live, as well as the danger and difficulty of the work have led to the derogation by other people of fishing as an occupation.

These conditions have also fostered the development of occupational multiplicity among fishermen (Berleant-Schiller, 1977; Richardson, 1983). These occupational patterns are the result of physical, economic, and socio-cultural circumstances to which the inhabitants of the islands have had to adapt. In the more developed countries, single full-time occupations are the ideal if not the norm. In contrast, multiple part-time occupations are often the preferred adaptation in mixed economies (where there is a blend of subsistence and market activities) and especially in coastal fishing settings (Maiolo and Orbach, 1982; Anderson and Wadel, 1972; Pollnac, 1981). Brana-Shute and Brana-Shute (1980) describe the typical range of tasks that might be assumed by a part-time fisherman in St. Vincent, St. Lucia, or Dominica:

- tending an agricultural plot for household consumption and some sale
- estate work during "crop season" to secure cash wages
- odd jobbing for cash, liquor, tobacco, or reciprocal swap labor
- hunting, fishing, or gathering
- occasional government work; clearing brush, cleaning culverts, grading roadways

The same authors comment that there is equal concern with keeping cash flowing as there is with acquiring it, and point out that poorer people in the West Indies have historically had to rely on each other for mutual support and assistance. For example, income remittances from family emigrants play a important role in maintaining household consumption expenditures during the "off-season". The result is that people are not independent wage earners, but must invest considerable effort in cultivating a social network to call upon in times of need.

In remote island economies no single indigenous resource or source of income is sufficient, and multiple adaptation strategies predominate. When these communities become involved with outside sources of supply or demand, potentially disruptive dependencies are created. Single occupations linked to such dependencies are often viewed by islanders as undesirable. From the point of view of the islanders, such single occupations often involve more (not less) risk and uncertainty than a well-balanced blend of multiple occupations (Chibnik, 1980; Pollnac and Poggie, 1978). In this sense, the multiple occupations and the mixed economy are rational adaptations to the islanders' own perceptions of available resources and constraints.

These circumstances mean that "development" in the sense of higher capitalization of a basically artisanal fishing enterprise or single-occupation wage labor in a larger fishing

enterprise is viewed by many islanders as (and may in fact be) less desirable alternatives compared to their present condition. Increased fishing effort among part-time fishermen may be difficult to achieve unless significant benefits can be demonstrated. Even more difficult is adoption of an occupational style which removes the individual from the securities of his social support network. Brana-Shute and Brana-Shute (1980) point out that this can impose considerable emotional as well as financial hardship. Occupational multiplicity results in a dynamism between fisheries and other sectors that is often overlooked; significant changes in distribution of the labor force as a result of development in one sector can have adverse impacts on other portions of the local economy.

The distinction between full and part-time fishermen is important when determining development strategies for "artisanal fisheries," since the two groups are likely to respond in very different ways to specific innovations. The above discussion suggests that it may be very difficult to recruit part-time fishermen into a full-time fishery, and it is by no means certain that this is desirable. Since part-time fishermen are a majority in the RDO/C area, the degree to which innovations become widespread will depend upon the extent to which such innovations are compatible with part-time fishing. On the other hand, certain innovations can only be effective if applied on a full-time basis, and the audience (i.e., full-time fishermen) must be clearly targeted at the time of introduction.

Cultural factors may affect acceptance of changes inherent in development projects. Individual people and communities that are the locus of economic and social development activities have conscious (or readily discernable) rational patterns of behavior and beliefs that are frequently a consequence of and/or an adaptation to their operating environment. Understanding these behaviors and beliefs is essential for development and management efforts to succeed. People respond to incentives in the context of the available alternatives. Cultural practices set many of these alternatives.

In the Grenadines, for example, land-based work is "women's work" and to be avoided (J. Sutphen, personal communication). The fisherman sees fishing as a way of life, and (if he is an older established fisherman) views it as superior to others, even though he may not fish full-time, is politically and socially marginal to the rest of island society, and is poor. Ritual practices and beliefs can have direct implications for development planners. In St. Lucia, for example, the Savanne Bay boat owner is responsible for ensuring the divine protection of his boat and crew. He does this not by calling the priest to bless the fleet, but rather in the following manner. When his new boat is nearly completed, he sends away the builder, and once alone, drills a hole somewhere in the boat, into which he inserts a written prayer. He then pegs the hole, sands it, and paints as much of the boat as he can so that no one will be able to remove the prayer. His crew trust him to have done this, and will not go out in a boat unless they know it has been blessed and protected in this way (Koester, personal communication). The process would be considerably more difficult with a prefabricated fiberglass boat, a commonly recommended item in fishery development schemes.

4. Small-Scale Fishermen and Industry Organization

In situations of economic development and social change, there is a notable

tendency among small-scale fishermen to become involved with some form of "middleman" as their product enters more extensive market channels. Increasing capital costs and production often lead to the development of specialists in finance and marketing. As size and complexity of fishing equipment increase, there is less liklihood that individual fishermen will own their own gear. This promotes social stratification and inequality (Pollnac, 1981). Many analysts see this trend as detrimental to the long-term interests of the fishermen (Alexander, 1982), largely because of the shift of control over the fishing enterprise from fishermen to middleman and because of the "rent" which is extracted from the system by the middleman. Others maintain that middlemen may, in many cases, serve necessary functions in the maintenance and development of fishing industries (Maiolo and Orbach, 1982; Pollnac, 1977; Emmerson, 1980), functions which the fishermen themselves either cannot or do not wish to perform, or which it would be more efficient and effective for someone else to perform. All development, not fisheries alone, tends to follow a pattern toward greater inequality. A development program must include mechanisms to distribute benefits broadly to the community.

One pervasive response to the potential problem of the middleman and to the challenge of small-scale fisheries development in general has been to use various forms of cooperative organization to stimulate and guide development. The general objectives of cooperative organization are to amass capital which would otherwise be unavailable, to keep control over the business decisions within the groups of fishermen themselves, and to achieve economics of scale in such areas as equipment and supply purchase or marketing volume. These objectives are all possible in theory, but for the most part (particularly in the case of small-scale artisanal fisheries) have been notably unsuccessful (Poggie, 1980; OECD, 1976).

There are several reasons for the failure of fishing cooperatives in general which include insufficient capital, poor fiscal and administrative management, factionalism and internal competition, lack of marketing or processing expertise, competition from other commercial enterprises, and political complication with respect to permits and licenses for such processes as import and export. Even in the face of this record, however, many countries and development agencies continue to push cooperative organization as a fundamental means of economic development (Poggie, 1980).

There are a few exceptions to the "failure" rule for fishing cooperatives. In general, these cases are ones where the cooperative nature of the enterprise was combined with good business management and adequate education and capitalization, and where the enterprise was run much like other forms of organization (partnership, corporation) except that there was some form of cooperative ownership of the enterprise (Orbach, 1980; Poggie and Gersuny, 1974). One is tempted to say that cooperative organization in fisheries has succeeded in only those cases where the enterprise would have succeeded under almost any other form of organization as well.

5. Fisheries Management in Development Policy

Cato and Prochaska (1978) summarize an important feature of many fisheries: In general, expansion of an industry entails greater demands on raw materials or inputs. This

in turn increases the value of the inputs and hence the cost of the product, while the increased availability of the product tends to lower final product prices. Growth is controlled by the limitations on profits imposed by rising cost of inputs and falling product prices. But many fisheries are based upon common property renewable natural resources, and no price is paid for inputs. Thus, the dynamic constraints on growth discussed above are not fully operative. As a result, growth and fishing effort can increase beyond the level needed for maximum economic yield, until the increased harvest costs due to overfishing curtail production.

At present, Eastern Caribbean fisheries are open-access; anyone can fish who chooses to do so (with the exception of expatriots in some cases). The resources are free, and there is no market price mechanism to reflect scarcity. Coupled with demand exceeding supply, overfishing is probable since there is no check on supply or harvesting cost to deter fishing effort. On the contrary, there is every incentive to increase effort. Thus, when the market fails to capture resource scarcity, economic pressures normally will lead to overfishing and lower incomes. Panayotou (1982) points out that for this reason, maximum economic yield cannot be attained in an open-access fishery.

While access may be open, exit from an overcaptialized fishery may be difficult:

- Fishing assets cannot easily be liquidated under these conditions.
- Chronic indebtedness may impair mobility.
- Geographic isolation common among small scale fishermen may limit alternative employment opportunities.
- The time required to relocate and find new employment may be unavailable to fishermen barely able to catch enough to stay alive.
- Other occupations may not be available.
- Occupational multiplicity means that to find alternative employment may be abandoning all other occupations as well.
- Traditional fishing communities are a subculture which cannot be easily adapted to other activities (Panayotou, 1982).

It is clearly not desirable that development efforts contribute to eventual overcapitalization; ideally, fisheries development should encourage systems which mitigate against this condition. The need for planning is further underscored by the closely coupled nature of the fisheries production cycle, as well as the fact that fisheries can only operate in specific areas. But the planning process is complicated by the generally unknown character of how fisheries activities are organized. This means that much that is important about island fisheries is not objectively quantified in a form useful to planning or resource protection. Relative to planners' knowledge, fishing maintains the character of an "informal" sector, even though it is highly organized and may be quite efficient. Much less is known objectively about fisheries than about tourism and manufacturing. Considering the peculiarities of fishing described above, development policy must

- be cautionary in general,
- include provisions for improved understanding of local fishing organizations, and
- recognize that all of the problems presently visible in established fisheries can

be readily transferred to newly developed fisheries, unless the natural resources and their interaction with the rest of the fishery system are clearly understood; this understanding can only come from an integrated approach which includes reliable determination of resource capacities, and evaluates socio-economic impacts in a pilot project context.

The fact that optimum economic yield cannot be attained in an open-access fishery poses a basic problem for all of the subject islands. There are already a great number of fishermen with their attendant fishing capacity competing for what, at least in the case of traditional inshore resources, is an already overexploited resource base (this does not mean that there is no development potential -- but to attain this potential current fishing patterns must change). Even where the local resource base is not overexploited, it is often the case that the capacity exists to fully exploit the resource with low levels of technological development should market and other conditions warrant.

It is, of course, possible to harvest these resources more efficiently in the strict economic sense, but with a limited resource base that necessarily means at least a changing distribution of the benefits from the use of those resources, and at most the displacement of large numbers of less efficient producers from the harvesting sector (see Langdon, 1982 for a description of the distributive effects of purportedly more economically efficient harvesting systems). It is not logically or practically possible to further develop already overexploited resources without some restrictions on either harvest or participation. Even if greater efficiencies in harvest or production are possible, the state of the resource base dictates that they cannot be accomplished without some alteration of existing participation in the fishery.

There are a variety of ameliorative actions which might be taken:

- develop the capacity and efficiency of a few participants and eliminate less efficient harvestors
- allocate the resource among different categories of harvestor
- prohibit fishing in selected areas
- prohibit fishing during certain seasons
- prohibit harvest of critical life stages
- restrict harvest to certain size classes
- limit types of gear which may be utilized
- develop entirely new resource bases (but this will only postpone and eventually extend the problems unless development of new resources is undertaken with greater understanding of the fishery system than has been the case in the past)

Each of these alternatives is, at least in theory, possible; but they point up the fact that fishery development must go hand in hand with a comprehensive management regime which takes into account biology, ecology, economics, and socio-cultural factors.

One approach in industrialized countries to these situations is termed "limited entry" (Rettig and Ginter, 1980). This is based on the concept that the number of participants in a fishery should be limited to achieve economic and perhaps even biological efficiencies in the fishery. If the number of participants is limited, the theory goes, the benefits of the

fishing will enable the smaller number of producers to construct a viable industry and to develop self-sustaining individual fishing enterprises.

There are a number of limited entry systems in effect around the world, primarily in industrialized nations. Throughout history, however, some forms of entry or access limitation to marine harvests also have been practiced by indigenous peoples in small-scale fisheries (Klee, 1978; Spoehr, 1980; Johannes, 1978). Such limitations have been integral parts of the groups' socio-cultural adaptation rather than an externally-imposed system of policy and management. Recently, however, Bermuda instituted a limited entry system where permits were limited to those choosing to participate full-time in the fishery. The results of that system are not yet clear, but it is an example of an attempt by an island nation (albeit not a Less Developed Country in the sense of the Eastern Caribbean) to address the dual problems of overexploitation and overcapitalization by limiting entry to the fishery.

Among the assumptions underlying limited entry is that individuals have incentive only to harvest and not to conserve (Rettig and Ginter, 1980). If this is true, limited entry schemes only limit the total number of individuals; there is no effect on individual harvest capacity. In fact, fishermen under many limited entry schemes have become increasingly productive. Under these circumstances, effort must be constantly reduced to maintain desired yields.

With respect to the present case, it is not clear that the benefits of limiting entry to the fisheries in general for the purposes of economic development would outweigh the loss of nutritional and economic benefits derived by present participants. Limited entry presupposes the existence of alternative occupations, a supposition which is not valid in many areas of the Eastern Caribbean. It may be desirable, however, to consider limiting entry into certain new fisheries which are not presently critical to local subsistence.

Restrictive fisheries legislation in the Eastern Caribbean has not been particularly effective. With the exception of Dominica and Montserrat, all the RDO/C countries for years have had regulations for the protection of spiny lobster stocks; but these stocks are widely acknowledged to be in growing danger of overexploitation. A central problem is the cost of enforcement. The 1983/84 budget for the fisheries enforcement agency in the U.S. Virgin Islands (Division of Fisheries and Wildlife), for example, was US$ 360,000. Coupled with this problem is the questionable political wisdom of enforcing regulations for which there is little popular support. But compliance is obviously essential if management efforts are to have any impact. At present, the most realistic approach is to

emphasize education and outreach programs to broaden public support for fishery management regulations (harmonized fishery regulations are being enacted by all RDO/C countries at present as a result of FAO-sponsored workshops in 1983-84)

develop alternatives to overexploited fisheries, and establish the capacity of these new resources as an integral part of their development

explore options for stabilizing or increasing natural production of heavily exploited stocks, and determine the capacity of these stocks to support exploitation as a guide for development policy

In summary, small-scale fisheries worldwide and in the Eastern Caribbean in particular, have unique social, cultural, and economic characteristics. Small-scale fishing is often considered a marginal yet important economic enterprise. Attempts to impose new organizational forms on small-scale fishermen have been notably unsuccessful, most often because of lack of attention to social and economic constraints as perceived by the fishermen themselves. Infrastructure in small-scale fishing communities is generally inadequate, and marketing beyond the local community and region is difficult. These characteristics define certain high-potential pathways for fishery development, as set out in later sections of this report.

E. Mariculture

(prepared by Paul Sandifer)

Traditional fishing is dependent upon production processes which fishermen do not attempt to control. As harvests approach (or exceed) levels of maximum sustainable yield, increased production of seafood can only come through augmentation of natural production processes. The change in approach is analogous to the role of agriculture in augmenting hunting and gathering as a means of acquiring food on land. Broadly viewed, mariculture may include ANY manipulation to natural productive processes, ranging from providing artificial habitats for wild stocks to intensive culture operations which attempt to control every aspect of production from egg to adult to egg.

Natural fishery resources are undisputably limited, and the potential role of mariculture in production of marine food in the Eastern Caribbean is clearly important. The concept is intellectually attractive and has captured many imaginations. But it is unlikely that reliable and practical mariculture techniques can be developed in the space of a few years; again, consider the centuries of experience which form the basis for modern agriculture. Traditional mariculture practices in the Pacific and Asia have been developed through generations of trial-and-error.

This reality should not be viewed as a deterrent to mariculture development. On the contrary, such development offers the only means for increasing the availability of marine species which are currently harvested at or beyond sustainable levels; and the understanding necessary to achieve such results can only be obtained through experience. But it should be understood that, at present, most (if not all) mariculture projects are primarily technology development or adaptation efforts -- we are still a great distance from the "cookbook stage."

This section reviews considerations which apply to mariculture projects, and discusses current experience and development potentials. Recommendations for specific projects are made in Section VI.

1. Risk Assessment

Mariculture combines farming and fishing. Both are risky commercial enterprises, and costs of production typically rise faster than the prices received for the products.

Mariculture offers an alternative means of seafood production, but still must be considered *at least as risky* as farming or fishing. Several reasons for this relatively high degree of risk are:

- Mariculture crops are subject to disease, predator or other problems.
- Due to capital requirements, the mariculturist often has a relatively low level of control over the culture environment.
- Particularly in the Eastern Caribbean, the mariculturist deals essentially with wild animals. With very few exceptions, mariculture species have not yet been genetically improved for cultivation.
- There is a general lack of husbandry experience with aquatic organisms as compared with domesticated terrestrial organisms.
- In most areas, mariculture has little, if any, track record. Thus it is difficult to find local models to emulate.
- Like farming and many types of commercial fishing, mariculture operations generally require a large initial investment if they are to reach a commercial scale.
- Much mariculture technology is as much "art" or skill as science. Such arts and skills are not always easily transferred and often must be modified or relearned to fit the particular requirements of a new site.
- Eastern Caribbean mariculture operations are apt to be particularly vulnerable to hurricane and storm damage.

The degree of risk in mariculture development is also a function of the type of operations envisioned. For example, the least risk (and often the least benefit) is associated with subsistence mariculture. Here, the farmer establishes a "backyard" fish or shrimp pond for his family's utilization. One step above this in both risks and benefits is the aquatic farmer who produces more than his family can use and begins to sell the excess product in his local community. At the next step, he may enlarge his mariculture operation and cooperate with other producers to begin supplying a small portion of the urban institutional market. Because of the necessary size of the operation and thus the investment, considerably greater risk is associated with the small corporate mariculture business that targets a significant element of the domestic market. Finally, the larger corporate entity that targets an export market (although it may also supply a domestic market) is likely to be the riskiest and to require the greatest investment.

Despite their greater risks, corporate mariculture projects are likely to achieve the greatest economic returns. Such operations, however, may create few jobs or alternatively offer relatively low wages. In any case, it is desirable that mariculture operations have a significant amount of local participation, target domestic markets first, and then develop into export companies as production capacity is developed to properly support export activities.

To minimize, as much as possible, the risks associated with mariculture projects:

- Determine if mariculture is appropriate for the area. If not, forget it. Do *not* pursue mariculture development simply because other islands are doing so and because it is successful in some areas.
- Decide how mariculture should fit into an overall island/country development

strategy for agriculture and fisheries. A specific mariculture strategy should be developed for the Eastern Caribbean, with heavy participation by residents of the area.

- Adopt realistic goals for the project. In the Eastern Caribbean especially, start-up projects should target domestic markets and import substitution. Since much of the seafood served to tourists in the region is imported, substitution with domestically-grown products would mean that more of the hard currencies spent by tourists in the region would remain there. Similarly, added values due to local processing and handling would also remain in the region. Successful mariculture operations may eventually target foreign markets, but placing the FIRST emphasis on satisfying local demand provides an opportunity to work out the "bugs" in the production system as well as benefitting other sectors (e.g., tourism). Export markets generally require a high quality consistent product, and involve much more extensive handling and transport considerations. If several local mariculture operations are involved, marketing associations may be needed.
- Require in-depth expert review of all development projects to insure that they are well planned and adequately financed.
- Success stories, like that of Ecuador, should be studied. For example, major factors contributing to the success of shrimp mariculture in Ecuador include:
  - > an excellent climate for shrimp growth
  - > large expanses of suitable land adjacent to highly productive estuarine waters and lack of major competing uses for these lands
  - > a tremendous and easily harvested local supply of seed and brood stock of preferred species year-around in the wild
  - > locally available raw material for production of feeds
  - > moderate energy costs
  - > low labor costs
  - > a large and expanding market with unsatisfied demand
- Design for minimum damage from hurricanes. The probability of these disasters must be figured into the economic analysis.

2. Endemic vs Exotic Species

Attempts to control food production are replete with trial-and-error introductions of important species of plants and animals. Today, most foods come from a relatively few species and many of these, including a number of luxury items, are grown wherever there are suitable environments around the world. In the United States, much of agricultural production is based on introduced species, and this is true in most countries.

Not surprisingly, a similar but as yet more limited situation exists for aquatic food products. As with terrestrial species, those organisms that

- are valuable as food, industrial or recreational products,
- grow well in captivity, are hardy, and
- adapt to a variety of environments

are being transplanted around the world. Some such introductions are highly successful,

some only moderately so, and others are dismal failures. Of special concern are introductions that have led to serious disease and/or pest problems, or which may compete with highly valued local species.

At a "Symposium on Exotic Species in Mariculture", Dr. Roger Mann concluded:

> The introduction of exotic species for mariculture purposes should be considered only as a 'last resort' action. Where any feasible alternative exists, the introduction of an exotic species should be discouraged strongly. Introductions are generally irreversible actions, the product of which is unpredictable. (Mann, 1979)

Nonetheless, introductions and transplantations must be viewed as necessary facts of the "real world." Terrestrial food production in most, if not all, countries is dominated by introduced species. Food production businesses, including mariculture farms, must be able to compete successfully if they are to survive. This often means introducing species which are successfully cultured and marketed by other mariculture operations. However, species should not be introduced unless really needed and until necessary safety precautions are taken. An introduced species should:

- Fill a need, because of the absence of a similar desirable species in the locality of transplantation.
- Not compete with valuable native species to the extent of contributing to their decline
- Live and grow, but not reproduce, in the natural environment of the transplantation area; it would therefore only support a put-and-take operation and should not permanently displace any other species
- Not be accompanied by enemies, parasites, or diseases which might attack native species
- Not be unusually susceptible to pathogens or parasites in the transplantation area
- Live and reproduce in equilibrium with its culture environment (i.e., the organism should not be characterized by explosive growth or reproduction followed by precipitous demise of virtually the entire population caused by exceeding the carrying capacity of the environment)

(adapted from Dean, 1979)

The following guidelines are suggested to govern introduction:

- Endemic species of interest should first be evaluated as fully as possible. Culture characteristics should be determined if not known and compared with those of the species under consideration for introduction. Such comparisons should also include relevant costs for acquisition and maintenance of seed and brood stock for both species, relative availability, and any market advantages or disadvantages of either. Where little information on the native species of possible interest exists, the necessary applied research must be done to permit appropriate decisions on introductions.

- The main threats of introduced organisms are to the health of other aquatic organisms in the area of transplantation and to a lesser extent to public health. Therefore, quarantine facilities should be established by government to handle introduced organisms. Parent stock would be imported, inspected for disease, maintained in quarantine, spawned, and destroyed. The F1 progeny would be reared in quarantine until all reasonable tests indicate that they are disease-free and then released for use in mariculture. Alternatively, seed or brood stocks of a species could be imported via a disease-free certification program in another country.
- Some sort of benefit-cost analysis should be conducted for the introduction. Who will benefit from the introduction? How? What are the potential problems or losses that may occur as results of the introduction? Do the potential returns justify the risks?
- Local regulations should be evaluated to ensure that they provide adequate protection but do not preclude important options.

3. Environmental Impacts

Guidelines provided for evaluating environmental impact of mariculture projects have been defined (Phelps, 1981), and should be routinely applied to all proposed mariculture operations. If constructed and managed properly, mariculture projects should have minor environmental impacts. The most significant negative effects are likely to be

- the consequences of introduced species
- destruction of wetlands, especially mangroves

With regard to the latter, wholesale alteration of wetlands should not be allowed. In any case, mangrove swamplands and saltmarshes are often not good areas for pond construction.

Other possible impacts of mariculture operations include:

Increased eutrophication -- Fertilizers are typically added to pond waters to induce algal blooms. Although most of the nutrients are used directly in the ponds, the effluents are generally enriched. If such effluents are discharged into a closed water body such as a lake, it is possible that eutrophication in that area would be accelerated. If discharged into rapidly flowing waters or the open ocean, it is unlikely that any impact would be noticeable. The same is true of the biochemical oxygen demand of the effluent. These effluents, however, may have significant impacts on partially enclosed marine systems such as coral reef lagoons. Plant fertilizers can adversely affect such systems by promoting the growth of algae which overgrow living reef corals, or which multiply in the water column and decrease light penetration.

Chemical contamination -- If chemicals are used to control weeds, some of these may be released in effluents. However, it is expected that such chemicals would be rarely used and their concentrations in discharge waters would be extremely low. If this was an area of major concern, a discharge system could be designed with appropriate safety treatment facilities.

Sedimentation and Mechanical Damage -- Some dredging may be necessary to construct seawater access and distribution channels. This should have no signficant negative impact, if properly planned and managed.

Depletion of Water Reserves -- Water use requirements can be significant. This may be of concern if large amounts of fresh water are needed. Freshwater aquaculture may be a viable proposition in islands such as Dominica, Grenada or St Vincent. It is clearly less promising in such areas as the Grenadines or Antigua.

Competition with Capture Fisheries -- Requirements for wild-caught juveniles can occasionally cause problems for production in a wild fishery (e.g., Ecuador).

Competition with Agriculture -- Mariculture operations can result in salt-contamination of coastal lands. Preferably, prime agricultural lands should not be used for salt water culture operations.

Acidification -- Dredging and pond construction may occasionally expose soils that become very acidic and result in low pH's in pond waters. Careful planning and soil analysis prior to farm construction should avoid this problem.

Overall, environmental problems associated with mariculture projects generally should be minor and easily handled.

4. Potential Species for Cultivation

This list is not intended to be all-inclusive. Rather, the intent is to identify some species that appear to have reasonable potential for mariculture in the Eastern Caribbean and to briefly evaluate some other species that have been suggested for cultivation in the region.

a. Algae

Culture of algae for direct consumption and to supply industrial products (e.g., carrageenan) has developed primarily in the Pacific. The economics of algal culture systems are poorly understood, and serious technical problems must be solved before intensive cultivation systems become viable. Recent work with small-scale culture of *Gracilaria* species in St. Lucia appears to have considerable potential as an adjunct activity for artisanal fishermen.

b. Molluscs

(1) **Queen conch** (*Strombus gigas*): The mariculture potential of this species has been studied over the last several years and considerable progress has been made in the laboratory. However, a commercial-scale hatchery technology for mass production of metamorphosed juveniles has not been developed and demonstrated. Much work remains to be done in the areas of larval feeds, optimum culture conditions, mortality control, and mechanisms for triggering metamorphosis -- hatchery technology is still in an early stage of development. Another problem is that the growth rate of juveniles appears to be too slow for captive culture. In addition, considerably more information is needed on food

No longer true see TWI of Caicos Conch Farm in Turks & Caicos Islands

requirements, suitable grow-out systems, means of improving growth rates, etc., and there is a general lack of pilot-scale grow-out studies.

Overall, it appears that the technology for queen conch mariculture is not sufficiently developed to support commercial operations. However, the available technology may be sufficiently advanced to begin to be used in fishery enhancement/ rehabilitation projects. In such instances, only hatchery technology is required, and the juveniles produced are released into the natural habitat. The need for such rehabilitation measures is likely to be very site specific, depending on the level of fishing effort, the importance of the fishery to the island, and the status of the habitat.

(2) **Oysters:** The mangrove oyster, *Crassostrea rhizophorae*, occurs throughout the Caribbean and is cultured to some extent in Cuba. However, it is not judged to be a good candidate for commercial mariculture in the Eastern Caribbean. Naturally occurring mangrove oysters typically set intertidally in mangroves where they grow rather slowly, often producing a stunted, poorly shaped animal. Culture techniques can overcome these problems to an extent, but the mangrove oyster is not considered a prime product.

The American oyster, *Crassostrea virginica*, can do well in the tropics as evidenced by its successful pilot-scale culture in Hawaii. The technology employed there is intensive tray culture in concrete trenches. A major problem in the Eastern Caribbean would be marketing. It is unlikely that one could get a high enough price for the product for it to become an export product. Therefore, it would have to be targeted for use in tourist restaurants as an import substitute.

Overall, a good deal more experimental rearing of oysters (including the Pacific oyster *C. gigas*) should be conducted before oyster farm development projects are undertaken in the Eastern Caribbean. The potential for polyculture of oysters in shrimp ponds or other mariculture systems should be evaluated carefully.

(3) **Other Molluscs:** The false angel wing clam, *Pseudopleura*, should be examined as a posible polyculture candidate for use with shrimp. The clam feeds on benthic algae, mixes bottom sediments, and produces tremendous strings of pseudofeces which could effectively package food for juvenile shrimp. A scallop, *Argopecten amplicostatus*, also deserves study for possible culture application in the Caribbean.

c. Crustaceans

(1) **Spiny Lobster** (*Panulirus argus*): "It is generally conceded that the potential for culture of spiny lobsters is very low" (Osterling and Provenzano, 1985). No hatchery technology exists, and it is doubtful that one will be developed within the next decade. Other major problems are

- acquiring sufficient numbers of juveniles from the wild
- a very long grow-out period
- aggressive behavior of the lobsters
- a lack of suitable diets
- a lack of well-developed grow-out systems

Tamm (1980) suggested that extensive culture ("ranching") in large salt water impoundments might be possible, but this idea has not been tested. Habitat protection and enhancement and strict enforcement of fishery regulations are more likely to help maintain production of spiny lobsters than mariculture operations.

(2) **American Lobster** (*Homarus americanus*): Hatchery technology for American lobsters is well developed, but grow-out systems are not yet ready for commercial application. This situation is clearly pointed out in two recent reviews (Conklin and Chang, 1983; D'Abramo and Conklin, 1985). Besides a lack of tested grow-out systems, development of an adequate formulated diet for juvenile to adult lobsters is judged to still be anumber of years away (Conklin and Chang, 1983). Growth of American lobsters under controlled conditions has been shown to increase with increased temperature. Over the past ten years, several projects have been proposed or implemented for American lobster culture in the Eastern Caribbean (notably in Anguilla), based on the assumption that this observation makes this species a promising candidate for tropical mariculture. The lack of success of these efforts underscores the hazards associated with extrapolation of laboratory results to commercial operations at a greatly increased scale, as well as the added risk entailed by attempting to culture species in climates where they are not normally found. At present, little, if any, grow-out results are available from true pilot scale projects.

(3) **Penaeid Shrimp**: A great deal of enthusiasm for shrimp mariculture has resulted from the success of such ventures in Ecuador and Panama. Some of the factors contributing to this success are listed above. It is worth noting that some of these factors (large expanses of land adjacent to esutaries; abundant natural supply of larvae and broodstock) are not typical of the RDO/C countries, while others (such as inexpensive coastal land and low wages) may not be compatible with other development objectives.

The technology for marine shrimp culture is still developing, but it is sufficiently advanced to support successful mariculture operations in numerous areas of Latin and South America and Southeast Asia. Currently, there are a number of marine shrimp projects in the Caribbean (Weidner, 1985):

- Anguilla -- Aquaculture Technologies is conducting shrimp hatchery research
- Antigua -- Antigua Shrimpery is developing a small private farm to produce exotic species (*P. vannamei* and *P. stylirostris*) for the local market
- Bahamas -- Maritek Corporation and Morton Salt are working with exotic species
- Cuba -- the government is experimenting with the native *P. schmitti*
- Dominican Republic -- one small farm is using wild-caught *P. schmitti;* larger farms to produce exotic species are being planned
- St. Kitts -- Leeward Island Shrimp Company is developing a natural salt pond for culture of *P. vannamei*; several crops have been harvested and sold to local buyers
- U.S. Virgin Islands -- Until very recently, Maritek Corporation had a hatchery producing *P. vannamei* and *P. japonicus*, but this facility is now reported to be out of operation

Small scale shrimp production at Leeward Islands Shrimp Company. St. Kitts. Photo by Sandy Goodwin.

P. schmitti is widely distributed along the Atlantic coast of South America to Laguna, Brazil (Farfante, 1969). It currently supports capture fisheries in a number of countries such as Brazil, Colombia, Honduras, and Nicaragua. Moderately successful pond culture operations are underway with this species in Brazil and Colombia. *P. schmitti* has been successfully spawned in the laboratory and pond-reared adults have been spawned in Brazil with good results (Martinez *et al.*, 1984; Chamberlain, 1985). A major advantage of this native species may be the likely availability of wild juveniles and brood stock in some areas with which to initiate pilot-scale operations. With a local supply of animals, one does not become dependent on foreign suppliers nor does one have to deal with transportation difficulties, quarantine procedure, or delays necessitated by rearing one's own broodstock.

Of the exotic species, *P. vannamei* and *P. stylirostris* probably have the best potential for use in the Caribbean. Both are Pacific species, and they are the species of choice in Ecuador and many other areas. However, *P. vannamei* reared in captivity are sometimes difficult to spawn, necessitating acquisition of more wild broodstock. Maturation and spawning are more dependably achieved with *P. stylirostris*, but this species produces much less predictable yields in pond grow-out. A recent review (Weidner, 1985) notes that availability of postlarvae is an increasingly serious problem, even in Ecuador.

(4) **Freshwater Prawns** (*Macrobrachium rosenbergii*): Production technology is by no means completely developed, but it is adequate and dependable enough

for commercial use. The Western Hemisphere prawn aquaculture industry began in Hawaii in the mid-1970's following about 10 years of research and development activities. By 1978, the industry had a little more than 40 ha under cultivation in Hawaii, and the area of ponds stabilized at about 125 ha by 1980 (Sandifer and Smith, 1985). A major problem is that while the product has been well received in local markets in Hawaii, it has not penetrated the mainland shrimp and lobster tail markets in a big way. At least one large firm got out of the business in Hawaii in the early 1980's, ostensibly because of marketing problems. Similarly, one mainland farm has had difficulties marketing its product as a specialty item deserving of a higher price than shrimp. Other firms have had different experiences, supplying special Oriental markets in urban areas, European markets, etc. Overall, the best markets for freshwater prawns have tended to be local hotels and restaurants that cater to tourists. In such outlets, prawns typically command an excellent price. In some cases, such markets already existed and were being supplied sporadically from wild stocks (e.g., Puerto Rico and Mexico).

A few private freshwater prawn projects have failed in the Caribbean, most notably in Puerto Rico and Jamaica. Disease was a problem in one of the latter cases, when the imported species (*M. rosenbergii*) was found to have little resistance to local pathogens. A variety of factors, including underdeveloped technology, severe hurricane damage, lack of adequate capital resources, and management problems may have been responsible for these failures. However, it should not be surprising that some mariculture projects do not succeed; the failure rate for small businesses of all kinds is considerable.

At present there are a number of freshwater prawn projects underway in the Caribbean. These include what will be an approximately 50 ha farm in Puerto Rico, 90 ha in Martinique, two farms in Jamaica, and smaller projects in the Bahamas (Andros Island), Dominica, Dominican Republic, Grenada, Guadeloupe, and Haiti (Weidner, 1985; personal observations). Of the Caribbean species of *Macrobrachium*, *M. acanthurus* appears to have greatest potential. Though smaller than *M. carcinus*, the larval development period is shorter, physical tolerance is higher, and the animal is less aggressive in high densities (W. Hunte, personal communication). Overall, prawn culture appears promising for the Caribbean, but it will be limited by the availability of freshwater and the size of local tourist markets. Marketing and seed supply problems will have to be dealt with. If a seed supply is available, small-scale (backyard) prawn farming can develop as a source of supplemental income for certain island residents.

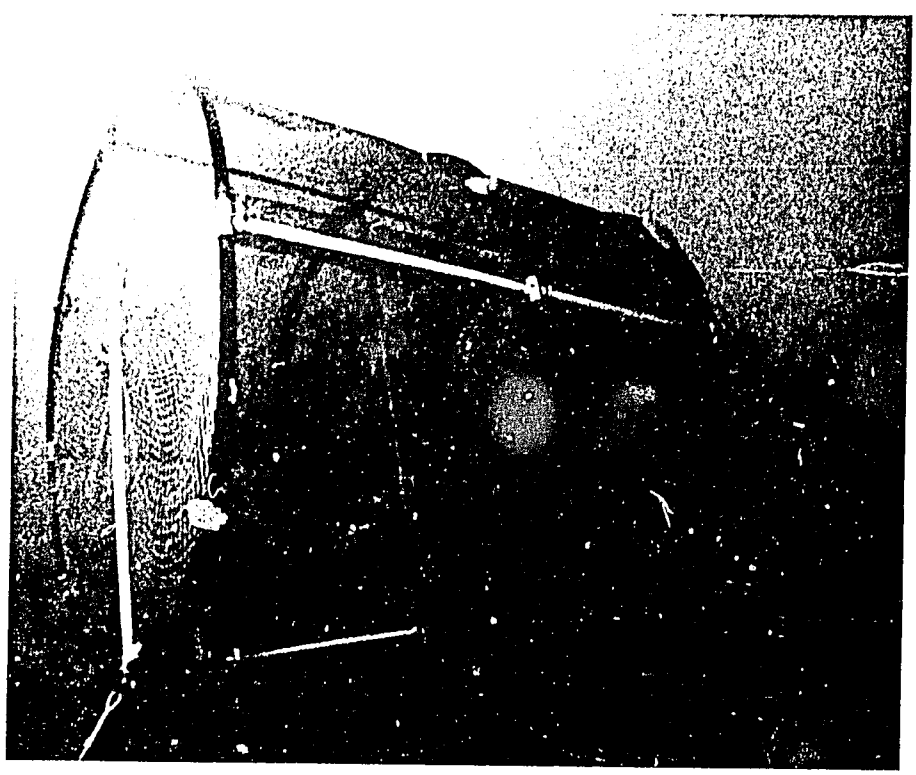
(5) **Brine Shrimp** (*Artemia* sp.): Brine shrimp are widely used as a food for commercial mariculture, as well as for the pet shop trade, and have potential for use in feeds for other animals (e.g., chickens). USAID has sponsored a recent study (Goodwin *et al.*, 1984) of the mariculture potential of indigenous Eastern Caribbean brine shrimp. The principal findings of this study were that indigenous brine shrimp have good nutritional characteristics when reared on naturally occuring salt pond phytoplankton. These algae respond favorably to fertilization with locally available products such as chicken manure and brewery grain waste. The study offers evidence that brine shrimp culture in endemic salt ponds can be a viable proposition, particularly as a cottage industry, and suggests that the next step is further evaluation in the context of one or more pilot projects targeted toward commercial production.

(6) **Crabs:** Although a variety of crabs are commercially important, in general they appear to have little potential for mariculture (see Osterling and Provenzano, 1985). Exceptions to this are production of soft-shell blue crabs in the United States and true farming of another blue crab (*Portunus trituberculatus*) in Japan and Taiwan. Major problems in crab culture include aggression and cannibalism, relatively slow growth rates, lack of satisfactory diets, lack of effective grow-out systems, and low meat yields. The last factor is very important since it controls the price one is likely to receive for the cultured crab. Typically, picking yields in commercial crab steaming plants are only on the order of 15% and are virtually always less than 20%. Even if crabs are picked raw and there is no significant water loss, yields would be expected to average well below 50%.

There is currently interest in the Caribbean in the potential mariculture of a native spider crab, *Mithrax spinosissimus*. Technical data are not available to establish the feasibility of large-scale culture, though pilot projects are underway in Antigua and the Dominican Republic which should provide such information. According to an industry source, spider crabs are not widely marketed at present. Until market studies are done, it is questionable whether *Mithrax* could be substituted for other spider crabs such as the snow crab, which itself is a relatively low priced substitute for Alaskan king crabs. A considerable amount of market research should be done before a high priority is given to developing crab mariculture in the Caribbean.

(d) **Fin Fish**

At present, the only investigations of mariculture potential of Caribbean fin fish appear to have been done in Martinique where preliminary results for cage culture of yellowtail snapper (*Ocyurus chrysurus*), permit (*Trachinotus falcatus*), and palometta (*Trachinotus goodei*) are promising. Because the Caribbean is a net importer of fish, means of increasing domestic production, at least of high-value forms, should be evaluated.



Cage culture of fin fish is a promising technology for the Eastern Caribbean.
Photo by Sandy Goodwin

Finfish mariculture offers opportunities for import substitution as well as production of high quality non-ciguatoxic fish. Species of European sea bass, *Dicentrarchus*, are being evaluated for culture in Martinique, and several crops have been exported to France. Other species that should be considered include:

(1) **Redfish** (*Sciaenops ocellata* ; also known as red drum and channel bass): Technology for controlled maturation and spawning is well developed and relatively easy. Fingerling production requires ponds, but the technology is simple and millions of fingerlings have been reared. Grow-out has been less well demonstrated, and no pilot farm data are as yet available. However, data from both wild and cultured populations indicate a rapid growth rate and excellent tolerance of pond conditions. Anticipated yields are on the order of 3,000 - 5,000+ lbs of 1 +/- lb fish/acre/year. The species also appears amenable to cage culture, although little work has been done in this area. One company is already working with *Sciaenops* in the Bahamas, and research to evaluate its culture potential for the Caribbean is being proposed in Martinique. Some markets exist in the U.S., but the best target market would probably be local tourist restaurants where a "redfish" is likely to be well accepted. Pilot production and test marketing trials are needed.

(2) **Epinephilid Groupers**: Groupers are being cage-cultured successfully in Hong Kong and Singapore. Work is underway on captive spawning and hatchery technology, but the industry relies primarily on wild seed. A variety of groupers occur in the Caribbean, and certain species should be evaluated to determine their mariculture potential.

(3) **Hybrid Striped Bass** (*Morone saxatilis* hybrids): Culture requirements are very much like those described for redfish. Controlled maturation and spawning have been demonstrated, but the methodology is not yet reliable enough for commercial application. The technology for fingerling production in ponds is very well developed, and grow-out trials have been conducted in ponds and cages with highly promising results. There is already some small commercial development in the U.S. Demand often exceeds supply in U. S. markets, since the East Coast striped bass populations have declined drastically. Additional work is needed on disease control and feeds (also true for redfish).

(4) **Tilapia**: Culture technology for tilapias is well developed and production farms exist in many areas of the world, including the Caribbean (e.g., Jamaica). *Tilapia* production is relatively easy, and the product is good. However, in most instances it is produced for domestic consumption only. There is little export market for *Tilapia*, and it is generally not considered to be a satisfactory substitute for high-value imported fish. In many island communities there is a cultural bias against freshwater fish in general and those with the appearance of *Tilapia* (silver-black color, etc.) in particular. This can be partially overcome through marketing efforts and use of more brightly colored hybrid fish.

In summary, culture of most finfish species that appear promising for the Caribbean is still in the experimental stage. Pilot-scale evaluations for some of these species should be undertaken as soon as possible.

An Aquaculture/Mariculture Project Evaluation System is provided in Appendix A (cf. also, Pillay, 1977).

III. PAST AND CURRENT FISHERIES DEVELOPMENT ACTIVITIES

A. Lessons of Experience

1. The Experience

The Eastern Caribbean has attracted increasing amounts of bilateral and multilateral foreign assistance since the mid- 1960's and especially since 1980. Fisheries development in the region has received varying degrees of attention since 1945. During the 1940's the Anglo-American Caribbean Commission undertook studies which concluded that fisheries development should emphasize careful management and cautious application of limited technology to increase catches without depleting stocks. The development proposals of the Commission were characterized by emphasis on the importance and vulnerability of traditional fisheries, the needs of artisanal fishers, and the real differences between Caribbean nations in resources, potential, and economic conditions. Technological innovation was to be fitted into the known resources and the local economy (Berleant-Schiller, 1981).

This perspective changed with the emergence of regionalism and the West Indies Federation. Typically, imitation of developed nations was seen as the route to obtaining the benefits enjoyed by those nations and desired by the Caribbean islands. In the case of fisheries, this translated to greater attention to mechanized commercial fisheries. In the 1960's, the desire for modern technology dominated development activities, and emphasis was placed on projections of fisheries potential which would attract investment capital.

One conspicuous product of this trend was the United Nations Development Program/Food and Agriculture Organization Caribbean Fishery Development Project (1965-1971). Three major resources were delineated by this project: a demersal trawl fishery limited to the continental shelf off northeastern South America; snapper/grouper/jack fisheries on banks adjacent to Central America, the northern Leewards, and the Guianas; and scattered shark, baitfish, and pelagic resources. Wolf and Rathjen (1974) concluded that the latter were of "insufficient magnitude to offer large-scale commercial development . . . [and] there appears to be little hope of development of a tuna fishery by the longline or live bait methods."

Thus, ***the most extensive resource assessment conducted to date did not show promise for large-scale commercial fisheries development in the Eastern Caribbean.***

But while this was an essentially exploratory operation, "the basic development decisions were built into the project; they did not emerge from its research phase. . . The entire project emphasized the exploitation of new fish resources on a scale large enough to attract private investment" (Berleant-Schiller, 1981). Despite the conclusions of the UNDP/FAO project and mounting negative experience, the highly capitalized industrial model of fisheries development has persisted for over 20 years. Between 1970 and 1983, the Caribbean Development Bank provided direct financing and technical assistance grants in excess of US$ 6 million to the fisheries sector, in addition to indirect lending estimated at over US$ 2 million. Of five projects actually implemented, three have failed with a total

value in excess of US$ 4.2 million. The trend has not been confined to the Eastern Caribbean: between 1964 and 1981 the World Bank provided US$ 259 million in loans for 27 fishery projects, with nearly 60% utilized for large scale fishery development. But repeatedly, rates of return on such investments have been less than anticipated (Sfeir-Younis, 1982).

Overly optimistic projections of potential yield are common:

- A US$ 1.11 million CDB loan for Trinidadian shrimp trawlers to operate in Brazil and Guyana was withdrawn when the company was unable to meet payments because fishing proved uncertain in Brazil.

- In St. Kitts, an expatriot investor established a "deep sea" fishing operation to harvest the Saba Bank. Catches proved inadequate to meet fuel costs, leading to a shifted emphasis toward nearshore fishing. The resulting conflict with local fishermen contributed to the collapse of the enterprise.

- Another expatriot investor has proposed to establish a fleet of vessels to harvest spiny lobster in Grenada for export -- despite the existence of two local operations already engaged in similar trade, a local demand equal to twice the present supply, and widespread concern that current exploitation is already close to maximum sustainable yield.

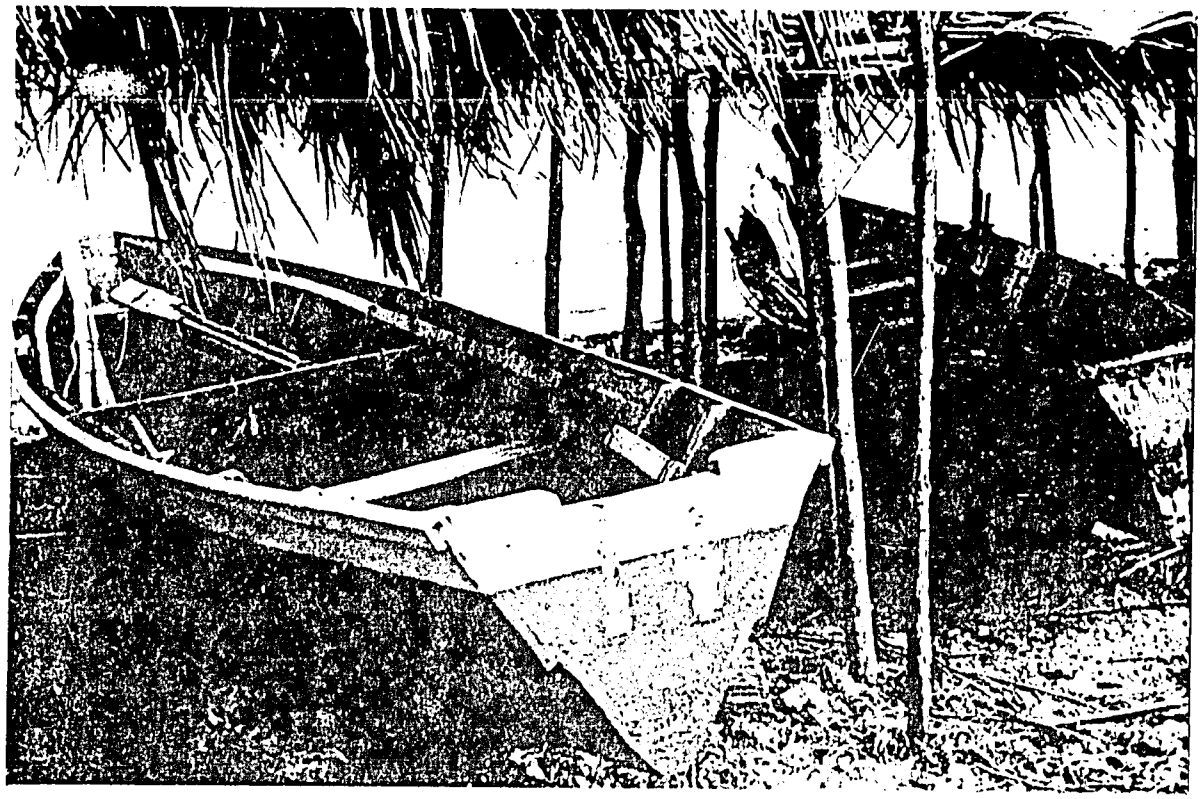
Inappropriate technology is an inevitable consequence of the large-scale fisheries development model. CDB provided a US$ 2.37 million loan for boats and shore facilities for fisheries development in Antigua. The project suffered a variety of ills, many of which were foretold prior to its initiation:

This proposal has been under criticism for a variety of reasons, such as:

- the recommendation of boats that are too expensive, too large, and too complicated to fit in with the social structure and capabilities of Antiguan fishermen;
- the questionable reliability of the data on which calculations of increased catches and anticipated profits were based;
- uncertainty as to the adequacy of the training component of the project;
- the difficulty of finding competent Antiguan managers and technicians and securing the necessary local support for the effective operation of the landing and processing facilities to be put in place

(Brownell, 1978)

Despite this warning, the project was implemented under the large-scale model -- and generated insufficient revenue to finance operating expenses due to poor fleet performance, inappropriate equipment, unseaworthy vessels, and inexperienced crew.



Traditional fishing canoes. St. Lucia. Photo by Sandy Goodwin.

The apparent disregard for history also seems evident among efforts to improve artisanal fishing vessels. Such schemes have been implemented in St. Vincent, Dominica, Montserrat, St. Kitts, Antigua, and St. Lucia, with designs ranging from fiberglass "Boston whaler" types to wooden sloops over 13 m in length. St. Lucia, for example, has been the recipient of four distinct projects to modify ("improve") local fishing vessels (St.Hill, 1984).

The first, funded by the Colonial Development and Welfare Fund in 1961, provided diesel powered skiffs on a loan basis to graduates of the St. Lucia Fishermen's Training School. When few loans were repaid and the boats were abandoned or used for non-fishing purposes, the conclusion was reached that unsuitable recruits had been selected.

The second project, funded by FAO in the mid-1970's, provided three fiberglass boats as part of the Caribbean Fisheries Development Project. Fishermen lost interest in these vessels because (a) initial costs were too high (3 - 4 times the cost of a local canoe), (b) repairs called for skills not available locally, and (c) local markets could not absorb additional inputs of fish. Once again, the boats were abandoned or used for non-fishing purposes.

The third project was funded by EDF in the early 1980's as the "Windward Islands Boat Development Project," calling for introduction of 100 fiberglass boats with cold storage capacity. This project was terminated at an early stage with the realization that the proposed change in technology was too great for existing marketing and distribution systems.

It is to the credit of St. Lucia's fisheries personnel that awareness of previous experience seems evident in the fourth and current vessel improvement project, funded by CIDA. Three types of fiberglass boat are being made available on a rotating basis to local cooperatives for fishermen's evaluation prior to making decisions on designs to be promoted.

Not surprisingly, local fishermen typically regard fishery development projects with suspicion, and often are not involved during the initial conceptual and planning phases:

- A fisheries project organized by a Canadian Rotary Club for S.. Kitts featured a large wooden vessel, much bigger than those used in local fisheries. Fishermen did not seize upon the opportunity to be part of the project, and the boat was ultimately abandoned on the bayfront.

- CDB provided US$ 0.758 million for shore facilities, boat, and training in the British Virgin Islands. The project failed because insufficient revenue was generated due to inadequate throughput of fish. Local fishermen did not use the new market because they habitually combined fish selling trips with shopping expeditions in the nearby U.S islands.

- Giudicelli (1978) remarks that "the failure of the [fisheries] development [in Montserrat] in the past years is primarily due more to improper orientation than to a lack of financial assistance. It is also possibly due to the lack of motivation of the people towards fishing . . . Here are maybe the worst handicaps to any fisheries development in the country."

A number of fishery development projects have suffered from the "turnkey syndrome" -- the belief that a single innovation will be successful and have a major impact, ignoring the often complex interactions with other components of the fishery sector. In the mid-1970's, the Canadian International Development Agency provided a cold storage facility for use by fishermen in the northeastern Grenada community of Grenville, and insulated trucks to carry the catch to other areas. Local fishermen, however, did not regularly use the facility because sales were adequate through established channels. Fish which were occasionally stored were often difficult to sell due to local prejudice against iced fish. Eventually, an attempt was made to freeze a very large seine catch, resulting in damage to the refrigeration equipment. Provisions had not been made for spare parts or technicians to repair the facility, which subsequently remained out of service for several years. The insulated trucks were converted for hauling sod and prisoners. The facility has recently been re-activated with more successful results as part of a more comprehensive fisheries development program.

Sfeir-Younis (1982) comments that inadequate assessment of social, institutional, and economic constraints have consistently resulted in failed fishery development projects.

While these constraints can be difficult or impossible to accurately assess in advance, they can be readily identified through pilot projects established as a preliminary step to major undertakings. It is significant in this regard to note that a recent CDB project to provide US$ 0.604 million for marketing and cold storage facilities in Dominica was considered too large by the recipient country, which requested a reappraisal.

2. The Lessons

The high-capitalization industrial fisheries model is not appropriate to the Eastern Caribbean. Repeated attempts to apply this model have been notably unsuccessful, and most objective evidence suggests that fishery resource potentials are not of a scale which would be commercially attractive in larger nations. In addition, large-scale projects engender a greater risk of rapid depletion of fishery stocks, especially in the short run, while the overriding goal should be the enhancement of long-term viability and profitability. Local fishery potentials have great importance to Eastern Caribbean nations, however, and attaining these potentials requires an alternative model for fisheries development.

Development projects must be based upon realistic estimates of probable yield. The fisheries resources base available to the Eastern Caribbean is limited. Experience and available evidence suggest that the magnitude of these resources is unlikely to be of a scale which will support highly capitalized industrial fisheries. But again, these resources have significant potential for the smaller-scale economies of the Eastern Caribbean islands. Smaller-scale efforts have greater potential for adaptation because they fit into the local context and tend not to drastically alter traditional mores.

Innovations in fishing technology for the Eastern Caribbean should be undertaken in the context of "technology development" or "technology adaptation", rather than "technology transfer". Because of the unique characteristics of Eastern Caribbean fisheries, it is unlikely that direct transfer of fishing technology used in other regions will be effective. The extent to which a fishing technique is appropriate is not governed solely by absolute economic efficiency or efficacy in harvesting target fish species. Rather, it is the impact of the technique on the entire fishery system (marketing, processing, social organization of fishermen, etc.) which determines the overall "effectiveness" of a particular innovation. Provision must be made for close monitoring and modifications during initial stages of innovation, on every site where such innovations are proposed.

Local fishermen must be intimately involved with fishery development projects. Aside from the obvious benefit of increasing the likelihood of eventual local adoption of innovations, such participation can often provide information on local perspective, resource opportunities, and obstacles to success which would otherwise be unavailable. Fishermen are the strongest and most important allies in any fishery development project -- and usually the most neglected.

It is striking that the majority of projects which have either succeeded or show promise of doing so have been those directed toward small-scale fisheries in which the target group had a large measure of control. This suggests that the appropriate operative

concept may be "mutual cooperation for development", rather than the more avuncular "development assistance."

Innovations to Eastern Caribbean fisheries should be undertaken in stages. Because the essential characteristics of Eastern Caribbean fisheries (natural resources, social systems, economics) are so poorly understood, yet highly sensitive and vulnerable to exogenous stress, it is imperative to evaluate the impacts and efficacy of innovations in the specific local context, and to provide a mechanism through which the innovation process can be modified in response to new information resulting from such evaluation. This can best be accomplished when innovations are undertaken on a pilot scale. As a rule, innovations intended to address the needs of an entire island should be based on one to two years' experience with these innovations

- on a smaller scale
- on the specific target island

In summary, appropriate technologies should be

- **small enough to be readily adaptable,** understood and operable by local fishermen
- **demonstrably profitable,** either by increasing catch per trip or reducing costs per trip
- **small enough to cause minimal dislocations** within the existing fishing system

B. Current Activity

Current and proposed fisheries activities are summarized by country in Table 7. Following is a description of the activities of organizations which are or have been involved with fisheries development in the RDO/C region.

1. Barbados Institute of Management and Productivity (BIMAP)

BIMAP operates under memoranda of agreement with individual Eastern Caribbean countries. Under these agreements, firms which desire BIMAP services pay a fee for an analysis of needs. Assistance might be provided for business training in the fishery sector, though no such activities have been undertaken to date.

2. Bellairs Research Institute/University of the West Indies, Cave Hill

Bellairs Institute has, for the past 30 years, maintained a reference library and undertaken a variety of research projects on marine resources in the Eastern Caribbean. Through its affiliation with McGill University, a wide range of expertise is available to the Institute, while its affiliation with the University of the West Indies provides access to

Table 7

Summary of Current and Proposed Fishery Projects in the Eastern Caribbean

	ANU	DOM	GND	MNI	SKB	SLU	SVD
Culture							
Shrimp mariculture	F						
Mithrax mariculture	F						
Seamoss mariculture	P					F	
Spiny lobster mariculture	P						
Conch mariculture							P
Evaluate mariculture prospects							P
Prawn aquaculture		F					F
Management							
Spiny lobster stock assessment	P						
Turtle stock assessment						F	
Conch Management					F		
Spiny Lobster Management					F		
Coastal Resource Survey					P	P	
Fisheries Statistics		F		P	F	F	
Computers					F	F	
Production							
Coastal Infrastructure		P		P		F	P
Cold Storage Facilities		P		P		F	P
Artisanal Fisheries Development			F				
Introduction of Larger Vessels		F					
Fisheries Extension					F	F	P
Vessel Modification			F		P	F	P
Training							
Training by Master Fisherman			P				
Training in Coop Management			P				
Fisherman Training			P		F	F	P
Miscellaneous							
Artificial Reefs			P	F	P		
Fish Aggregating Devices					F		
Marine Conservation Areas			F		P	F	P
Public Information/Education			F		F	F	

ANU = Antigua; DOM = Dominica; GND = Grenada; MNI = Montserrat; SKB = St. Kitts; SLU = St. Lucia; SVD = St. Vincent

F = Funded

P = Proposed, not funded

regional expertise and promotes sensitivity to regional needs. Current joint research projects between Bellairs and the University of the West Indies include:

- stock structure, abundance and yield predictions for flying fish and dolphin in the Caribbean
- experimental trap fishing to assess stock abundance and optimum mesh size in the Barbados trap fishery (with FAO)
- effects of pollutants on coral reef communities
- laboratory rearing for artificial stocking and fishery rehabilitation of the white sea urchin *Tripneustes ventricosus*
- summarizing the available data base on ocean pelagics in the Lesser Antilles (with FAO)

3. British Development Division (BDD)

BDD provides assistance on a government-to-government basis in the form of budgetary or capital assistance, technical cooperation, training, and disaster relief. Fisheries-related projects are no longer supported (A.Tairsch, personal communication).

4. Canadian International Development Agency (CIDA)

CIDA provides development assistance through three programs: Bilateral (government to government), Multilateral (through international financial and development institutions), and Special (through non-governmental organizations). Involvement with fisheries development in the Eastern Caribbean has ranged from grants of a few thousand dollars to fishing cooperatives to fish landing complexes costing several million. While an extensive project is in preparation for St. Vincent, it seems likely that future CIDA involvement will emphasize regional activity (J. Wood, personal communication).

CIDA is considering two major projects related to fisheries in the CARICOM region:

- Marine Resource Survey
- Training in Marine Space Management

The following description is from a memorandum provided by CIDA titled "Management and Development of the Non-Living and Living Marine Resources in the Exclusive Economic Zones of the CARICOM Member States" dated February, 1984.

The objectives of the Marine Resource Survey are to:

(a) conduct a regional resource survey to determine
  (1) species of fish in the region
  (2) seasonal and spatial distributions
  (3) seasonal and spatial catch rates
  (4) abundance of resources and exploitable biomass
  (5) fishing techniques best suited to resources
  (6) sustainable yield
  (7) physical and chemical oceanographic characteristics

(b) establish permanent national and regional capabilities to permit resource surveys to be undertaken on a regular basis
(c) improve the fisheries database and establish a regional marine information center
(d) determine the magnitude and distribution of commercially significant aquatic resources in coastal regions
(e) determine the current state of each commercially significant resource, what fisheries should be developed, which are overexploited, which should be closed, and which should be rehabilitated
(f) assess shared stocks among neighboring countries

In areas where resources are known to be unexploited (e.g. pelagics in the Atlantic Ocean east of the Lesser Antilles) the objective will be to stimulate investment interest by countries and private companies to start or expand a fishery. Where resources are not large enough to support industrial fisheries the objective will be to refine assessments of the size of the resource and the sustainable yield, and recommend optimum management strategy. The detailed resource surveys will be carried out over a seven year period using a 55 ft - 75 ft research vessel.

Training will be provided through the University of the West Indies for senior level fisheries administrators, technicians responsible for data collection and analysis, and undergraduate and graduate UWI students who wish to establish careers in fisheries development and management.

Managerial and technical staff for the project will be drawn from Canadian companies or universities. Under a counterpart scheme, an individual from the CARICOM region will assume duties as Project Manager during the fourth year of implementation. Barbados has been proposed as the site for project headquarters.

The project would be designed by a Project Planning Mission composed of a project coordination and design expert, a marine resource survey expert, and a fisheries statistics expert.

There appear to be many similarities between this project and the FAO/UNDP Caribbean Fishery Development Project. It should be noted that the latter project operated with a total of 15 vessel years, while the proposed project is expected to accomplish much more with less than half as much ship time. Several other features are noteworthy and provide an indication of the perspective guiding the project:

- the absence of social-economic expertise in the design team or proposed staff roster
- the absence of participation by local fishermen at any stage

- the view of migratory pelagic fishes as "unexploited" in waters adjacent to the Lesser Antilles.

If this project is implemented, there is little doubt that a great deal of new and useful information will be generated. But many key issues (e.g., development of techniques for mariculture and fisheries enhancement; resolution of local and regional marketing needs; adaptation of technical information to the social and economic context of small island fisheries; development of resource management systems within local constraints) will not be addressed. Ideally, this highly ambitious undertaking should be complemented by activities targeted specifically to the needs, potentials, and constraints of Eastern Caribbean fisheries. This is crucial, because without attention to the socio-economic context it is highly probable that the mistaken strategies of the past will be repeated with undue emphasis on increased harvesting while neglecting the fragility of the resource base and pervious nature of traditional fishery systems.

5. Caribbean Basin Initiative (CBI)

CBI is stimulating participation of the U.S. private sector in the Eastern Caribbean. A variety of agencies are involved in this effort, including Caribbean/Central American Action, Overseas Private Investment Corporation, Caribbean Basin Promotion Center. Specific assistance to private sector development in the region is provided the Caribbean Project Development Facility and Caribbean Financial Services Corporation. Several fisheries-related projects proposed under these programs reflect a need for better information on available resources, economic constraints, and social systems. This appears to be a common constraint to realizing benefits from overseas investment in Eastern Caribbean fisheries.

6. Caribbean Community Secretariat (CARICOM)

In 1980, CARICOM coordinated a regional fisheries economic study and a regional fisheries marketing survey. CARICOM is seeking to play a key role in regional fisheries development. At its third Technical Fisheries Seminar in March, 1985, the following topics were discussed which are indicative of the scope of CARICOM's intended involvement:

- Insurance
- Aquaculture Research Centre (being developed by Jamaica and FAO)
- Artisanal Fisheries Training
- Research, Development, and Promotion of Fishery Products
- Safety Measures
- Resource Assessment (CIDA project)
- Intraregional Cooperation
- Inter-Agency Coordination
- Protection and Development of exclusive economic zones

CARICOM has not established a formal Fisheries Desk, and has expressed the intention of collaborating with OECS and FAO in the above areas. The differing needs and potentials of the smaller Eastern Caribbean states from other CARICOM members may pose some problems to this organization's role in fisheries development.

7. Caribbean Conservation Association (CCA)

CCA is engaged in a program of development and management assistance to Eastern Caribbean fisheries (Marine Resources Program for the Eastern Caribbean). This program is being implemented by Environmental Research Projects (a U. S. not-for-profit corporation). Recent projects include fisheries assistance to St. Kitts, development of artificial reefs in Montserrat, design of a marine advisory network for the Eastern Caribbean, and fisheries workshops in collaboration with the Gulf and Caribbean Fisheries Institute. CCA is also engaged in a collaborative program with the University of Michigan for development planning in natural areas (Eastern Caribbean Natural Area Management Program).

8. Caribbean Development Bank (CDB)

CDB's overall investment policy includes: provision of low interest loans and technical assistance through financial intermediaries to small fishermen and fisheries cooperatives; investment financing and technical assistance for regional joint ventures or national projects for deep sea fishing; supporting feasible mari- and aquaculture projects; and cooperating with other agencies in co-financing fisheries development projects. CDB also serves as a conduit for funding from the Inter-American Development Bank (IDB).

A summary of CDB's fishery-related projects was presented at the CARICOM Third Technical Fisheries Seminar (Castries, St. Lucia 25-29 March, 1985). In addition to those described in the preceeding section these projects include:

- Dominica -- A US $1.455 million agricultural credit facility was established which includes loans to fisheries; credit is being utilized by fishermen to upgrade gear; the project is ongoing.

- Grenada -- US$ 2.279 million has been provided for artisanal fisheries development ; four fish market/centers have been rehabilitated; training has been initiated; the project is ongoing.

- St. Kitts -- A US$ 0.5 million project for fisheries development is in preparation.

9. The Caribbean Group for Cooperation in Economic Development

Established in 1977 to provide development assistance to the countries of the Caribbean Region, the Caribbean Group is chaired by the World Bank with assistance from the International Monetary Fund, the United Nations Development Programme, the Caribbean Development Bank, the Inter-American Development Bank, and the Organization of American States. Membership in the Group includes donor agencies from 18 countries, as well as 20 recipient countries. Two institutions have been formed as a result of the Group's work: The Caribbean Project Development Facility provides assistance for private sector project preparation, and the Caribbean Financial Services Corporation provides medium- and long-term credits for private sector projects. To assist the OECS economic secretariat in coordinating economic policy among its members, the

Caribbean Group has established an Inter-Agency Resident Mission which is concerned principally with public sector investment programs, development of information systems for economic management, improvement of public sector management, and assistance in securing financing for and implementing priority development projects.

10. Commission of the European Communities (EEC)

EEC provides funding through either the European Development Fund or the European Investment Bank for economic and social development in African, Caribbean, and Pacific countries. Capital funding, technical assistance, training, and disaster relief are included under this mandate. A special micro-projects program is available to fund projects in local communities. Current projects include funding for the Speightstown fish market (Barbados) and freshwater prawn culture (Dominica and St. Lucia).

11. Commonwealth Fund for Technical Cooperation (CFTC)

CFTC is a multilateral development fund which provides assistance in the form of on-site technical advisors and scholarships for training students and government personnel abroad. CFTC Fisheries and Cooperatives Advisors have been recently active in Dominica and the Leeward Islands.

12. Dalhousie Ocean Studies Programme (DOSP)

For the past five years, DOSP has conducted studies and workshops on marine law and policy issues in the Eastern Caribbean with funding from CIDA and RIO. Published reports specifically address Grenada, St. Lucia, Dominica, and the Leeward Islands.

13. Gulf and Caribbean Fisheries Institute (GCFI)

For the past 37 years, GCFI has provided an annual forum for the exchange of current information pertaining to exploitation and management of Caribbean fisheries. GCFI has recently committed to a continuing program focussing on assistance to small-scale Caribbean fisheries, and has conducted a number of workshops for fishermen and resource managers. A joint session for OECS fisheries ministers is planned for its 1985 meeting.

14. Inter-American Foundation (IAF)

IAF provides grants for self-help projects to non-governmental organizations in the Caribbean, Central and South America. Emphasis in the fisheries sector has been upon building cooperatives, though other approaches to fisheries development are also of interest. Current support includes technical assistance projects in St. Kitts and problem solving workshops (both in collaboration with Caribbean Conservation Association, Gulf and Caribbean Fisheries Institute, and Environmental Research Projects).

15. Inter-American Institute for Cooperation in Agriculture (IICA)

IICA has implemented a computer-based system to improve landings and price data on fisheries in Barbados. The immediate value of the system is enhanced by the fact that catch-effort data are available in Barbados for the past 26 years on the more important species in the pelagic fishery, and have formed the basis for graduate theses at the University of the West Indies (e.g., Storey, 1983; Oxenford, 1985). The Institute is interested in expanding the system to other islands within the next few years.

16. International Development Research Centre (IDRC)

IDRC's mandate is to stimulate and support research for the benefit of developing countries. Capital assistance, technical assistance, and training are provided to projects designed to solve problems through application of the methods of scientific enquiry. There are two projects currently underway in the RDO/C region; sea moss culture (St. Lucia) and conch management (St. Kitts).

17. Island Resources Foundation (IRF)

IRF has, over the last 13 years, maintained a reference library and undertaken a variety of development and management projects related to Eastern Caribbean natural resources. A wide variety of professional expertise is available to the Foundation through its Research Associates program, and has recently been applied to a variety of coastal planning and impact assessment activities in the region. IRF emphasizes the use of experienced persons within the Eastern Caribbean for such activities.

18. Office of Tropical Scientific and Technical Research (ORSTOM)

ORSTOM is a French research organization concerned primarily with oceanography and freshwater biology. ORSTOM is presently engaged in a series of fish biomass surveys in the Caribbean region using echo integration techniques.

19. Organization of American States (OAS)

OAS provides a variety of capital, technical and training assistance services to member states. Through its Skills Training Project (jointly sponsored by USAID) fishermen in St. Lucia have been trained for employment in the Castries fishing complex, and farmers in Dominica have received instruction in aquaculture. The same project might provide management and technical training for other fisheries-related projects (B. Fiuck and N. Halvonik, personal communication).

20. Organization of Eastern Caribbean States (OECS)

OECS is an active participant in recent sub-regional fisheries development activities, including FAO's workshops on harmonization of fisheries legislation and Lesser Antilles fisheries development projects, and intends to coordinate closely with CARICOM in development of that organization's fisheries programs. OECS plans to establish a Fisheries

Desk to provide technical services to its member states. Initially, this would consist of two fisheries administrators and two legal advisors from the region who would receive specialized training in the United States. Funding for the Fisheries Desk is under consideration by the Canadian International Centre for Ocean Development (ICOD).

21. United Nations Food and Agriculture Organization (FAO)

In addition to the Caribbean Fishery Development Project, FAO has been active in a variety of fishery development activities, and is conspicuous in the effort which has been directed toward fisheries management as well as technological innovation. In 1978, a workshop on fisheries statistics was held for representatives from fisheries units throughout the Eastern Caribbean. While this training was clearly beneficial to the participants, provisions were not made for on-site follow-up. As a result, this training resulted in little immediate improvement to the fisheries data base. A working party on statistics has been established, however, and projects are underway to improve regional documentation of fisheries landings.

More recently, with funding from the Government of Norway, FAO sponsored a series of workshops on the harmonization of regional legislation among the OECS countries. The fact that this was accomplished in little more than a year, and that the proposed acts and regulations have been widely accepted has been ascribed to the fact that the project advisors allowed the workshop participants to do the bulk of the work themselves (P. Lavender, personal communication).

Through its Western Central Atlantic Fisheries Commission (WECAFC), FAO has recently established a Committee for the Development and Management of Fisheries in the Lesser Antilles. The Committee has considered a variety of needs including status of resources and rehabilitation, advice and training for fisheries administrators, fishermen training, product development and processing, marketing, nutritional concerns, tourism, and conservation. Projects directed toward resource surveys, coastal surveillance, and a Technical Support Unit for the Lesser Antilles have been proposed, but it has not been possible to identify sources of funding.

WECAFC has recently been authorized (C. dos Santos, personal communication) to implement a "Project for the Activation of the Regional Small-Scale Fisheries Training Role of the Caribbean Fisheries Training and Development Institute [CFTDI, Trinidad] and the Associated Technical Extension Unit." Principal provisions of this project are courses on extension methodology, organization of a mobile fisheries technical extension unit, intensive courses on specific topics at various locations in the region, and assistance to CFTDI in developing its curriculum and proposals for long-term funding.

This project is the result of a workshop held in 1983 on artisanal fisheries training (FAO, 1984). A key recommendation of this workshop was the formation of a Technical Cooperation Network for Artisanal Fisheries based on exchange between developing countries. The University of the West Indies, CFTDI, and Inland Fisheries Institute of the Jamaica Ministry of Agriculture were designated as key implementing agencies.

22. United Nations Educational, Scientific and Cultural Organization/International Oceanographic Commission (UNESCO/IOC)

A project has been approved for UNESCO/IOC to provide experts to the Caribbean to develop a sub-regional project on marine information sciences in the EEZ's of participating countries.

One of the major scientific programs being developed by UNESCO is the Major Interregional Project on Research and Training Leading to the Integrated Management of Coastal Systems (COMAR). Among the projects developed through this program is a beach stability pilot project for small islands of the Eastern Caribbean. The goal of this project is to assist in developing national capabilities to conserve and manage beach and nearshore resources. Workshops on coast and beach erosion are being held throughout the region, and a project is being developed to study and compare interaction and productivity of coastal ecosystems.

23. United Nations Environment Program (UNEP)

Under its Regional Seas Programme, UNEP has identified six priority projects directed toward protecting and developing the marine environment in the Caribbean:

- development of environmental public awareness
- seminar on beach clearing methods for oil spills
- survey on environmental legislation
- workshop on environmental management of coastal development
- training seminars on environmental impact assessment and watershed management
- draft of regional agreements discussing environmental issues

Implementation of these projects has been delayed by shortage of funds.

24. U.S. National Oceanic and Atmospheric Administration (NOAA)

NOAA is preparing a Caribbean Regional Marine Profile for USAID. The objectives of this profile are to

- describe distribution and abundance of marine resource (living and non-living) in the region
- define current state of development of these resources
- define principal management issues
- identify institutional mechanisms to address these issues
- survey current training in marine resource management
- describe current efforts of various agencies to meet marine resource management needs
- recommend a balanced approach for marine resource management in the region

The National Marine Fisheries Service (NMFS) has proposed a program for

funding under the Caribbean Basin Initiative to enhance the commercial and recreational fishing industry and tourism in the Eastern Caribbean. Key features are establishment of a fisheries academy in Puerto Rico, provision of technical and financial fisheries support to island communities to meet basic facilities and service needs, promotion of management of overexploited fisheries, and promotion of a Caribbean wide tourism package -- "Pearls of the Sea." There are no indications of input from within the region for this proposal, and issues including relevance to national goals and impact on existing fishery systems within the Eastern Caribbean have not been addressed.

IV. SUMMARY OF REGIONAL TRENDS

Throughout the RDO/C region, there is a growing need to maximize local benefits from indigenous fishery resources. The actual magnitude of these resources and means through which their potentials may be achieved, however, remain obscure. Emphasis on a capital-intensive approach to fisheries development may jeopardize these potentials, and contributes to an increasing need for resource management. Local capabilities for such management are improving, concomitant with a widespread desire for self-determination and a trend toward regional cooperation in fisheries affairs.

At present, roughly 11,000 metric tons of fish are landed annually in the RDO/C countries, and are supplemented by over $EC 50 million worth of imported fish to meet local demand. By 1990, demand in these countries is projected to approach 18,000 metric tons. These circumstances together with emergence of the concept of 200-mile exclusive economic zones have contributed to a growing interest in fisheries development in the region, where modernization of the local fishing industry is a universal objective.

As discussed in the previous section, a "modern" fishery is generally perceived to be synonymous with fisheries in developed countries, and there is a tendency to ignore several important features of small-scale fisheries. These fisheries produce nearly half the world marine catch used for direct human consumption (the proportion is even greater in the Eastern Caribbean), but require one-fifth the capital and one-fourth the fuel per ton of fish landed, and create a hundred times more jobs per dollar invested than large-scale fisheries (Panayotou, 1982). These are important considerations in countries where capital and foreign exchange are scarce while unemployment and fuel costs are high.

Considerable attention is being directed toward increased harvest of migratory pelagic fishes. Peacock (1976) remarked that

> Pelagic fish catch rates are generally insufficiently high to encourage expansion of fisheries based purely on this resource . . . [A] larger boat may be able to run several more lines but the scattered nature of this resource limits the number of encounters with fish that are possible, and thus the greater investment is not justified... However, recent work by L. Devambez in St. Lucia has suggested that catch-rates may be improved by improved fishing techniques, and that the use of cheaper, marine-ply boats powered by small diesels can possibly be justified.

There is little doubt that more fish are available to be caught among the pelagic resources. Recent experience with improved landing facilities in St. Lucia (described above) corroborates this impression, as does the fact that the addition of 12 "ice-boats" to the Barbados fishing fleet increased landings by 80% (W. Hunte, personal communication). Not unreasonably, a project to increase effort and efficiency (including marketing) in the pelagic harvest is now being implemented in St. Lucia, and what appears to be a similar plan is in the offing for St. Vincent. The same approach has been recommended for Grenada; Dominica plans to develop an offshore fleet for similar purposes. But, like all

fishery stocks, pelagic resources are limited. It is not inconsequential that Barbados actively fishes at least part of the same stocks and other countries within the Eastern Caribbean as well as outside the region have similar designs, while the capacity of the pelagic resources to support this sort of effort is not known.

To some extent, the current activity directed toward increasing the harvest of pelagic fishes, even without precise estimates of sustainable yield, is probably justified: Pollnac (1981) points out that "where there is little or no fishing, and fishermen seem to have no trouble catching all the fish they want, a preliminary decision can probably be made that there is no need for assessment of stocks." This situation appears to exist in St. Lucia, for example, during the first half of the year.

But Pollnac stresses that if such a decision is made "initial development should be small and should include a well-designed program to obtain statistics on catch and effort for future assessments of stock to insure proper management of the resources." These constraints are not being uniformly applied to current development activities directed toward pelagic stocks. Glanz (1984) notes that

> the ability of a fish population to regenerate itself is directly tied to, and dependent upon, the balance that is established between its rate of regeneration, which depends primarily on environmental processes, and its rate of exploitation ... This suggests that pelagic fish populations must be perceived as only conditionally renewable and, hence, managed more rationally.

Very little fisheries management is actually practiced at the present time. Most of the RDO/C countries have appointed new fisheries personnel in the past five years, and the overall level of technical competence has increased considerably. Without exception, there is agreement with the concept of managing fisheries for sustained use, but management efforts are hampered by absence of information needed for management, personnel shortages, and political reluctance to reduce effort on certain species without offering attractive alternatives. Despite these handicaps, there is a high level of commitment to management among RDO/C fisheries units.

There is a growing interest in regional cooperation, particularly through OECS. The completion of draft harmonized fisheries legislation is tangible evidence of this trend. This activity occurs at a time when there is significantly less trade among the members of CARICOM than in 1980, despite trade preferences and availability of supply inside the market. Reasons include the overall recession in the region, policies adopted by larger countries (e.g., Jamaica replacing Guyanese-produced rice with supplies from the US; increased documentation requirements in Trinidad), and exchange rate imbalances within the CARICOM community (Caribbean Group, 1984).

Collaboration has also been stimulated by increasing intrusion of foreign fishing vessels. St. Vincent and Barbados have seized at least one foreign vessel this year; fishermen from Montserrat report being fired upon by a foreign vessel apparently hauling Montserratian fish traps; Antiguan fishermen report that French, Japanese, Korean, and Venezuelan vessels regularly operate within their country's EEZ.

The increased technical capability within fisheries units and heightened regional identity coincides with a general trend toward self-determination. There is growing dissatisfaction with development assistance programs which appear to ignore indigenous expertise in favor of highly paid foreign consultants whose lack of sensitivity and understanding of local conditions is often a serious handicap. There continue to be gaps in technical expertise and personnel shortages, but local fisheries personnel should have a much stronger role in the development process than has previously been the case.

V. ANALYSIS OF CONSTRAINTS AND AMELIORATION

A. Constraints

For the purposes of this report, it is considered appropriate to distinguish policy, institutional, technical, and financial constraints.

1. Policy Constraints

a. Lack of Appropriate Development Model

Because of the small size and interlocking nature of inshore systems, as well as the variety of habitats and types of resources, it may not be possible to define a single development model which is appropriate to all of the RDO/C countries. The history of development efforts directed toward Eastern Caribbean fisheries suggests that the large-scale, relatively high-capital fisheries model is inappropriate to the region, and emphasis on this model has been a major constraint to progress in this sector.

One effect of this is the dilution of development effort directed toward the potentials of small-scale fisheries. Another is direct conflicts between large- and small-scale fishermen. Panayotou (1982) states that even where large vessels are excluded by law from inshore areas, higher fish densities in shallow water combined with enforcement difficulties result in open competition between large- and small-scale operators. The results are typically violent and include arson and murder. It is disquieting to note that boat-burning appears to be a regular means of dealing with unpopular intruders in at least one island (Union, St. Vincent Grenadines).

Another consequence may be the oft-stated problem of governments' inattention to fisheries. The desire to demonstrate "progress" and ability to the local electorate as well as the world at large makes the capital-intensive model attractive. It is obviously inappropriate to judge the quality of small island fisheries by their similarity to those of developed nations, but this is the only yardstick available. The subsequent failure of attempts to implement the capital-intensive model tends to erode enthusiasm for fisheries development within local governments. At the same time, inappropriate actions (e.g., price controls), resulting at least partially from poor understanding of local fishery systems, tend to impede development

b. Lack of Management Controls

To a lesser extent, the open access character of Eastern Caribbean fisheries is also a policy constraint. This is undoubtedly a problem in the case of heavily exploited fisheries such as conch, spiny lobster, and shallow- water reef stocks. This constraint will expand to include other stocks as well, unless development efforts are cognizant of the problem and include some mechanisms to limit effort in fisheries being developed.

2. Institutional Constraints

a. Shortage of Technical Personnel

A critical component of effective fisheries development is an extension program which provides liaison between fisheries development planners, technical personnel, and local fishermen. Unfortunately, fisheries extension services are among the weakest links in the existing small-scale fisheries development structure (FAO, 1983). Most government fisheries units in the Lesser Antilles are staffed by less than half a dozen individuals, including clerical personnel. These same individuals are expected to serve as counterparts for projects financed and sometimes partially staffed by external agencies; when several such projects operate simultaneously (as is the current case in most islands) local staff become very thinly spread. Declaration of exclusive economic zones results in the need to plan for their management, but personnel are generally unavailable to carry out such planning. The result is exacerbation of a chronic problem with fisheries development. Increased government support is needed to carry out effective programs, but this support is unlikely to be forthcoming until local fisheries units achieve visible and locally important accomplishments.

The report of the 15th session of the FAO Committee on Fisheries notes that among the developing countries training is needed at administrative, fisheries officer, technical specialist, and fishermen levels. Similarly, the Caribbean Development Bank (1985) has identified inadequacy of resource personnel in fisheries administration and management as a major obstacle underscoring the need for more training at all levels (these problems are not unique to the fishery sector; in 1983 there were an estimated 65 unfilled professional staff positions in the OECS governments (Caribbean Group, 1984).

Training has been provided or offered to Eastern Caribbean fisheries personnel in a number of countries, mostly notably Korea, Yugoslavia, and the United States (University of Rhode Island). The re-opening of the Caribbean Fisheries Training and Development Institute in Trinidad provides additional regional training opportunities. It is often difficult, however, to put training into practice when the trainees return from offshore institutions, because relevant work programs have not been developed, or because necessary equipment and support services are lacking.

Loss of personnel to training programs which span several years can seriously impede the activities of fisheries units which are understaffed to begin with. While this is a temporary problem, it arises at a critical period in the development of Eastern Caribbean fisheries when competent fisheries management is desperately needed.

b. Inadequate Infrastructure

Periodic surpluses of locally produced fish, high quantities of imported fish, and chronic supply deficiencies in remote villages suggest that improvements are needed to processing and marketing components of the fishery sector in all of the RDO/C islands.

The need is not simply for physical infrastructure. Gluts in fish supply are largely a product of the seasonal but highly productive nature of migratory pelagic fisheries. Recent

experience in St. Lucia suggests that even with improved physical infrastructure, existing technology can supply fish at a rate which exceeds local consumption and rapidly overloads holding facilities. This experience also suggests that operation of centrallized facilities may be initially hampered by fishermen who are unwilling to accept a lower price for a larger volume of fish. Dealing with excess supplies requires current and accurate information on external markets, reliable and economical transport to these markets, and possibly substantial storage and processing capacity. The problem is that these markets and services could not be used for roughly six months when the pelagic species are not available.

The circumstance of excess supply is not a new phenomenon, but an established conduit for excess catch has yet to appear (interest of overseas buyers has been primarily in spiny lobster and conch, both of which are in danger of overexploitation). The problems encountered with effectively using by-catch in shrimp fisheries suggest that there may be no ready answer.

3. Technical Constraints

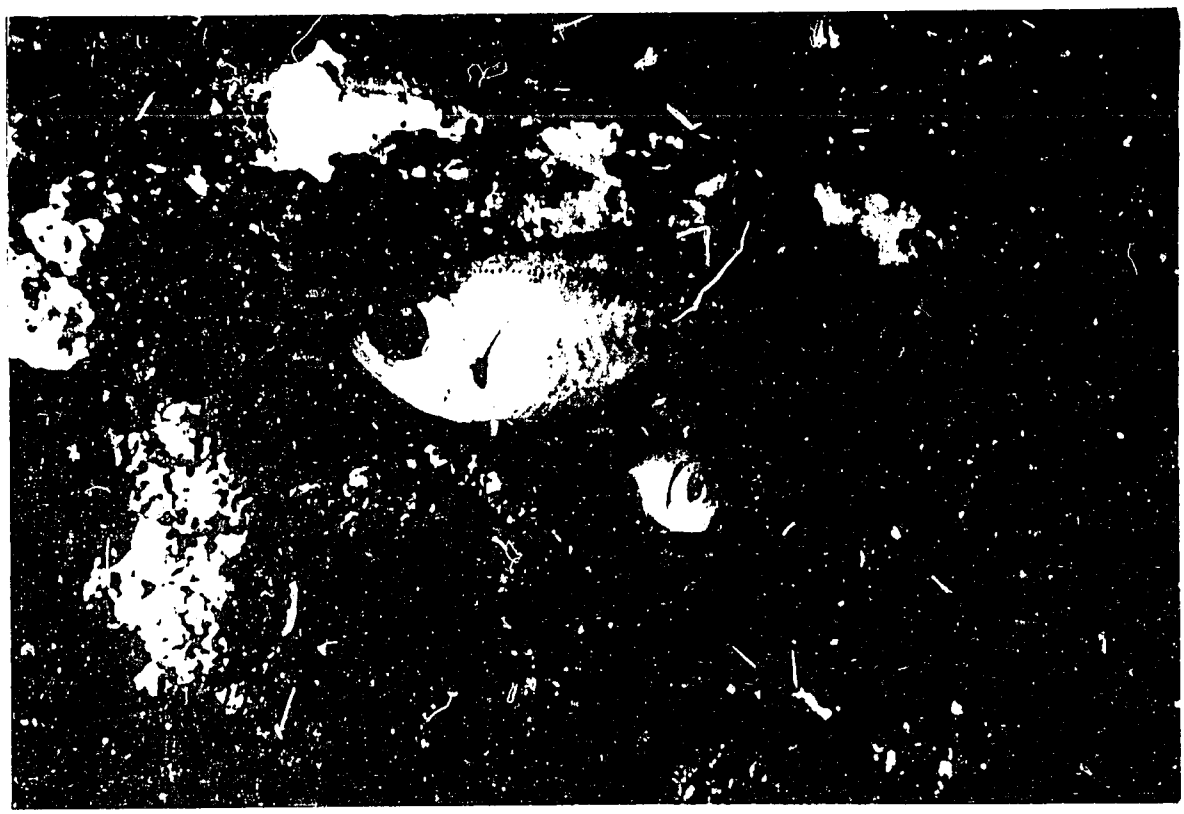
a. Limited Resource Base

Natural fishery resources are clearly limited in the Eastern Caribbean. It is worth noting that only modest technology has been needed to harvest nearshore reef fish, conch, and spiny lobster stocks to the point of undeniable depletion. This does not mean that there is no development potential; there are still underexploited stocks in the region of a magnitude to have significant impact on a small island scale. Nor does present overexploitation necessarily imply that these fisheries are fully "developed", because manipulations such as habitat enhancement or nursery areas may increase sustainable yields.

The point is, resource limitations must be a primary consideration in any type of innovative development. The decline of spiny lobster populations in the Grenadines, for example, has been linked to the increased mechanization of artisanal fishing fleet (Adams. 1972). Modern technology makes it possible to overexploit any fishery; as a result, it is imperative that fisheries development be guided by the productive capacity of the stocks being harvested.

b. Environmental Degradation

Destruction of critical habitats (e.g., coral reefs and mangroves) and contamination of nearshore waters are growing threats to fisheries in the Eastern Caribbean. An example of the need for concern with general quality of the marine environment is given by Olsen *et al.* (1984). If, as the authors suggest, the dinoflagellate *Gambierdiscus toxicus* (which grows on the surface of various marine macro-algae) is the causitive agent for ciguatera, it is possible that alteration of nutrient levels or physical factors (e.g., temperature) could produce a bloom of dinoflagellates resulting in increased concentrations of ciguatoxin among grazing species (which include conch and many edible fishes).



Coral reefs provide shelter for many food species. Dominica.
Photo by Mel Goodwin

c. Inadequate Equipment and Technology

Inadequate gear supply is a widespread complaint among Eastern Caribbean fishermen, and there are a variety of modifications which might be made to current fishing techniques which probably would improve efficiency and productivity of artisanal fleets. Examples include use of timed float releases or color-coded buoys to reduce trap theft; mechanical trap haulers to permit fishing in deeper waters; depth sounders to locate promising fishing areas; vertical longlines for deepwater bottom fish. The extent of such innovations, however, should be determined by available fishery resources and probable impact on local social/economic systems. Locally appropriate technology is definitely a constraint, but determination of what is "appropriate" usually requires site-specific pilot projects, and often involves adaptation of existing technology or development of new technology. History suggests that direct technology transfer is seldom a viable solution.

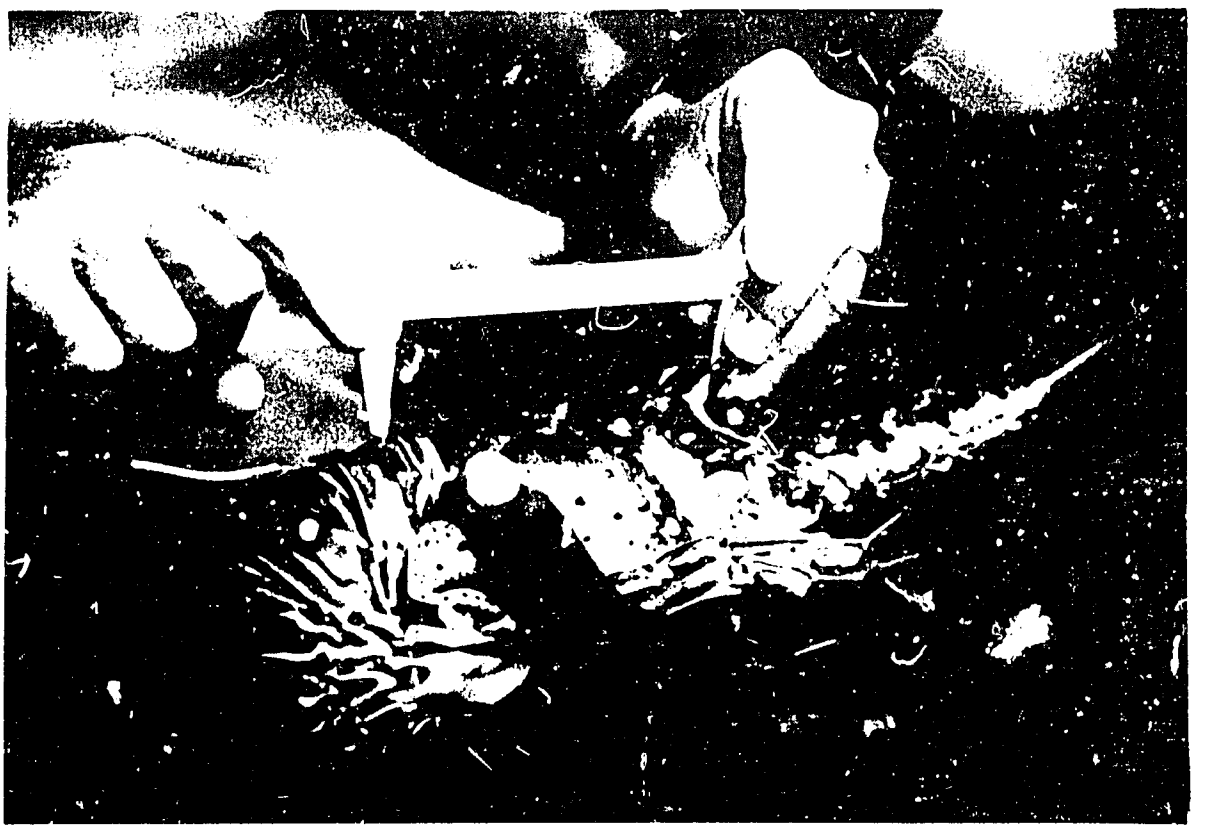
Interest in developing an offshore commercial fishing fleet seems to be virtually universal among island nations, but such ventures have been characterized by repeated failure. The appearance of ocean-going commercial fishing vessels from Japan, Korea, Venezuela and the United States in Eastern Caribbean waters is indicative of the level of

competition which new fleets will face, and suggests that more distant resources are already heavily exploited. The optimum harvest of migratory pelagic fishes may require modest innovations in local fishing fleets, but such changes should be consistent with the productive characteristics of the stocks being harvested, as well as the absorptive capacity of available markets.

The technological constraint also extends to proven or transferable mariculture systems. There are a variety of promising options as discussed above, but none of these have been convincingly proven on a pilot scale in the RDO/C countries.

d. Inadequate Understanding of Fishery Systems

Generalized predictions of yield are not adequate for rational investment in Eastern Caribbean fisheries. The need for information on specific locales and stocks to be fished has recently been acknowledged by the FAO Committee on Fisheries (FAO, 1983), the Caribbean Development Bank (CDB, 1985), Du Bois (1984), and fishermen themselves (W. Bynoe, personal communication); Craib and Kettler (1978) reported that stock assessment was the number one priority expressed by a group of 25 developing countries surveyed to determine fishery development needs. But at present, such information is not available.



Management of lobster stocks begins with collection of data on existing stocks. Montserrat. Photo by Sandy Goodwin

4. Financial Constraints

The FAO Committee on Fisheries (FAO, 1983) noted that lack of adequate financing and credit poses strong limitations for small scale fishermen. Though some credit facilities are offered by Eastern Caribbean governments, these are generally inadequate to meet local fishermen's financing needs. On the other hand, several development banks in the Eastern Caribbean have evidenced interest in the fisheries sector, and the authors have encountered a number of fishermen who have successfully negotiated loans from commercial banks. Credit is generally a problem because the majority of fishermen are perceived to be poor risks.

Development of fisheries management and extension services are also constrained by available finance. These services require a variety of technical expertise and equipment which is beyond the current fisheries budgets of most RDO/C countries. It is doubtful, in the foreseeable future, that these countries will be able to justify budgetary increases for specialized personnel or fisheries research programs. These services, however, are essential to effective development of fisheries potential in the region.

B. Amelioration

Panayotou (1982) lists five criteria for fishery development assistance projects which are well-suited to the Eastern Caribbean:

- The project should not hurt the fishermen (some efforts which have produced apparent short-term benefits have subsequently worsened the fishermen's economic position)
- The project should focus on factors of production which cannot be provided by the fishermen themselves
- The project should be such that the fishery can eventually outgrow the need for it (e.g., subsidies are ill-advised because they are difficult to withdraw)
- Cost-effectiveness should be high
- The project should minimize distortion in market structures

1. Policy Constraints

There are alternatives to highly capitalized fishing fleets. The use of fish aggregating devices to bring pelagic fishes within the reach of near-shore vessels is one possibility. Simple modifications (such as those suggested by Giudicelli, 1978, for Grenada) to existing vessels to permit exploitation of deep shelf resources are another. Such options have not been tried, despite the dismal history and dubious prospects for conventional commercial fisheries in the Eastern Caribbean.

Investigation of these sorts of options should be an experimental scale joint effort by fishermen and fisheries development personnel. Development and testing of locally appropriate mariculture systems should be undertaken on a similar basis. Modifications to Eastern Caribbean fishing fleets will affect local social and economic systems as well as the natural resource base in ways which cannot be predicted. A pilot evaluation provides the

opportunity to assess these effects so that the desirability of expansion can be properly evaluated. This approach will also help alleviate problems of open access, as it is considerably easier to limit entry in the first instance than to reduce participation in established fisheries.

2. Institutional Constraints

a. Shortage of Human Resources

While a limited number of scholarships might be made available for key fisheries personnel to attend offshore institutions, primary emphasis should be given to on-site training projects which complement instruction received elsewhere, and to providing an on-site context within which new skills can be applied. This is particularly important when training has been undertaken in temperate fisheries in developed countries.

It neither desirable nor realistic for the RDO/C countries to substantially increase their recurrent budgets by adding specialized technical personnel or research programs to their fisheries units. A viable alternative is to share human resources among the islands, probably through OECS or similar agencies. While improved understanding of local fishery systems will depend to a large extent upon external development aid, it is important that such projects also develop alternative means for on-going monitoring of fishery systems (e.g., increased participation of fishermen in management activities and use of information generated in the course of normal fishing operations).

McHugh (1978) points out that effective fishery management may not entail large staffing requirements. Because legislative and administrative approaches to fishery management seldom solve fishery problems, a laissez-faire approach may make the greatest economic sense. Laissez-faire in this case does not mean doing nothing at all, rather doing the minimum needed to protect the public interest (particularly, to protect declining stocks). Such an approach is unlikely to gain support in the U.S. where the fisheries bureaucracy is well-established, but the desirability of a modified laissez-faire approach should be evaluated as part of Eastern Caribbean fisheries development.

Expatriot personnel can be useful in overcoming manpower shortages, provided such personnel have adequate technical ability and social sensitivity to function effectively in the small island environment. Where this option is used, provision must be made for local staff to be fully aware of the expatriot's activities, and for staff-in-training to participate in these activities to the greatest extent possible (e.g., during summer vacation periods).

b. Inadequate Infrastructure

Many of the problems of local supply appear amenable to relatively simple solutions: small ice trucks to distribute fish to remote areas; salting/drying facilities to preserve excess catch and perhaps substitute for imported saltfish; cold storage to hold fish for a few days until it is sold.

Options for dealing with the problem of large surplus landings in migratory pelagic fisheries should be explored on a pilot basis. One possibility is for fishermen to sell excess

catch to foreign vessels currently operating in Eastern Caribbean waters. Provision of services (dockage, provisions, etc.) as part of such a program could provide additional benefits to the local economy.

Another strategy is to temporarily employ a highly mobile (probably foreign) fishing fleet to take advantage of these periodic increases in fish abundance. The new Law of the Sea provides that coastal states may grant foreign nations access to surplus production in their exclusive economic zones. Licensing fees and/or catch sharing exchanged for such access can allow small nations to exploit explosive changes in abundance without risking the severe consequences of overcapitalization. Sfeir-Younis (1982), however, cautions that "In fact, such arrangements are not always advantageous. Benefits have often failed to materialize, while fish resources, in some cases, have been seriously depleted." This option should be explored with extreme caution, and effective mechanisms for verifying compliance must be in place before contractual arrangements are made. Such arrangements might provide for employment of local crew or observers to provide a learning experience as well as insure that contractual terms are honored.

A survey of potential markets, their requirements (product form, quantity, etc.), and the economic feasibility of supplying these markets from small island fisheries is the next step in dealing with this problem.

3. Technical Constraints

a. Limited Resource Base

Amelioration of overexploitation requires a reduction of fishing effort on the stocks concerned. Realistically, this probably means shifting fishing effort to other stocks; the experience of many countries has been that it is very difficult to reduce the number of active fishermen as a means of limiting fishing pressure on scarce resources (FAO, 1983). Mariculture has significant potential both for alleviating overexploitation and for expanding the availability of marine food products. Other possibilities include establishment of protected reserve areas, habitat enhancement, or restocking formerly productive sites. None of these techniques can be effective, however, without the cooperation of fishermen, nor are they guaranteed to restore depleted stocks to a useable state. Improved understanding of available fishery resources is critical to alleviating this constraint.

b. Environmental Degradation

A major obstacle to alleviating this problem is the absence of planning information which establishes the specific value of local fishing areas, and their relative importance compared with similar sites in the same country. This problem could be eliminated through simple inventories of critical coastal habitats, ideally as part of a Country Environmental Profile. Because significant benefits accrue simply from the process of preparing such a profile (Dickinson, 1984), the local Fisheries Unit should be a key participant in coastal inventory activity. External support personnel will often be needed to compensate for personnel shortages and to provide training in relevant techniques.

c. Inadequate Equipment and Technology

Beneficial technological improvements to Eastern Caribbean fisheries require improved understanding of local fishery systems, as well as pilot-scale projects to develop and adapt appropriate harvest and management techniques. Simple expansion of current fishing activity is not desirable, because current practice ignores some resources while overexploiting others. Direct technology transfer on a large scale is also undesirable, because the efficacy of innovations can only be evaluated in practice, and modification to accommodate local conditions is usually required.

d. Inadequate Understanding of Fishery Systems

Improved information on abundance and fluctuations of fishery stocks, economics of local fishing operations, and social systems operating in fishing communities is an absolute prerequisite for rational fisheries development. Given the imprecision of current understanding, the choice is either

> **Cautious development** which attempts to take advantage of high abundance without long-term commitments, or
>
> **Rapid introduction of innovations** which risks eventual overcapitalization in favor of immediate benefits

The potential consequences of the first course of action are possible loss of some initial benefits, though long-range benefits would not be seriously affected. The second option, on the other hand, may result in a short-term period of high gains followed by long-term losses, social and economic unrest, and even collapse of the fishery (Csirke, 1984). Neither alternative is wholly satisfactory, though the first option is most likely to provide for the long-term welfare and stability of the RDO/C countries. At the same time, improved understanding of relevant fishery systems is essential for optimum development.

Management and development decisions may be grouped into three categories described by Miller (1978):

- decisions intended to apportion and conserve fishery resources
- decisions intended to maximize local benefits from resource use
- decisions intended to maximize resources for the future

In the Eastern Caribbean, goals corresponding to all three categories are needed to insure optimal benefits to local societies. This means that specific local data are needed on social factors as well as biological and economic conditions. Cato and Prochaska (1980) summarize the types of data required (Table 8). Major gaps in current information are concentrated at the fisherman level, suggesting that particular attention is needed here to provide an adequate planning base.

The most workable means of acquiring this information in the Eastern Caribbean appears to be in the context of small-scale development directed toward specific resources. This approach would provide site-specific information on available resources, as well as a

TABLE 8

Socio-Economic Information Needs for Caribbean Small-Scale Fisheries
(from Cato and Prochaska, 1980)

I. Economic Information Base

A. Production Statistics
- 1. Landings
  - a. Pounds
  - b. Value
- 2. Effort
  - a. Boats and Vessels
    - i. Number
    - ii. Size by length
    - iii. Classified by motor size
  - b. Fishermen and Helpers
    - i. Full-time
    - ii. Part-time
    - iii. Number of helpers
    - iv. Monthly and annual fishing rate
  - c. Gear Units by Specific Type
- 3. Cross Classification of Landings and Effort

B. Market Statistics
- 1. Employment
  - a. Number of Wholesalers, Processors, Middlemen, Importers and Exporters
  - b. Employment in the Marketing Sector
- 2. Prices
  - a. Fishermen Level
    - i. Prices received from wholesalers
    - ii. Prices received from retailers
    - iii. Prices received from consumers
  - b. Wholesale Level
    - i. Price received from retailers
    - ii. Price received from consumers
  - c. Retail Level
    - i. Price received from consumers
  - d. Import and Export Prices
  - e. Processed Product Prices
- 3. Volume
  - a. Fisherman Level
    - i. Volume of sales to wholesalers
    - ii. Volume of sales to retailers
    - iii. Volume of sales received from consumers
  - b. Wholesale Level
    - i. Volume of sales received from retailers
    - ii. Volume of sales received from consumers
  - c. Retail Level
    - i. Volume of sales received from consumers
  - d. Volume of Imports and Exports
    - i. Import sales to various market levels
  - e. Volume of Processed Product

II. Research Needs

A. Production
- 1. Costs and returns budget for each major fishery by gear type and size of operation
- 2. Industry and firm production and cost functions

B. Consumption and Demand
- 1. Demand equations by major fisheries

C. Marketing
- 1. Description of product flows
- 2. Descriptive study of marketing and processing activities
- 3. Feasibility of new methods
- 4. Analysis of data base

D. Social and economic profile of fishermen

baseline to permit effects of further development to be monitored. In addition, more accurate yield estimates would be possible to improve investment and development decisions. Of increasing importance is the capability within individual Fishery Units to undertake basic compilation and analysis of local information. Microcomputers offer the means for such capability, and at the same time provide powerful opportunities for information exchange between islands. More sophisticated analyses and regional compilations could be undertaken in selected facilities. Compatible microcomputer facilities are expected to be in place in St. Lucia, St. Kitts, and the Bellairs Research Insititute by mid-1985, and may form the basis for a project to improve local capability for handling fisheries information.

e. Ciguatera

Promising research programs are underway to develop a rapid test for detecting ciguatoxic fish, notably at the University of Puerto Rico and the Medical University of South Carolina. These programs should be supported.

4. Financial Constraints

The most effective means of removing these constraints from local fishermen is to reduce the element of risk in fisheries so that fishermen can participate in conventional credit systems. An effective fisheries development program would provide local bankers with visible evidence of the potential of local fisheries, and the performance of individual fishermen in such programs can be used to help evaluate their credit-worthiness.

VI. A PROPOSED FISHERY DEVELOPMENT PROGRAM FOR THE EASTERN CARIBBEAN

A. Rationale

1. Background

In general, fishery resources of the Eastern Caribbean are not sufficiently abundant to support the degree of exploitation practised in temperate regions, but do offer significant potential benefits to the Eastern Caribbean island nations whose economies and indigenous living marine resources are of a similar scale. Efforts to develop Eastern Caribbean fisheries have been largely characterized by repeated attempts to directly transfer technology used in other regions, and by failure to address the unique biological, social, and economic features of Eastern Caribbean fishery systems.

It is difficult to overstate the importance and need for an alternative approach to fisheries development in this region. Development decisions are presently being undertaken with little or no information on the productive biological systems, and are influenced by a largely unrealistic concept of "the optimum fishery." In the absence of an alternative, conventional development strategies continue to be applied, ignoring the history of past failures and often missing the real opportunities for improvement. These strategies are not likely to provide sustained benefits, and may jeopardize the stability of small nations having limited capacity to absorb social and economic consequences of overcapitalization and resource depletion which are often concomitant with such strategies.

The need is to improve local capabilities for

Understanding the natural resource, social, and economic components of Eastern Caribbean fisheries;

Developing utilization and management systems based on this understanding; and

Integrating these elements in the implementation of activities appropriate to the circumstances and constraints characteristic of theRDO/C region to establish a viable "Eastern Caribbean model" for fisheries development.

Advocacy for such an approach is not unique to this report. Emmerson (1980) urges a combined sensitivity to fishery resources as well as fishing communities, "lest well-intentioned developers end up escalating the scale of failure of a fishery that may be or soon become biologically exhausted." Similarly, an Eastern Caribbean fishery officer points out that to be successful development strategies must have the support of major interest groups within the sector, must be readily assimilated into the existing industry, and must evolve from clearly identified problems, constraints, and relevant solutions (Joseph, 1985). But at present there is no indication that other agencies are likely to undertake the task of developing and demonstrating this route to fisheries development. The probable

consequence of no action by USAID is that the needs will not be met, and much of the potential of Eastern Caribbean fisheries may be jeopardized.

The proposed strategy is intended to provide a realistic model for achieving the development potential of Eastern Caribbean fishery resources. Key features of this model are:

- close attention to local objectives, collaboration with local personnel, and strengthening of local capabilities
- increased fisheries production and reduced overexploitation through attention to underutilized resources
- technological innovations resulting from development and adaptation in the local context
- maintenance of those social and economic systems (e.g., traditional resource allocation; fishing communities) which provide for optimum local distribution of benefits from fishing while maintaining the natural resource base
- rapid, visible, and ongoing results through extension projects directed toward current local concerns

The proposed Fishery Development Program will be characterized by an incremental approach to innovations, in contrast to the "giant leap" or "turnkey" approach which has been repeatedly unsuccessful. Other features which distinguish this Programfrom other ongoing projects include

- a pilot project approach within which technologies may be developed and adapted to local conditions and evaluated for their impact on fishery resources and socio-economic systems, thus avoiding the hazards of large-scale implementation of activities which have not been tested in the specific local context
- identification and development of underexploited resources in a pilot-scale context which includes all components of the fishery system (harvest, processing, marketing) and integrates resource management with resource development
- close attention to socio-economic factors which affect the feasibility of resource management and exploitation strategies
- a high degree of flexibility to accommodate local objectives and circumstances
- a mechanism for planning and monitoring the progress of specific projects to insure timely recognition and resolution of potential difficulties
- attention to means for increasing natural production as well as harvest capabilities
- development of regional support capabilities through activities which address specific local concerns

This Program will also complement ongoing efforts of other agencies by

- improving local and regional capability for fisheries management and development
- providing mechanisms and information for improved understanding of the unique features of fishery systems in the RDO/C countries
- developing and evaluating techniques which can be used to achieve the objectives of other programs
- providing the means for exchange of fisheries-related information between countries and programs

2. Relationship to National Strategies

Throughout the Eastern Caribbean, improved local availability of fish and development of underexploited resources are key objectives of fishery development plans. In some cases, import substitution is also a specific objective. Employment *per se* is seldom a direct objective, though youth training in fisheries is a component of fisheries programs in several countries. [It is clear, however, that maintenance of existing opportunities in the fishery sector is critical; a strategy which reduced benefits to most fishermen in favor of a few would be unacceptable.] In addition, there is widespread concern for depleted fishery resources and protection of the marine environment. The proposed Program is designed to meet these concerns.

As previously indicated, fisheries development strategies in recent years have been dominated by the high-capital, industrialized fisheries model. National policies have also been influenced considerably by the interests and perspectives of donor agencies; if financing is offered for a multi-million dollar fisheries project, few politicians are likely to decline.

On the other hand, there is an increasing awareness of the limited nature of marine resources, and Ministerial-level officials in all of the RDO/C countries are conscious of the history of failure that has characterized many previous fishery development efforts. Fisheries Division personnel are better trained and more committed to sound management and development than at any time in the past. The proposed model directly addresses major priorities of national fisheries development strategies in the RDO/C countries. The divergence from previous approaches may require explanation, but is likely to be attractive in that an alternative is offered to strategies which have not been effective in the past. At the same time, a high degree of flexibility is provided to accommodate local objectives and the need for customization in addressing the unique problems and circumstances in each RDO/C country.

3. Relationship to Mission Strategy

The objectives of United States economic assistance, as presented in FY 86 CDSS, are

- to promote an early return to healthy economic growth patterns that strengthen free institutions and enterprise in the region;
- to foster economic self-reliance; and
- to encourage Caribbean regional cooperation where this will facilitate more efficient utilization of the area's human and natural resources.

The goals of RDO/C's agriculture and rural development strategy are to increase family income by upgrading productivity among small producers, and to increase food production and exports. The proposed Fishery Development Program will contribute to these goals. Elements of the strategy include applied research and extension, market development, infrastructure, mariculture development, and commodity-specific projects. In addition, the Mission has evidenced concern for regional environmental problems and interest in supporting specific programs implemented by indigenous organizations. The proposed Fishery Development Program is totally consistent with these objectives, goals, and concerns, and will complement regional efforts as well as address country-specific needs.

The proposed program is also compatible with recommendations made in a 1982 evaluation of AID fishery and aquaculture programs (National Research Council, 1982). It should be noted, however, that the latter report focussed largely upon the role of U.S. academic institutions in international development; while such institutions offer an important source of expertise for many components of the Fishery Development Program, at least equal emphasis must be placed upon the involvement of local and regional agencies with relevant experience in the RDO/C countries.

B. Objectives

1. Goal

The Program goals are to increase the productivity of the fishery sector in the RDO/C countries, and to meet specific local objectives for sustained benefits in terms of income, food availability, and self-sufficiency.

2. Purpose

The Program purpose is to assist local and regional fisheries development and management agencies with

- improved understanding of available fishery resources, including productive capacity and means for optimal utilization
- improved flexibility and capacity of local fishing fleets to extract maximum benefits from indigenous fishery resources on a sustained basis, and to stimulate the natural innovative capacity of small-scale fishing populations

- improved processing, marketing, and distribution components of local fishery systems to provide optimal local benefit
- development and implementation of techniques for increasing production of selected fishery species through mariculture and manipulations of natural stocks
- evaluation of fisheries development and management efforts to permit continuing improvements to these efforts and to provide a basis for related projects in the future

These objectives reflect three strategic perspectives which have been previously discussed:

A versatile, multi-purpose fishing operation may be much more viable than a highly specialized one because of the unpredictable (at present) but limited character of available fishery resources. At the same time, flexibility offers the option of reducing effort on heavily exploited stocks in favor of underutilized species (McHugh, 1978). The extent to which this option can be applied depends heavily upon knowledge and understanding of fishery resources.

Individual fishermen are the key to management of fishery resources. McConnell and Norton (1978) assert that the cheapest and most efficient way to maintain and increase fish stocks is to utilize the motives of the fishermen. In the Eastern Caribbean, the best (and possibly only) means of reducing pressure on overexploited stocks is to provide alternatives. Unless the needs of individual fishermen are met, present patterns of exploitation are not likely to change. The costs of enforcing restrictive legislation are prohibitive for the RDO/C countries.

Development assistance must be targeted toward supporting local efforts to achieve local objectives (though such support may be delivered through regional agencies when appropriate). Many previous failed attempts at fisheries development can be traced to inattention to local perspectives. Because of financial and personnel constraints, the role of governments in the fisheries development process should be to provide information and support services (research, extension, infrastructure, etc.) to private sector participants in local fisheries, and to establish broad policies for fisheries development that will maximize local benefits.

It is stressed, however, that specific approaches must be developed in concert with the appropriate fisheries development and management agencies in each country. The overall process must be one of collaboration, rather than "doing it for them". The role of local Fisheries Divisions in this process must be maximized. Sustained benefits from fisheries depend upon sound management of natural resources, which in turn depends upon effective resource management capabilities at the local level. A specific intention of this program is to improve the abilities and efficiency of these Divisions which often are understaffed and underfunded.

C. Program Elements

The proposed Fishery Development Program will directly address six of the constraints discussed in Section V:

Limited Resource Base (underexploited resources will be developed,as well as mariculture and other manipulations to augment natural production of selected species)

Inadequate Infrastructure (improvements to processing, storage, marketing, and distribution systems will be made on an as-needed basis in conjunction with developments under 1)

Environmental Degradation (information will be provided to assist planners with identification of areas critical to local fisheries)

Inadequate Equipment and Technology (innovations in harvest, culture, processing, and marketing will be made in conjunction with developments under 1)

Inadequate Understanding of Fishery Systems (a system will be developed for acquisition and exchange of information on fishery resources and relevant social/economic systems, and implemented in conjunction with developments under 1)

Ciguatera (development of a means for rapidly detecting ciguatoxic fishes will be supported)

Amelioration of these constraints through the proposed Program will also alleviate the four remaining constraints:

Inappropriate Development Model (a viable alternative will be provided)

Open Access (alternatives will be provided and information obtained on optimal levels of development)

Shortage of Personnel (local capabilities and efficiency will be improved and management approaches will be developed which are compatible with these constraints)

Inadequate Finance (risk elements in fishing operations will be reduced to improve access to existing financial services)

Three major categories of activity are proposed:

Support Services to coordinate initial planning and provide ongoing monitoring of project impacts on local fishery systems so that necessary modifications can be indentified; to provide immediate assistance to fishermen in dealing with certain problems; and to improve access and exchange of information needed for fisheries development and management in the RDO/C region

Adaptation and Implementation of Technical Innovations for harvest of wild stocks and mariculture, including research and development, pilot scale testing and adaptation, and implementation at optimum initial scale

Resource Management to improve local information and capabilities needed to develop and preserve key fishery stocks, including inventory of natural resources, monitoring of fishery systems, and activities to protect or improve the natural resource base

In order for the program to be effective (i.e., for a viable alternative model to result) certain activities must be undertaken in each category. The following projects have been identified. Projects 1.a, 2.a, and 3.a are considered essential.

Activity Category 1.
Support Services

Project 1.a: Program Management, Coordination, Monitoring, and Evaluation

To insure that the objectives of the Fishery Development Program are being met, a project should be implemented to organize the design of certain key projects, monitor the progress of component projects, and determine their impact on local fishery systems. Project 1.a will

- ensure that key projects address local objectives and are implemented in ways which will provide for maximum local participation and capacity building; particular attention will be directed to meeting on-site training needs associated with these projects
- ensure that activities of the Fisheries Development Program are coordinated with ongoing projects of other agencies, as this is seen as a highly cost-effective means of acquiring crucial information and of extending the results of Program projects
- identify and regularly evaluate indicators in the natural production, harvest, processing, marketing, and distribution components of fishery systems associated with each area in which Program activities are being implemented to provide Project personnel with timely indications of probable difficulties in meeting stated objectives and of modifications which may be needed to Project workplans.

Pollnac (1981) points out that

> It is essential to monitor the perception of innovations continuously and sensitively. This type of feedback can make possible reformulation [of project components] . . . and prevent its untimely rejection.

Particularly important are socio-economic analyses. As is the case with natural resource components, baseline analyses (described in Projects 2.b.1 and 3.b) are needed to determine initial demographic characteristics, as well as impact analyses of the effects of projects on these characteristics. These analyses should focus on the small-scale fishing household, and specifically address the issue of occupational multiplicity, factors which influence participation in the fishery sector, and effects of these factors on fishery development projects.

This project will involve the following key functions: Program Coordination, Fiscal Management, Scientific (technical) Coordination, and Socio-Economic Coordination. Technical consultants will be retained on a short-term basis to constitute a Monitoring Team for periodic project reviews, and to assist with specific problems as the need arises within individual projects. Whenever possible, these consultants will be drawn from within the RDO/C countries. When adequate expertise is not available within the region, provision will be made for counterparts to external consultants to improve indigenous capabilities. Major tasks to be carried out under this project include:

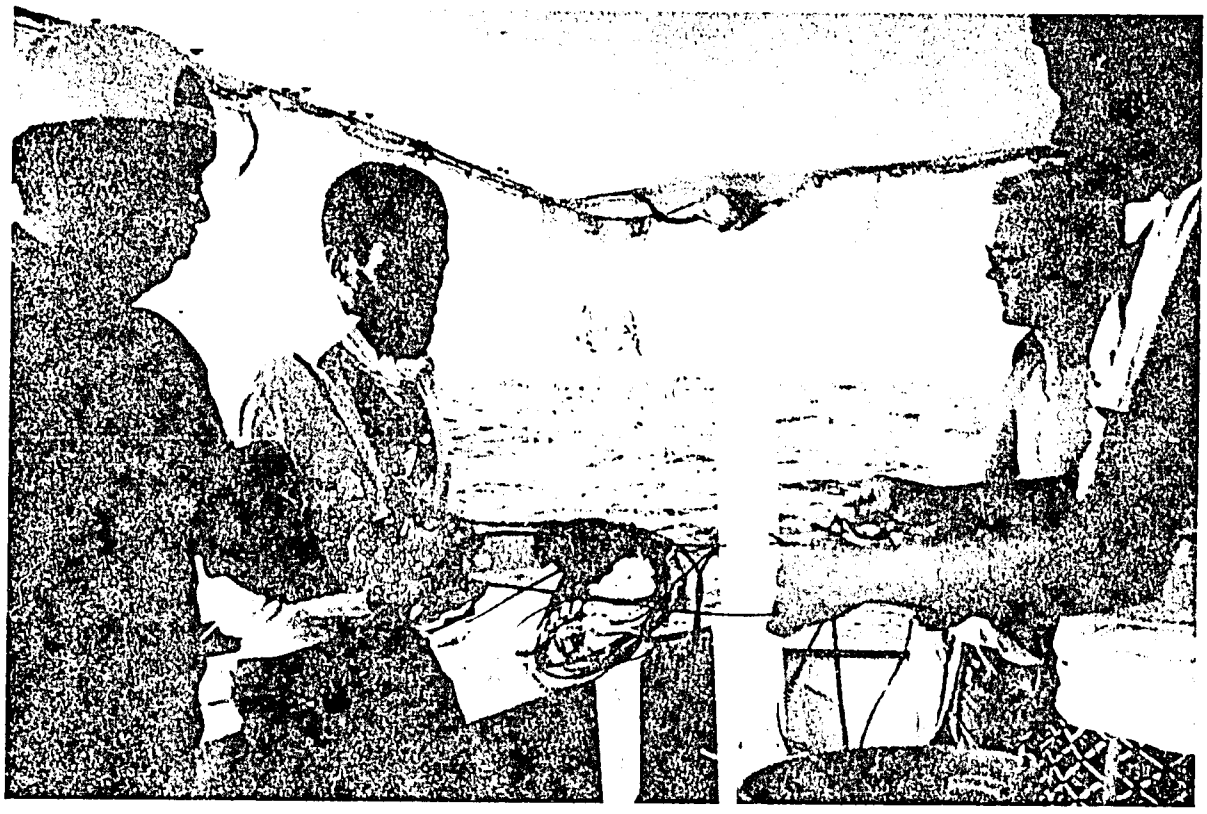
- Program Coordinator works with local counterparts in each country to identify elements of core projects.
- Program, Technical, and Socio-Economic Coordinators work with collaborating agencies to assemble project teams for each core project.
- Program Coordinator assists personnel of other projects within the Fishery Development Program with development of appropriate workplans.
- Monitoring Team identifies impact indicators for evaluation of individual projects or groups of projects in each country.
- Training is provided, where necessary, to local personnel for acquisition of monitoring information.
- Program Coordinator and/or other Program staff visit project sites quarterly.
- Monitoring Team meets tri-annually to review project progress and overall effectiveness of the Program.
- Program Coordinator and staff maintain regular contact with individual projects to identify problems, and assist with appropriate remedial action when necessary.

Because these activities are an integral component of effective fishery development planning, local fisheries units are expected to be intimately involved with the project. It is recognized, however, that specialized expertise may be needed for certain components

(e.g., economic or social impact). Because the monitoring function is essential to emergence of an effective model for Eastern Caribbean fisheries development, it is highly desirable that responsibility for this project be assigned to an indigenous organization with established expertise in resource management, impact assessment, and marine resource development in the Eastern Caribbean.

Project 1.b: Development of Extension Services

Project 1.b should be implemented in each of the RDO/C countries to provide a fisheries component to the Caribbean Agricultural Extension Program. The purpose of these projects is to enable local fisheries management and development agencies to provide rapid assistance to local fishermen with common problems, including equipment supply, engine maintenance and repair, safety, and survival at sea. In addition, these projects would provide a vehicle for exchange of information between fishermen and fisheries managers.



Eastern Caribbean fishermen learn longlining techniques from Bermudian fishermen at Gulf and Caribbean Fisheries Institute workshop in Nassau, Bahamas. Photo by Kathy Putnam

These projects might include:

- provision of demonstration equipment
- subsidy for fishermen's purchase of safety equipment
- "seed money" for fishing gear supply services
- transportation for extension personnel (absence of reliable dedicated transport impedes interaction between fisheries personnel and fishermen in every island)
- support of on-site training programs conducted by local personnel on topics of fishing technology, fiscal management for cooperatives and individual fishermen, resource management practices for fishermen, and transfer of skills acquired abroad (this activity is intended to complement training programs at the Caribbean Fisheries Training and Development Institute by assisting CFTDI trainees with local extension activities when their training is completed)
- access to information through bibliographic services, other extension programs within the region, and marine advisory services outside the Caribbean
- improved access to manufacturers and suppliers of fishing equipment and to means for obtaining preferential pricing for purchases by local fishermen (this will provide rapid amelioration for one of the fishermen's most frequent complaints)

These projects should be administered by local fisheries units with assistance from regional institutions.

Project 1.c: Development of a Fisheries Management Information System

Sustainable fisheries development in the Eastern Caribbean requires certain services which are logically provided by government (research, establishment of development policy, extension, administration of EEZ's, etc.), which imply an increased flow of information through local fisheries units. But these facilities are notoriously understaffed and overcommitted at present. Some increases in staffing are certainly possible, but given that an increase to recurrent expenses in local budgets is undesirable, fisheries units at some point will be obliged to compete with other sectors for increased support, or to improve the capabilities and efficiency of existing personnel.

There is increasing evidence (e.g., Ingle, *et al.*, 1983) that microcomputers can be a particularly effective means for achieving the latter result in developing countries. Project 1.c would:

- identify specific information acquisition and processing needs of fishery related sectors
- design a prototype network based on existing information sources to meet these needs
- implement the prototype on a trial basis, providing low-cost hardware, software, technical training, and access to technical consultants to RDO/C fisheries units

- provide limited support to indigenous institutions for participation in the prototype network
- monitor the effectiveness of the prototype network in meeting the defined needs
- modify the prototype as necessary, and identify additional potential

This project is intended to complement efforts to develop networks and information systems in other sectors. Given the activity of other donors, a unilateral development strategy for fisheries is not a realistic concept. Information on projects completed and in-progress should be readily available to all organizations. The introduction of microcomputer facilities to Fisheries Units offers a powerful means of improving information exchange, local analytical capabilities, and linkages with extra-regional organizations.

A high-level formallized computer network is specifically not recommended because past experience suggests that the difficulties with implementing such systems are likely to compromise the entire effort. Instead, practical means of accessing existing data bases (perhaps via a mainland institution) and for exchanging information between islands should be emphasized. Simple exchange of data disks is an alternative to unreliable telephone systems. A contract with LIAT's small parcel service might be negotiated for this purpose. Compatibility between systems is an obvious requirement, but this does not necessarily mean that systems must be identical. A more useful approach would be to build into the network facilities for exchanging information among different systems. This would greatly broaden potential participation in the network and its overall usefulness.

Local fisheries units will be the principal initial users of the network, but a wide variety of other local and regional agencies are expected to benefit from its establishment. Overall responsibility for project design and monitoring should rest with an external (though preferably indigenous) agency familiar with Eastern Caribbean fisheries. Technical expertise could be acquired by such an agency on a consulting basis. The prototype will be designed so that, once implemented, the network will be largely self-supporting. A three-year project is proposed at the end of which hardware would be in place, local personnel would be trained to use the network, and ongoing linkages information exchange would be established.

Project 1.d: Development of Simple Means for Detecting Ciguatoxic Fish

Because ciguatera is one of the major impediments to full utilization of fishery resources in the leeward islands, a Phase I project should be supported to develop an easily-applied test for ciguatoxicity. Particularly important is an adequate supply of toxic material (the toxin is so potent that a great deal of tissue is needed to produce even a minute amount of purified toxin) which might be extracted at a simple laboratory facility within the region. When funds have been available, local fishermen and fisheries management personnel have provided this type of assistance to research programs dedicated to producing the sort of test envisioned. Support would be made available to institutions with experience in this field for collection and extraction of material, as well as for applied research directed toward perfecting simply assay methods.

Activity Category 2.
Resource Management

Project 2.a: Preparation of Fishery Resource Baselines and Development of Resource Monitoring Capabilities

Information is needed on natural production, economic, cultural and social components of local fisheries systems to plan specific fishery development projects and evaluate their impact. This is a widely recognized need, but (despite genuine efforts by local fisheries units) is not fully met in the RDO/C countries, either because personnel are not available, or because of difficulty in analyzing information which is available. Project 2.a would focus in particular upon descriptive characteristics of fisherman households (described above) and upon reliable estimates of sustainable yield of major resources and the extent to which these resources are shared within the region.

Personnel, technical counsel, and equipment would be provided to acquire baseline information on sustainable yields of local fishery stocks, current and desirable levels of fishing effort, and relevant socio-economic characteristics over a three year period. During this time, local personnel would be trained in relevant techniques, and systems would be implemented through which estimates of sustainable yield and abundance may be updated and improved on a continuing basis. In addition, previous historic and bibliographic information would be compiled, the latter possibly with short annotated summaries. The historical information would be useful for comparison with baseline information (e.g., for interpreting reliability, illegal landings, unreported catch, etc.).

Specific information needs and acquisition strategies (cf., for example, Stevenson, Pollnac, and Logan, 1982) for currently exploited and underutilized resources as well as socio-economic characteristics will be identified as part of Project 1.a. Bellairs Research Institute and the University of the West Indies are expected to be particularly useful in planning and training activities associated with this project. The proposed time period will coincide with implementation of other projects, but the resulting information will still constitute a baseline for future evaluation of Program impact. Recent FAO/OECS workshops on fisheries legislation have recommended a similar, though more restricted project to compile fishery landing statistics.

This project would include:

- provision for hiring and training local personnel to collect relevant information on fish landings and socio-economic characteristics where such personnel are not already employed
- provision of a microcomputer system to facilitate collation and analysis of landings information
- technical consultation for the interpretation of acquired information

Provision of microcomputer equipment is expected to be coupled with implementation of a Fisheries Management Information System (Project 1.c). Local fisheries personnel are expected to assume primary responsibility for this project.

Project 2.b: Coastal Resource Inventory

Information is urgently needed on the location, extent, and local importance of major marine habitats (coral reefs, seagrass beds, mangroves, etc.) for use in identifying critical areas which may require protection, to permit informed decisions to be made in regard to siting coastal development projects (particularly those involving industrial and tourist facilities), and to improve estimates of fishery resource abundance. Project 2.b should be implemented in each of the RDO/C countries to prepare such inventories (which might be undertaken as an adjunct to the acquisition of preliminary information on underutilized resources). This project should produce information which can be incorporated into Country Environmental Profiles.

Project 2.b would include:

- technical consultation in the design of inventory activities
- training for local personnel in relevant techniques
- provision of special equipment required
- hiring local vessel(s) as required
- technical assistance in compilation and interpretation of collected information
- development of use guidelines based on the results

Nearshore habitats are critical to many fishery stocks but are highly susceptible to inputs from activities on land.
Photo by Mel Goodwin

These inventories should be undertaken largely by local personnel, though assistance from expatriot PVO's may be required in some cases. A recent collaborative project in St. Lucia suggests that local dive clubs can provide a valuable source of additional personnel for this sort of undertaking. Personnel experienced with this type of activity should be available in the design and interpretation stages, and periodically during the actual inventory to verify procedures being used.

Project 2.c: Implementation of Specific Resource Management Strategies

It is anticipated that, in the near future, national and regional organizations are likely to develop strategies for managing specific fishery resources. Particularly promising are activities concerning administration of Exclusive Economic Zones and the concept of protected areas and multiple site Biosphere Reserves. Training to improve local administrative, regulatory, and enforcement capabilities as well as other requirements for implementation of these strategies should be considered for support under the proposed Fishery Development Program, provided basic criteria described above are met. Capital-intensive projects generally should not be considered unless costs are clearly "one-time", and continuing benefits are sufficiently guaranteed and of a magnitude to justify the expense.

Activity Category 3.
Adaptation and Implementation of Technical Innovations

A three-phase approach will be applied for implementing technical innovations in support of fisheries development and mariculture projects:

Phase I -- Research and Development, in which experimental or exploratory work is done to establish the technical feasibility (i.e., can it work at all?) of potential innovations. This would apply, for example, to preliminary efforts to culture a wild stock. This activity may be within or outside the Eastern Caribbean, and may involve linked activities at several sites. In many cases, this phase may already be completed (e.g., a potentially appropriate fishing technique which is being used elsewhere)

Phase II -- Pilot Scale Testing and Adaptation, to establish that the technique can work at the specific site where implementation is proposed. That is, the pilot phase should be undertaken on every potential site where implementation is contemplated). Local fishermen and fisheries managers will participate heavily in pilot projects, as this is the only way to evaluate how techniques "fit" into existing fishery systems. Such participation is expected to be much more intensive than is normally the case with "demonstration" projects.

This phase allows for "customization" of the technique to specific conditions on-site, and provides a period in which a decision can be made not to proceed with implementation prior to commitment of major capital. Where the decision is made to proceed, this phase provides a "confidence building" period important to local acceptance of innovations. Careful monitoring of pilot scale projects offers the means to obtain site-specific data while simultaneously addressing current needs and effecting positive development of the fishery sector.

The pilot phase should address all components of the fishery system: production, harvest, processing, and marketing. Potential project areas have been identified for each island based on local objectives and desired activity. A critical requirement for this stage is objective monitoring of impact on the natural resource base, social acceptability, marketing structure,economic impact, and input costs to provide data needed to complete the feasibility analysis outlined in Table 9. Particular attention must be paid to evaluation of social impact of the project and relevant demand analyses. When there appears to be potential for more intensive investment, the feasibility report should include expected cost of purchasing capital, costs experienced in the pilot phase, experienced increases in harvest and revenue, estimated return on investment, and projected schedule for pay-back of capital and interest.

Phase III -- Implementation At Optimum Initial Scale, usually as commercial ventures. Private sector involvement should be encouraged at this stage, as individual dedication and vested interest are powerful contributors to the success of these types of project. Particular care should be taken that adequate controls are provided for environmental protection and management of natural resources for sustained use.

At this time, considerable investment capital is available through various development banks and other institutions for development of commercial activities in the region; it is the impression of the authors that the shortage is of credit-worthy projects rather than capital. Considering existing AID contributions to various financing programs, provision of additional capital in support of this component of the Fisheries Strategy could be minimal. Consideration might be given to providing a limited number of "guarantees against loss" as collateral for an appropriate number of particpating fishermen to secure loans from conventional lending institutions. This would help fishermen develop a positive credit rating, and could facilitate establishment of specialized seasonal pay-back schedules needed in some fisheries.

RESOURCE DEVELOPMENT

Project 3a. Development of Underutilized Resources

An integrated project should be developed for each RDO/C country to identify underutilized resources, assess their development potential, and determine optimum means for harvest. These will be Phase I and II projects within which information on fishery systems can be obtained, including capacity of natural resources, social organization of fishing groups, significance of fishing income and consumption in the typical fisherman's household budget, and economic functioning of existing and potential fisheries.

Though specifics will vary for each country, it is expected that most projects will include deepwater bottom fishes, sharks, and molluscs (particularly octopus and squid) as targets for investigation. Considering the level of activity already proposed for increased harvest of pelagic fisheries, the certainty of competition from foreign vessels, the uncertain capacity of these resources, and the severity of potential impacts of overcapitalization in small islands, AID participation in offshore fleet development is considered inadvisable at this time. As results from current development projects and planned resource assessments become available, these should be reviewed to obtain indications of investment potentials.

Table 9

Outline of Feasibility Analysis for Fisheries Investment Projects

A. Market
1. Sales potential of proposed products
2. Market size during proposed production period
3. Product form required
   a. equipment required for processing
   b. cost of equipment and labor for processing
4. Cost of transportation
5. Demonstrated feasbility of marketing proposed product from proposed production area
6. Total value of expected sales

B. Production
1. Target fisheries
   a. yield estimates based on site-specific information which establish potential sustainable harvest
   b. estimates of current and projected fishing effort which indicate that MSY will not be exceeded
2. Equipment required for harvest
   a. pilot trials which establish the suitability of proposed equipment for the target stock(s)
   b. skill required for operation
   c. available service, parts, and maintenance facilities
   d. capital cost of equipment
   e. annual maintenance, depreciation, overhead, and operating costs
3. Human factors
   a. compatibility with existing fishery systems
   b. cost of labor

C. Finance
1. Cost of capital
2. Profit after expenses
3. Cash flow

D. Evaluation
1. Probable impact on natural resource base
2. Probable socio-economic impact
3. Projected Net Present Value
4. Comparison of projected return on investment with expected rate of return on a fixed-term deposit (should be at least 10% greater to be considered favorable)

(Based on Gibbons and Husack, 1980)

Innovative technology directed toward underutilized stocks will be evaluated as part of Project 3.a. Trial harvesting of promising species will be carried out by local fishermen using prototype equipment and techniques to allow the compatibility of innovations with local fishery systems to be assessed. Where necessary, modest infrastructure improvements will be made to facilitate test marketing. These projects will be closely linkedto the Monitoring and Evaluation Project described above, so that comprehensive assessments may be made of yield potentials to guide local development strategies.

Participation of local fishermen will be stressed to insure that the applicability of innovations to local needs is adequately evaluated, and to encourage diversification from overexploited stocks.

A prototype project for St. Kitts, for example, would include:

- technical consultation to specify equipment
- provision of technical assistance and equipment for initial exploratory trials to locate underutilized stocks and identify effective harvest methods, using a locally available boat chartered for this purpose; included in these trials will be mechanical trap haulers, deepwater traps, vertical longlines, octopus traps, longlines for pelagic species, gear for shark harvest, fish aggregating devices, and pair trawls (note that acquisition of a "research vessel" is specifically not recommended because of the recurrent financial burden this would impose on local government)
- local construction of two boats modified from designs in current use or chartering of suitable local boats and equipping these vessels for harvesting trials
- training fisherman participants in relevant techniques
- provision of small ice machines, cold storage boxes, and a small truck to assist marketing and distribution
- technical consultation on product processing, if necessary
- trial harvesting by local fishermen and test marketing
- technical assistance with monitoring and evaluating resource potentials, social impact, and economic feasibility

A similar project in St. Lucia could be directed toward prototype operations with a multipurpose fishing vessel for pelagic and nearshore fishing with direct participation by local fishermen and trial processing and marketing to determine the most effective approach to more comprehensive development.

Local fisheries staff will be intimately involved with planning and implementing all phases of these projects, and may identify requirements for additional personnel to assist with certain tasks on a case-by-case basis.

INFRASTRUCTURE IMPROVEMENT

Innovations in processing, storage, and distribution are expected to be included with projects to develop underutilized resources as noted above. There are, however, other cases in which similar innovations may be needed.

Project 3.b.1 Market Survey

A series of market surveys of for Eastern Caribbean fishery products should be undertaken. These surveys should include:

- consumer preferences and demand, and factors which influence these characteristics
- evaluation of the relative benefits of export promotion vs. import substitution
- cost-benefit and impact analyses for specific fishery products (e.g., conch, spiny lobster, snapper/grouper, migratory pelagics)
- institutional incentives/disincentives operating in the small-scale fishing context, particularly an analysis of domestic fish pricing
- economic profile of fishermen's households to identify specific constraints operating at the fisherman level in each RDO/C country as well as the true demand for innovation
- analysis of direct and indirect impacts of the fisheries sector on overall economies of the RDO/C countries

Project 3.b.2 Infrastructure Improvements

The widespread problems of distributing surplus catch have been discussed previously. In some cases, e.g., Dominica, considerable amelioration would result from provision of small ice machines, insulated storage boxes, and possibly transport vehicles. Such innovations would have to be accompanied by training in proper handling and consumer education to demonstrate the quality of iced or stored products. Similarly, imports of salt fish might be reduced if local facilities were established for processing excess catch during periods of glut. These facilities should be simple and involve low capital outlays.

Because of the desirability of minimizing dislocations to established marketing systems, large-scale fisheries infrastructure development is not recommended at this time. Instead, innovations should be implemented on a pilot-scale to provide a basis for for assessing social and economic impacts, as well as to meet immediate needs in established fisheries. Many of these innovations will be included in Project 3.a. In addition to the examples above, specific consideration should be given to

- improvements to fishing harbors and landing facilities
- training local shipwrights in use of new materials and designs for constructing vessels determined to be suitable for use in local fisheries
- pilot scale projects to test and evaluate marketing and processing innovations on a site-specific basis.

Such projects should be based on existing market and distribution systems whenever possible, and individuals who will operate and be responsble for such facilities should be clearly identified when the projects are formulated.

Local fisheries units should maintain close supervision of these projects, and may be charged with their daily operation if suitable personnel are available. Many of these projects may be carried out through the local private sector (e.g., individual marketing companies, fishing cooperatives, etc.).

Such projects would typically include:

- technical consultation to specify innovations
- training in operation and maintenance of facilities
- provision of equipment for specific handling, processing, or marketing innovations

MARICULTURE

At present, there is no mariculture system which has been shown to be sufficiently reliable that it can be recommended for widespread introduction in the Eastern Caribbean. However, several prospects are sufficiently promising to warrant support. Proposals for culture of other species will undoubtedly be received by RDO/C. It should be clearly determined whether these are Phase I, II, or III projects, and the evaluative criteria presented in Appenindix A should be rigorously applied.

Project 3.c.1 Marine Algae

Phase II pilot projects to culture Gracilaria species should be implemented to extend development work recently completed in St. Lucia with IDRC support. These projects would involve:

- an initial survey to identify promising culture sites and assess local markets for "sea moss"
- short-term intensive training of personnel from areas selected on the basis of this survey, preferably in conjunction with the on-going St. Lucia project
- on-site technical assistance with establishing plots
- provision of basic equipment for culture
- continuing access to technical counsel

Local fisheries personnel should be cognizant of these projects, but should not bear responsibility for day-to-day activities unless trained individuals can be assigned on a full-time basis. Because this is an evaluation/adaptation/ demonstration activity, provision should be made to hire and train local personnel for the initial effort. Expatriot personnel (e.g., Peace Corps or other PVO's) may be a valuable adjunct to these projects, but must not replace local participants. If pilot projects are successful, future support should be confined to costs of training and equipping individuals or cooperative groups in establishing similar culture operations. Potential sites include Antigua, Grenada, Grenadines, and St. Lucia.

Project 3.c.2 Bivalve Molluscs

A Phase I project should be undertaken to assess the mariculture potential of common Eastern Caribbean bivalve molluscs. For reasons of efficiency, this should be done in an established mariculture facility experienced with culture of bivalves. This project would provide estimates of growth, culture costs, available markets, and feasibility for application to the RDO/C countries. A brief survey would also be made to determine the occurrence of promising species in these countries, and location of potential culture sites.

Project 3.c.3 Brine Shrimp

A Phase II pilot project should be undertaken based on the AID-funded assessment of mariculture potential of indigenous Eastern Caribbean brine shrimp. This project would include:

- manipulation of a 20 ha pond to produce brine shrimp biomass and cysts
- a temporary applied research component to identify optimum culture conditions
- trial marketing to local, regional, and extra-regional consumers
- access to technical expertise and facilities for problem-solving and to monitor product quality

Because this is a technology evaluation project, a project manager experienced with pond aquaculture and preferably with brine shrimp is essential, along with a local counterpart/ trainee who can reasonably be expected to assume a managerial role in the future should also be included. Local fisheries personnel should be cognizant of the project's status, but should not be expected to assume responsibility for daily operations. Potential sites include Antigua, Grenadines, and St. Kitts.

Project 3.c.4 Fin Fish

Aquaculture organizations in Martinique are collaborating with the South Carolina Sea Grant Consortium in a promising series of projects to culture marine fin fishes. Phase II pilot projects should be undertaken to extend this experience to selected RDO/C countries. This project would include:

- identification and evaluation of potential sites for fin-fish cage culture in the RDO/C region
- short-term intensive training in cage culture techniques
- on-site technical assistance with establishment of local culture operations
- provision for continued access to technical expertise and facilities for problem solving as well as results of research dealing with diets, disease control, maturation, etc.
- feasibility analysis of expanded operations, based upon actual operating costs of pilot facilities and local market conditions
- identification and quantification of target markets and marketing trials

Guidelines for staffing of these projects are similar to those described for Marine Algae projects.

Project 3.c.5 Freshwater Prawns

Phase II and early Phase III projects currently underway with these species in the Eastern Caribbean should be closely monitored. Additional small Phase II and III projects should be undertaken at other sites if the prognosis for existing projects is favorable. These project should include:

- technical consultation and assistance with site selection
- short-term training in culture techniques
- on-site technical assistance for start-up and initial operation of both Phase II and III projects
- provision for continued access to technical assistance
- economic and social feasibility analyses on a site-by-site basis
- identification and quantification of immediately accessible markets
- determination of how best to handle post-larvae supply problem to allow small farms (up to a few hectares) to develop and prosper

Project 3.c.6 Mithrax

Phase II pilot scale activities begun in Antigua to culture "Caribbean King Crab" should be continued to establish the viability of this technique as a cottage industry appropriate to the RDO/C countries. Particular attention should be paid to:

- biological production parameters (growth rate, mortality, permissible density of animals in cages)
- economic production parameters (costs of culture, space required, manpower required)
- processing and handling
- trial marketing
- environmental impacts

It is particulary urged that commercial feasibility be clearly established (i.e., at least 10,000 crabs should be reared and marketed with sufficient financial return to exceed production costs) before additional support is granted for extension to other areas.

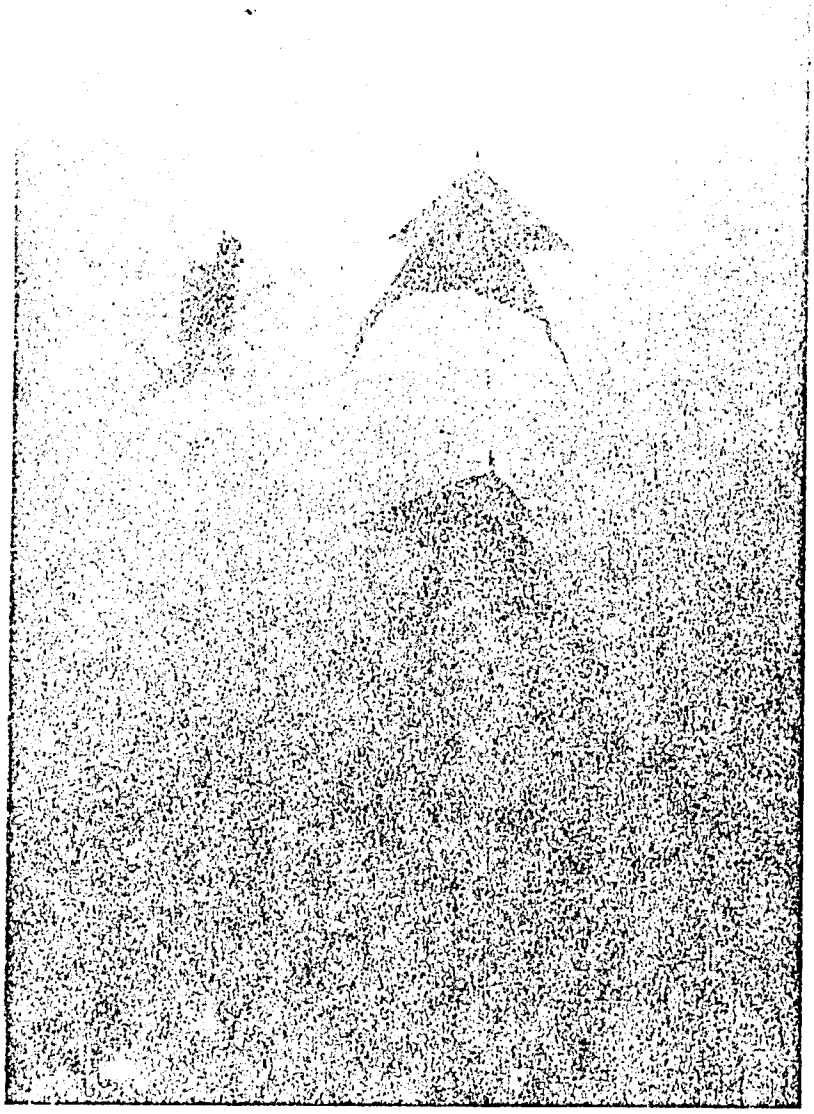
Project 3.c.7 Penaeid Shrimp

The factors which have contributed to the success of shrimp mariculture operations elsewhere are not prevalent in the Eastern Caribbean, and the level of capital investment and risk make this a dubious proposition for local participation. However, there may be potential for developing simple culture systems for native *Penaeus schmitti*. A Phase I project should be considered to determine distribution of this species around the RDO/C islands, and to evaluate its ease of culture in simple systems.

HABITAT ENHANCEMENT

Project 3.d.1 Fish Aggregating Devices

Pending a successful outcome of the AID-sponsored project to evaluate fish aggregating devices (FADs) for the Eastern Caribbean, additional Phase II projects should be implemented to extend this technology to other RDO/C countries. This technique is attractive in that it offers a low-cost means for increasing the catch of pelagic fishes and for



Commercial Fish Aggregating Device under evaluation in St. Kitts.
Photo by Sandy Goodwin

improving the economic efficiency of existing fishing fleets. Such projects, however, must address the issue of marketing, since the greatest catch (i.e., of migratory pelagic fishes) can be expected during the period when there are already local fish surpluses. In addition, handling and storage may become a much more serious issue as larger scombroid fishes (such as mackeral and tuna) are liable to become poisonous if allowed to partially decompose. For these reasons, it is suggested that Phase II FAD projects be combined with projects which include marketing, storage, and distribution components.

Project 3.d.2 Artificial Fishing Reefs

Phase II projects should be implemented to establish artificial fishing reefs in areas where natural reefs are scarce (e.g., Dominica, Montserrat, St. Vincent). Preliminary studies have been completed in Dominica and Montserrat to identify potential sites for such activity, and similar studies should precede implementation in other areas. To date, emphasis has been upon the use of derelict vehicles and mechanical wreckage for artificial reefs, reflecting a dual desire to improve fisheries and alleviate solid waste disposal problems. It is desirable, however, that future projects include simple structures designed specifically for habitat enhancement to permit an evaluation of the relative efficacy of the two approaches in producing useful food fishes.

These projects should include:

- technical assistance with site identification
- provision of technical assistance and materials for design and construction of "designed" structures
- provision for collection and installation of solid waste if this is to be used for habitat enhancement
- training for local personnel in construction, installation, and monitoring techniques
- provision for periodic monitoring of fish populations associated with enhanced habitats to establish optimum levels of harvest and to determine the effectiveness of the reefs

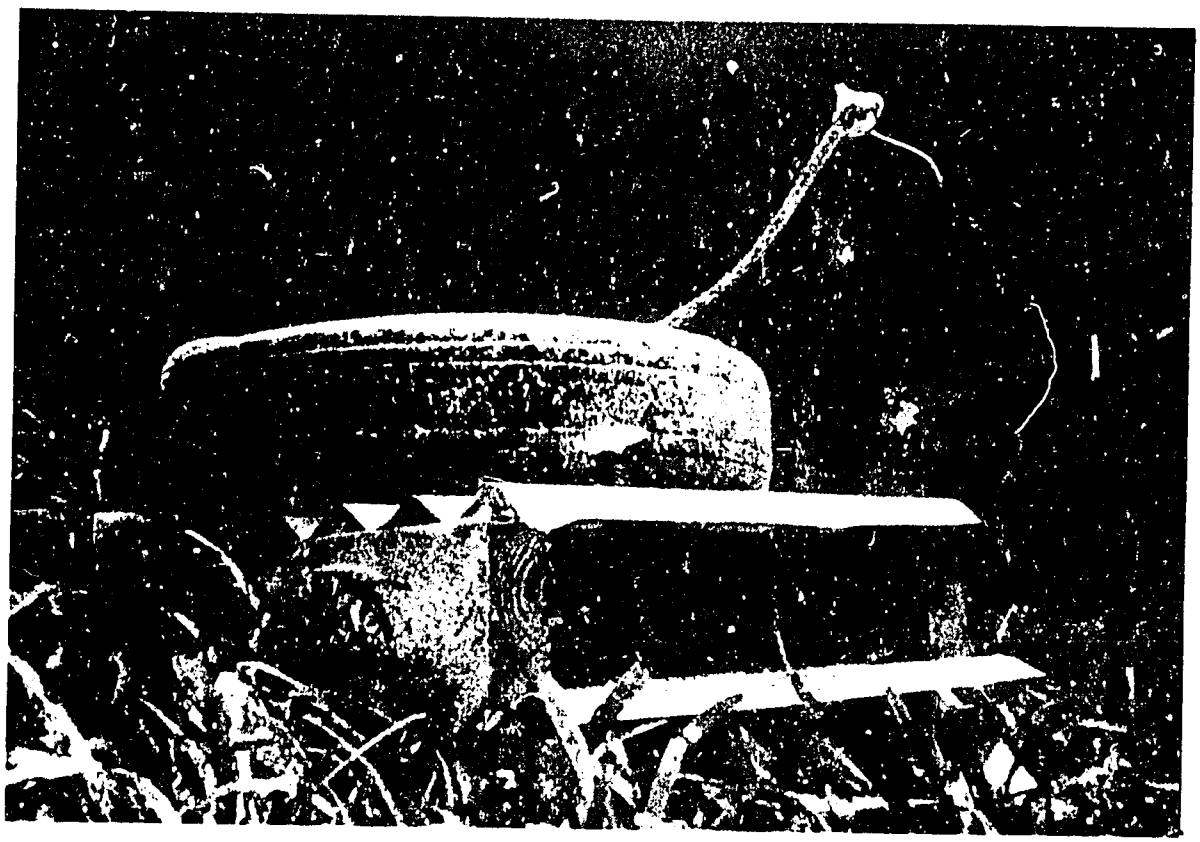
Local fisheries units should be involved in all aspects of these projects, and should be included with selected local fishermen in training activities. Monitoring is best done by cooperating fishermen under the supervision of local fisheries units.

Project 3.d.3 Spiny Lobster Production Enhancement

A Phase I project should be implemented to evaluate the use of artificial shelters for improving yields of spiny lobsters. This technique has been used in several countries including Mexico and Cuba, but the actual impact on natural production has not been established. This project would include:

- establishment of baseline information on natural production of spiny lobsters in the study area
- comparison of natural production with production of spiny lobsters in areas enhanced with artificial shelters
- comparison of the impact of habitat enhancement on production of spiny lobsters at various stages of development

Because this is essentially a research/development effort, the project should be a collaborative undertaking between local fisheries staff and external assistance personnel.



Artificial Habitat for juvenile lobsters. St. Kitts.
Photo by Sandy Goodwin

E. Project Implementation

Cost estimates for the proposed Fishery Development Program are summarized in Table 10. Within the Fishery Development Program, two groups of projects may be distinguished:

- a core group of interrelated projects which includes

  >Program Coordination and Monitoring
  >Preparation of Fishery Baselines
  >Coastal Resource Inventory
  >Development of Underutilized Resources
  >Development of a Fisheries Management Information System
  >Infrastructure Improvement
  >Development of Extension Services

- Mariculture, Habitat Enhancement, and Ciguatera Research Projects which are much less interrelated

Projects should be solicited for the suggested subject areas in Group (b), and evaluated according to criteria presented in the appendices to this report. All of these projects will be either Phase I (research and development) or Phase II (site specific pilot-scale implementation), and should be limited to a maximum duration of three years with annual support up to US$ 200,000. These limitations are expected to favor projects of a scale and technical level appropriate to the RDO/C region.

A different strategy is suggested for implementing core projects. Initial design of these projects for each of the RDO/C countries will be organized under the Program Coordination and Monitoring project. The contract for the latter project ideally should be awarded to an indigenous agency with qualifications described under Project 1.a. Appropriate consulting teams will be developed for each of the core projects. Emphasis will be placed upon inclusion of fisheries personnel (including fishermen) in the target islands and to sources with requisite technical expertise as well as hands-on experience with fisheries development in the Eastern Caribbean. Several entities (e.g., Bellairs Research Institute, FAO, GCFI, CCA, IRF, OECS) are tangibly involved with appropriate development of the Eastern Caribbean Fisheries Sector, while a variety of others (e.g., CARICOM, University of the West Indies) have evidenced interest in having such involvement. In addition to monitoring functions, Project 1.a is intended to provide for the coordinated participation of such organizations and agencies which will be highly advantageous to the proposed Fishery Development Program.

It is recognized that it may be desirable to phase the implementation of some projects so that they are not started simultaneously in all of the RDO/C countries. Projects dealing with underutilized resources and infrastructure improvements, for example, might be implemented for two countries in each of the first and second years of the program, and for the remaining three countries during the third year. This would provide an opportunity to build on experience, and also flexibility to avoid duplication of other agencies in regard to site-specific activities (e.g., CIDA's proposed program for St. Vincent). Inventory and

Table 10

Summary of Project Cost Estimates

Project	Cost (US$ '000) Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
1a. Program Coordination and Monitoring					
(a) Full-time Personnel	165	165	165	165	165
(b) Consultants	20	20	20	20	20
(c) Travel & Per Diem	20	20	20	20	20
(d) Support Services	25	25	25	25	25
(e) Indirect Costs	100	100	100	100	100
TOTAL	330	330	330	330	330
1b. Development of Extension Services Average Costs per Country					
(a) Technical Personnel	6	6	6	6	6
(b) Local Workshops	5	5	5	5	5
(c) Equipment	35	5	5	5	5
TOTAL	46	16	16	16	16
TOTAL for All Countries	322	112	112	112	112
1c. Fisheries Management Information System					
(a) Technical Personnel	20	20	20		
(b) Equipment	35	15	15		
(c) Support to Regional Institutions	42	42	42		
(d) Workshops	25		25		
(e) Support Services	2	2	2		
TOTAL	124	79	104		
2a. Fishery Resource Baselines Average Costs per Country					
(a) Technical Personnel	9	8	8		
(b) Local Personnel	11	11	11		
(c) Support Services	1	1	1		
TOTAL	20	20	20		
TOTAL for All Countries	147	140	140		

TABLE 10 (continued)

Project	Cost (US$ '000) Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
2b. Coastal Resource Inventory					
Average Costs per Country					
(a) Technical Personnel	11				
(b) Equipment	3				
(c) Local Operations	6				
(d) Support Services	1				
TOTAL	21				
TOTAL for All Countries	147				
2c. Implementation of Specific Resource Management Strategies	200	200	200	200	200
2d. Ciguatera Detection	100	100	100	100	100
3a. Underutilized Resources					
Average Costs per Country:					
(a) Technical Personnel	79	73	79		
(b) Equipment	5	40	5		
(c) Vessel Operations	10	10	10		
(d) Market Facilities	6	6	6		
(e) Local Personnel	-	9	9		
TOTAL	100	138	109		
TOTAL for All Countries	700	966	763		
3b1. Market Surveys					
(a) Technical Personnel	30				
(b) Support Services	10				
TOTAL	40				
3b2. Infrastructure Improvements					
Average Costs per Country					
(a) Technical Personnel	13				
(b) Equipment	30				
TOTAL	43				
TOTAL for All Countries	301				
3c. Mariculture	1000	1000	1000	1000	1000
3d. Habitat Enhancement	600	600	600	600	600
Inflation and Contingency	401	353	335	235	235
PROGRAM TOTAL	4412	3880	3684	2577	2577

baseline projects should be implemented as soon as possible, preferably as part of the process of preparing Country Environmental Profiles.

Within each country requisite activities, equipment, and staffing needs are expected to be similar for a number of the core projects (e.g., each of the projects would make use of equipment and services provided by a Fisheries Management Information System; survey activities undertaken to locate underutilized resources would provide essential information for coastal inventory). It is probable that, to a large extent, the same local individuals will be involved in each of the projects. The design activity is intended to ensure the most efficient use of human and financial resources to meet the individual requirements of each project. Because available personnel, related ongoing projects, and specific project requirements vary among the RDO/C countries, a unique design is expected to emerge for each. Whenever possible, Host Country Contracts will be used for acquisition of specific equipment and technical services specified by the design for each project. Procurement procedures will be monitored under Project 1.a.

Because it is dedicated specifically to the task, Project 1.a will assure adequate attention to the overall approach and lessons described above. Additionally, this approach will provide a mechanism for recognizing and resolving problems which might be major obstacles to individual site-specific projects. Finally, Project 1.a will help ensure that timetables and targets are met. At the same time, the option exists for local assumption of responsibility for design and implementation functions commensurate with available resources and expertise. This is essential to avoid duplication of other efforts, improve local capabilities, and achieve compatibility with programs of other agencies.

VII. COUNTRY PROFILES

Country Profile -- Antigua and Barbuda

[This profile was prepared primarily by D. Joseph,
with additional information from Anderson and Matthes, 1985]

1. General Descriptors

Population (1983): 77,908 (3)
Land Area: 441 sq km
GNP per capita (1983): US$ 1,516 (3)
GDP Growth Rate (1982): 3.3% (2)

2. Characteristics of the Fishing Fleet

The harvesting sector is small scale in nature. In Antigua the fishing fleet is composed of about 250 vessels operated by approximately 800 fishermen, while in Barbuda about 300 fishermen operate 100 vessels. These vessels range in size from the small in-shore craft to vessels of up to 55 ft in length. Most are within the 20 - 35 ft range, powered by outboard motors or small inboard diesel engines.

The principal fishing gear is the Antillean fish trap. Fishing from small vessels is done about two to three times per week, depending upon how far from shore traps are deployed. Some of the larger vessels fish in deeper and more distant waters offshore, and spend as much as three days at sea engaging in trap and/or line fishing. Some fishermen, especially those fishing in deeper waters, have increased their catch by use of baited fish traps. It is evident that those vessels fishing in deeper and more productive areas of the shelf obtain a higher catch per unit effort, and the size (and consequently market value) of individual fishes is greater than that of similar species captured closer to shore. The absolute magnitude of these resources, however, requires further investigation.

Annual fish landings were fairly constant during the five years prior to 1979, being estimated at about 2,000 tons annually. Between 1980 and 1984, there was a steady decrease in fish landings of about 15% per year; current landings are estimated at 800 metric tons. Estimated Value of the catch rose from EC$ 3.5 million in 1977 to EC$ 5.5 million in 1981 (4). This decrease in catch is a result of a number of factors which have a direct impact on the harvesting sector:

- lack of a regular ice supply to preserve the catch while at sea
- exodus of fishermen with large boats from the industry to participate in inter-island cargo trade
- overfishing of traditional near-shore fishing grounds
- lack of investment capital from both public and private sectors to improve technology

In contrast to the decline in landings, exports have risen: between 1977 and 1981 fish exports increased from 45 metric tons to over 350 metric tons per year. Between 1979 and 1981 lobster exports rose from 75.3 mt to 127.2 mt. Official landing figures do not

reflect sales to commercial consumers under private arrangements, nor do export figures account for at-sea sales to foreign vessels.

3. The Fisheries Resource Base

Antigua and Barbuda have a coastal shelf of 3,400 sq km; the largest among the RDO/C countries. The continental shelf is characterized by a series of reef systems that form a complex ecological community with the other living resources of the shelf. Separating the coral reef communities are mud flats and grass beds ideal for the setting of fish traps. The fishing industry of the country is based almost exclusively upon exploitation of demersal reef species within a twenty mile radius of the coast of both islands. Estimates of the annual sustainable yield of these stocks vary from 2400 to 4480 metric tons, though these estimates are subject to the same uncertainties as others discussed in Section II, and hence are of limited use.

Pelagic fish resources are available within the EEZ of Antigua and Barbuda. Exploratory fishing has produced evidence of a seasonal abundance of a number of economically important pelagic species. Estimates of the maximum sustainable yield of these stocks range from 3,000 to 5,500 tons per year (1, 4), but the information and techniques used to derive these figures are dubious for reasons discussed above. The pelagic resource is not commercially exploited by local fishermen due to lack of necessary technology, and represents significant development potential.

4. Handling, Processing and Marketing

Marketing of fish is an acute problem. More than 90% of the total fish production is landed in the capital, St. John's. Marketing infrastructure is inadequate to meet the needs of either the fishermen or the general public. Most fishermen land their catch at either the Point Wharf or the Public Market jetty. The entire catch is sometimes purchased by middlemen who export a significant quantity of high-value species to Guadeloupe and sell the remainder to local restaurants, hotels, supermarkets, or individuals. Alternatively, fishermen or their families assume marketing responsibilities (often after long hours at sea). Fish are sold directly ex vessel, presenting major inconveniences to buyer and seller alike. The jetties are poorly maintained and lack necessary facilities for safe berthing of vessels. They are not dedicated solely to fishing operations and on a busy day are overcrowded and unsafe for any marketing transaction.

5. Infrastructure

A public building in St. John's has been designated for marketing fish. Built during the period of British colonization, with little subsequent upgrading, the building is virtually unattended and lacks even basic quality control provisions. Fishermen use the building reluctantly, and only if rapid dockside disposal of fish is impossible due to a temporary glut. Many consumers who might need fish do not buy inside the market because of the appalling sanitary conditions. This building is not under the supervision of the Fisheries Division.

Lack of marketing and cold storage facilities have limited expansion of fishing in Barbuda. This is a major problem, as more than 50% of the adult male population of the island are fishermen.

Fishermen are willing to use ice, and as a result landings in St. John's are of relatively good quality. There is a shortage of ice, however; at present, Antigua Fisheries Limited has one small flake ice plant in operation offering ice at a subsidized price to fishermen.

There are no cooperative organizations in the country, though the Antigua Fishermen's Association (formed to protest the intrusion of foreign vessels) has evidenced some interest in collective gear purchase and duty-free fuel sales.

Credit facilities are limited. Small loans (about EC$ 5000) (at interest rates up to 12%) are granted by commerical banks who report a generally good repayment history. The Antigua and Barbuda Development Bank has had a less satisfactory experience with repayment of larger loans for fishing operations, and has become much more selective in granting such loans.

6. Market Analysis

1981 demand for fish in Antigua and Barbuda has been estimated to be 2550 metric tons, compared to a domestic supply of 1090 metric tons. Though official consolidated statistics are not available beyond 1980, the Fisheries Division estimates that the value of imports exceeded EC$ 14 million in 1981. Considering the decline in local landings, it is likely that imports have continued to increase in recent years, with a growing demand for frozen products. The country's population is expected to increase at a rate of 1.2% per annum between 1985 and 1990, while tourist stay-overs are expected to rise at an annual rate of 5% during the same period. Demand for fish is thus expected to increase to approximately 2881 metric tons by 1990. Assuming product forms are acceptable, the domestic market will be able to absorb a fishery production three times in excess of current landings (4).

Government has instituted price control regulations which establish maximum retail prices for fish. These are presently the "official" ex-vessel price, leaving no margin for additional processing or distribution.

7. Government Services

The Fisheries Division is under the authority of the Ministry of Agriculture, Lands, and Fisheries. The theoretical staff structure of the Division includes:

1 - Fisheries Officer
1 - Assistant Fisheries Officer
2 - Fisheries Assistants
8 - Statistics collectors
1 - Marine Biologist
1 - Fisheries Advisor
Clerical Staff

At present, the Assistant Fisheries Officer, Marine Biologist, and Fisheries Advisor are in place. A fisheries advisory committee has been established to guide planning and

Officially, government offers a variety of incentives to fishermen in an effort to increase production, including:

- subsidized ice supply
- tax and import duty concessions on fishing gear and vessels
- low-interest loans to fishermen
- fishermen training programs
- slipway and boatbuilding services

Problems have been reported (1) with implementation of these incentives: the Fisheries Division ice plant is out of service and cannot be repaired (though the Antigua Fisheries Limited plant continues to function); loans are no longer available; there is currently no provision for extension or training; and funds earmarked for purchase of gear and equipment have been frozen.

8. Government Priorities

Antigua and Barbuda has extended its maritime boundaries as far as the provisions of the 1982 Law of the Sea Convention would allow; the country's jurisdiction over its fisheries resources extends the length and breadth of its Exclusive Economic Zone. The extended jurisdiction over the fisheries resources off its coast provides great opportunities for Antigua and Barbuda to increase the production of fish, but any socio-economic improvement depends upon a positive administrative initiative.

There is no well-defined policy or strategy for fisheries development and management. Laissez-faire management and *ad hoc* development "strategies" represent the current fisheries policy of Antigua and Barbuda.

In the past five years, Government's efforts to stimulate development of the fishing industry have been embodied in the Antigua and Barbuda Fisheries Development Project. With financing from the Caribbean Development Bank, this project established "Antigua Fisheries Limited", an enterprise which was expected to be sold in shares to the public. The project failed due to poor planning, mismanagement, and failure to link innovations with the existing traditional fishing industry.

Recently, with assistance from FAO, Government has shifted its emphasis to artisanal fishermen with a view toward establishing a cohesive development plan. The plan presented to the Government of Antigua and Barbuda suggests that development be directed toward ensuring adequate supply of marine foods to meet local needs and to improving income and employment among fishermen. Explicit is the view that with appropriate management and development the country could meet its own needs for fish and also produce a surplus for export. To do so increased attention would be directed toward pelagic resources, exports would be reduced, and price controls (at least on prime fish species) would be eliminated (1).

References:

(1) Anderson and Matthes, 1985
(2) Caribbean Group, 1984
(3) Dalhousie Ocean Studies Programme, 1984
(4) Joseph, 1985

Country Profile -- Dominica

1. General Descriptors

Population (1983): 80,300 (1)
Land Area: 772 sq km (1)
GNP per capita (1982): US$ 896 (1)
GDP Growth Rate (1982): 3.3 (2)

2. Characteristics of the Fishing Fleet

There are an estimated 1,300 fishermen in Dominica, most of whom are employed in the industry part-time. An estimated 640 fishing vessels are in operation. Of these, 444 are canoes 5 - 8 m in length propelled by 6 - 25 hp outboard engines with auxiliary sail and/or oars. The remainder of the vessels are keel boats 4 - 8 m in length propelled by 25 - 48 hp outboards (3).

Estimates of annual landings range from 300 to 950 metric tons (1, 3). In the first half of the year, fishing effort is concentrated on migratory pelagic fishes using gill nets, beach seines, and handlines. Fishing effort during the remainder of the year is directed principally toward demersal resources using wire or wicker fish traps. Fishing takes place only during the day, and the rugged coast and rough seas are major constraints.

3. The Fisheries Resource Base

Dominica has a very narrow coastal shelf, and consequently limited demersal fish resources. These are heavily fished and have been subjected to dynamiting in recent years. The most significant resource is the migratory pelagic fishery which includes high-value species such as flying fish, tuna, dolphin and kingfish. The most productive fishing areas are on the east coast of the island.

Dominica has abundant supplies of fresh water and a number of areas which might be used for aquaculture. Following previous abortive efforts, an experimental freshwater prawn project is underway with technical assistance from Taiwan. A second project involving culture of Australian marron crayfish has been proposed by a U.S. consulting firm.

4. Handling, Processing and Marketing

Most fish is sold directly by fishermen to the public at or close to the landing site. Surpluses often occur in the beach seine and pelagic fisheries, and fishermen (particularly on the east coast) are obliged to transport excess fish to Roseau or other population centers. Fishing effort is often curtailed in anticipation of marketing difficulties. Smoking, drying and salting are practiced on a limited scale.

5. Infrastructure

There are no fishing harbors or protected landing sites. As a result, fishing vessels are generally brought ashore, often over rocks and boulders. No facilities exist for cold storage or freezing of fish, nor is ice available to fishermen. Market facilities are restricted to a municipal market in Roseau which is rarely used for fish. The Caribbean Development Bank has agreed to provide a EC$ 1.32 million loan to local cooperatives for cold storage and ice facilities in seven areas. Cooperatives have been reluctant to accept the loan, believing the project to be too large-scale. Review and revision of the project is reportedly underway.

Four cooperative societies are presently in existence. The Newtown Fishermen's Cooperative Society is actively engaged in efforts to increase pelagic fishing effort and has constructed gear storage and modest marketing facilities. The Dominica Fisheries Cooperative Society is primarily engaged in assisting with gear supply and duty-free concessions. Other cooperatives are in early formative stages.

The Dominica Agricultural and Industrial Development Bank administers a revolving fund for loans to fishermen (EC$ 6750 maximum) and cooperatives (EC$ 80,000 maximum) at interest rates of 5.5% and 4.5% respectively.

6. Market Analysis

Local per capita consumption of fish is estimated at 14 kg per year, a low figure for the Caribbean in general. Despite this, there is a chronic shortage of fish on the local market, and annual imports of fish are of the order of 260 metric tons. Government has established maximum retail fish prices of EC$ 2.25 per lb for prime fish to EC$ 1.05 per lb for low-grade fish, but local reports suggest that actual sale prices are usually at least EC$ 3.00 per lb. As a result, a great deal of imported frozen chicken is substituted for fish in local diets, accounting for the relatively low per capita fish consumption.

Dominica's population is expected to increase to 87,800 by 1990, and local demand for fish can be expected to at least remain constant. Considering the reluctance of fishermen to lower prices, the ineffectiveness of current price controls, and the increased costs associated with proposed handling, storage and marketing arrangements it seems unlikely that fish prices will compare favorably with frozen chicken unless import restrictions are imposed on the latter.

7. Government Services

The government Fisheries Division is located within the Ministry of Agriculture, Lands, Fisheries and Cooperatives. Staff consists of

1 - Fisheries Officer
2 - Fisheries Assistants
8 - Statistics Collectors
5 - Engine Mechanics

Fisheries Division personnel are dedicated and well-versed in relevant skills as a result of a variety of overseas training programs. Activities of the Division are hampered by lack of equipment, transportation, and personnel to implement specialized projects (e.g., aquaculture investigations, exploratory fishing operations, resource assessments, etc.). Programming capability is quite good, and priorities established by the Division appear generally appropriate to local circumstances. Recent progress has been aided substantially by a technical advisor provided through CFTC, whose tour of duty concludes in July, 1985.

Government has provision for duty-free concessions on outboard engines and fishing gear, but it is reported that concessions for engines have been suspended because of past instances of abuse.

8. Government Priorities

Government wishes to increase local consumption of fish with a view toward reducing imports of frozen chicken and improving local nutrition (E. Charles, personal communication). Within the Fisheries Division, "modernization" of the fishing fleet is viewed as a means to achieve "personal development" among local fishermen.

A recent FAO mission (1) has proposed that a fisheries development project be implemented which would:

- provide two vessels for training fishermen in improved techniques for east and west coast fisheries
- provide advice on planning and operating improved fish processing, storage and marketing facilities
- assist in strengthening cooperative societies
- assist with planning other fishery development activities

References

(1) Anderson and Matthes, 1985
(2) Caribbean Group, 1984
(3) Darroux, 1985

Country Profile -- Grenada

1. General Descriptors

Population (1982): 100,000
Land Area: 345 sq km (including Carriacou and Petit Martinique)
GNP per capita (1982): US$ 760
GNP Growth Rate (1982): 3.3% (1)

Recent political dislocations make it impossible to describe Grenada's current economic prospects in quantitative terms. Qualitatively, the outlook appears to have improved considerably in the last 18 months through the input of substantial foreign aid, encouragement to external investors, and social "positiveness" following the collapse of the former government. Development in the fisheries sector, however, may be proceeding without adequate regard for long-term local benefit and resource management.

2. Characteristics of the Fishing Fleet

Grenada is unusual in that a large majority (about 80%) of its estimated 1900 fishermen are employed in the industry full-time, engaging in a various combinations of trolling, beach seining, handline/pot fishing, and diving for lobster and conch. In 1978, 700 fishing vessels were estimated to be in operation, most of which are 6 - 10 m open "whalers" powered primarily by outboard engines. Smaller 3 - 6 m sailing canoes and a few decked sloops are also found in the fleet. Larger ferrocement vessels introduced by Cuban advisers during the Bishop government did not perform well in the Grenada fishery. Giudicelli (1978) concluded that

> Grenadian fishermen give evidence of a high technical level within the limits of their catching methods. They also take good care of their boats and gear. They have a positive attitude toward their trade and display keen interest in discussing their techniques, their problems, and the possible introduction of more productive methods ... boats built in Grenada are of excellent quality and well adapted to local conditions. It can be only recommended to help perpetuate the skill of local boat builders, to continue the well tested and adapted boats now used by fishermen, improving them if necessary, and discourage the importation of foreign built units.

Despite the fishermen's skill and dedication, returns from fishing effort are not high, with an average annual catch per boat of 8,256 pounds and net income to individual fishermen averaging EC$ 2,800 per year (the average income per worker in the same period was EC$ 3,300) (3).

Total fishery landings are difficult to estimate because a major fraction of the catch is not sold through official markets, and hence is unrecorded. Recorded landings in 1978, for example, totalled 1,059 mt; but actual landings have been estimated at approximately 2,908 mt (4). The Grenada Fisheries Unit estimated total 1979 landings at 4,085 mt, while

records totalled 742 mt for the same period (3). The apparent decline in market landings may reflect fishermen's refusal to participate in Government marketing programs, rather than an actual decline in catch.

3. The Fisheries Resource Base

Grenada, including the Grenada Grenadines, has a coastal shelf of 3100 sq km; the second largest of the RDO countries. The insular shelf is quite narrow on Grenada's west coast, extending an average of 1/2 mile to the 100 fm line. To the east the shelf varies in width from 2.5 miles in the southeast to to 7.5 mi in the northeast, and extends to the west-southwest in a 12 mi wide tongue for ca 20 mi, with an average depth of 15-20 fm. The Grenadine shelf has depths from 10-30 fm over the greater part of the area.

Landings from pelagic fisheries appear to account for at least 80% of the total landings, and could probably be increased since fishing effort has tended to be limited by difficulties associated with sales during periods of glut during the first half of the year. Deepwater demersal species are only lightly fished, and offer considerable potential for increased landings. Demersal and reef species may be more significant in present landings than might be judged from market data, since there is usually less trouble marketing these fish than is the case with larger pelagics; hence, the latter would be more likely to be sold to vendors.

Spiny lobster and conch stocks are heavily fished, and local entrepreneurs have established well-organized marketing systems and provide gear to fishermen who engage in regular harvest of both species. There has been concern with overfishing of these resources for at least ten years, but there is continued interest on the part of locals and expatriots alike in expanding harvest operations. Conch and spiny lobster stocks are in urgent need of effective management if these fisheries are to be maintained.

The extensive coastal shelf makes it likely that small coastal pelagic fishes, marine algae, and other species are present in quantities which could contribute significantly to overall fisheries production.

4. Processing and Handling

Most fish is marketed directly at the landing site without processing. Fish purchased by vendors is often transported without refrigeration to individual buyers or markets. Recently, a number of fishermen have been selling their excess catch to a local entrepreneur who is also engaged in a significant spiny lobster export business.

5. Infrastructure

There are six established public fish markets in Grenada. As noted above, the majority of the catch has not traditionally been sold through these outlets. Cold storage is available at the Grenville market. Ice is available in St. George's and Grenville.

The new international airport could be significant in transferring excess fisheries production to other markets within the Caribbean or elsewhere.

in 1980 (3) Assuming the island's population increases at a rate of 1% per year, and there is no increase in per capita consumption, total demand in 1990 is estimated at 4,919,280 kg. This is quite close to total estimated landings in 1979. Considering the potential for expansion of Grenada's fisheries, there is almost certainly potential for fish exports. The highly uncertain nature of landing estimates and absence of site-specific resource assessments make estimates of the actual magnitude of possible increases highly speculative.

7. Government Services

The Government Fisheries Unit has maintained landings records based on market throughput for at nearly 20 years, but these data are generally acknowledged to be incomplete. Technical capability of fisheries personnel has improved considerably during the past five years, but personnel shortages still cause extension, research, and management activities to be undertaken on a piecemeal basis.

8. Government Priorities

Increased emphasis has been placed on artisanal fisheries development in recent years due to a project funded by IFAD for artisanal fisheries development, and the failure of government operated ferrocement vessels donated by Cuba to the Peoples Revolutionary Government. In the intense activity following rescue operations in 1983, a number of fisheries- related projects have been proposed by expatriot individuals and organizations which show little understanding of the limitations and potentials of Eastern Caribbean fisheries discussed elsewhere in this report. Several Grenadian businessmen have expressed concern over this situation to the senior author. A discreet fisheries development policy has not been produced for Grenada, but is clearly needed.

References

(1) Caribbean Group, 1984
(2) Giucicelli, 1978
(3) Mitchell and Gold, 1982
(4) Pena and Wirth, 1979

Country Profile -- Montserrat

1. General Descriptors

Population (1980): 12,000 (2)
Land Area: 138 sq km
GNP per capita (1980): US$ 1370 (2)
GNP Growth Rate (1982): 1.4% (1)

2. Characteristics of the Fishing Fleet

There are approximately 200 fishermen in Montserrat, 20 of whom are employed in the industry full-time. An estimated 80 dory-style fishing vessels are in operation, most of which are powered by outboard engines. Vessel length ranges from 4.5 to 6.0 m. Hand-lines and fish traps are principal gears employed from these boats. A substantial amount of fishing is also done with beach seines. Annual landings in 1978 were estimated to be 55 tons (3); roughly half the 1968 estimate of 100 tons (4). Demersal and pelagic species are about equally represented in the catch.

Fishing activity is generally constrained by the lack of safe harbors and consequent need for vessels which can be brought ashore during rough weather. In 1978, an FAO consultant noted that motivation within the fishing industry was generally low, and that despite low productivity per unit fishing effort, the income and social status of fishermen was relatively good. This lack of motivation was seen as a major handicap to fisheries development in the country (3). For several years, an expatriot has operated a small commercial fishing business using a fiberglass "lobster" vessel fishing primarily in Antigua waters. There is no indication that the apparent success of this operation has stimulated additional activity among local fishermen.

3. The Fisheries Resource Base

Montserrat has a very small coastal shelf (108 sq km), and demersal stocks are consequently limited. Deeper shelf-edge stocks, however, are not heavily exploited at present. Migratory pelagic species, similarly, are not heavily exploited. Sharks offer a limited potential for increased fishing effort.

4. Handling, Processing and Marketing

With few exceptions, fishermen sell their catch directly to consumers without any processing. Some fishermen carry ice, principally for night fishing operations.

5. Infrastructure

Dedicated marketing and handling facilities are not available, and do not appear needed. Government has provided storage facilities for fishermen's gear, and operates a small ice machine which appears adequate to meet the current demand among fishermen.

7. Government Services

A fisheries assistant attached to the Ministry of Agriculture is responsible for government's services to the fishing industry. As noted above, government has provided modest infrastructural services to local fishermen, and has attempted a number of projects designed to improve the local fishing industry, including a demonstration/training program in purse-seining for pelagic stocks and development of artificial reefs. Government imports a limited amount of fishing gear which is made available to fishermen at favorable prices. Repeated attempts have been made to foster the development of fishing cooperatives, which have met with limited success.

8. Government Priorities

Government continues to evidence interest in fisheries development, primarily in the use of artificial habitat and fish aggregating structures.

Considering the apparent social constraints to an expanded fishing industry, assistance to the relatively small number of fishermen who are interested in innovations seems most appropriate. The 1978 FAO consultancy recommended a small-scale exploratory/demonstration project based on modified local vessels to determine techniques best suited to local fishermen and fishery resources. This is still a valid suggestion.

References

(1) Caribbean Group, 1984
(2) Dalhousie Ocean Studies Programme, 1984
(3) Giudicelli, 1978
(4) Vidaeus, 1970

Country Profile -- St. Kitts/Nevis

1. General Descriptors

Population (1980): 44,700 (St Kitts 35,400; Nevis 9,300) (1)
Land Area: 310 sq km (St Kitts 204 sq km; Nevis 106 sq km) (4)
GNP per capita (1983): US$ 867 (3)
GNP Growth Rate (1982): 4.1% (2)

2. Characteristics of the Fishing Fleet

There are an estimated 270 - 280 fishermen in St. Kitts and 275 in Nevis. An estimated 41% of St. Kitts fishermen and 56% of Nevis fishermen are employed in the industry full-time. The estimated number of fishing vessels operating in St. Kitts and Nevis are 165 and 118 respectively. With few exceptions these are modified dinghies or rowing boats 4 - 7 m long. All are constructed from wood, usually powered by outboard engines from 25 - 40 hp.

The majority of fishermen in both islands are engaged in trap and handline fishing. About 25 boats are used for seine fishing. Roughly 16 vessels specialize in lobster and conch fishing, usually with SCUBA equipment. Fishing effort is greatly reduced in St. Kitts during the cane-cutting season which coincides with the period in which migratory fish species are most abundant. As a result, the potential yield from the seine fishery is probably not being realized.

A regular fishery statistics program has not been implemented, but annual landings have been estimated (4) as follows:

	St. Kitts	Nevis
Fin Fish	398.6 mt	455.4 mt
Lobster	12.7 mt	16.8 mt
Conch	11.4 mt	70.9 mt
Turtle	5.9 mt	2.3 mt
TOTAL	428.6 mt	545.4 mt

3. The Fisheries Resource Base

The coastal shelf of St. Kitts and Nevis is substantial (595 sq km) relative to numbers of local fishermen. It is generally acknowledged that nearshore fishing grounds on leeward coasts of both islands are overexploited, particularly in the case of conch stocks. The windward and deepwater shelf areas, however, are presently underexploited along with migratory stocks, and sharks. In addition, there are probably stocks of bivalve and cephalopod molluscs with potential for small-scale exploitation.

Recent estimates of the potential yield of the St. Kitts/Nevis shelf vary from 674 mt to 2381 mt, and for reasons discussed previously are useless for planning or management.

4. Handling, Processing and Marketing

Fishermen generally sell directly to consumers at boat landing sites, and usually have little difficulty disposing of their catch. Gutting and use of ice at sea is extremely rare. Conch intended for export are frozen in private or occasionally in government-operated facilities. Many consumers have difficulty obtaining fish because of the absence of established markets and the unpredictable arrival times of fishermen at landing sites. During 1984, a commercial fishing/marketing business was begun in St. Kitts by expatriot investors. Though no longer in operation due to conflicts with local fishermen, this enterprise established that local consumers do not appear biased against iced fish, do not object to paying a somewhat higher price for a cleaned product, and enjoy the relatively stable supply of fish provided by an established fish market in contrast to erratic purchases at beaches or the roadside.

5. Infrastructure

There are no established marketing facilities for fish in St. Kitts or Nevis. Two ten-ton frozen storage rooms are located adjacent to the Fisheries Division, one of which is currently operational. These are not generally used by fishermen, but are rented to the Central Marketing Corporation. A limited amount (five tons maximum) of ice is available from the Government ice plant in Basseterre, but is usually sold outside the fishing industry. No ice or cold storage facilities are available in Nevis apart from privately owned chest freezers and hotel ice machines.

Credit facilities are limited. The Development Bank of St. Kitts/Nevis has made loans up to US$ 1,100 at 10.5% interest to fishermen for purchase of outboard engines. In addition, the Department of Agriculture has made interest-free loans averaging US$ 1,500 to fishermen for similar purposes. Funds for the latter program are now exhausted, though the Fisheries Division continues to accept loan applications.

There are five fishing cooperatives in varying stages of development. The Nevis Fishermen's Marketing and Supply Cooperative Society is quite active with strong leadership and a membership of about 70. Negotiations are underway with a variety of organizations for funding to establish a central landing and marketing terminal in Charlestown. The Newtown Fishermen's Coop has about 20 members, and has recently been reactivated. An outboard repair facility funded by USAID is in operation under the supervision of a Peace Corps volunteer. Fishing supplies have been purchased with assistance from the Fisheries Division, and are offered to members at favorable prices. The Sandy Point Fishing Cooperative is becoming more active, and has received funding from USAID for a building. The Capisterre (Dieppe Bay) Cooperative Society has about 25 members, and is in the process of acquiring fishing gear for resale to its members. The Old Road Cooperative Society is in preliminary stages of organization.

6. Market Analysis

In 1982, the landed weight equivalent of imported fish and fish products was 850 mt, suggesting that total demand (landed weight equivalent of imports plus local landings less exports) was 1748.7 mt, or 39.1 kg per capita; slightly higher than 1967 estimates (5)

which placed per capita demand at 38 kg. During the same period, the value of imported fish products rose from EC$ 403,600 to EC$ 1,555,665. The Dalhousie Ocean Studies Programme (3) predicts a slight increase (0.7% per year) in demand for fish in St. Kitts/Nevis over the period 1983-1990. Local demand might be even higher if fresh fish were regularly available, as the imported products (as well as fresh fish) are considerably more expensive than substitutes (e.g., frozen chicken). Growth of tourism in St. Kitts/Nevis can also be expected to increase demand for seafood, particularly "luxury" species (lobster, conch, etc.) and premium quality fin fish.

7. Government Services

The Government Fisheries Division operates within the Ministry of Agriculture, Lands, Housing and Development. Staff consists of one Fisheries Assistant and two Fisheries Trainees (St. Kitts and Nevis are each assigned one trainee). Additional support is provided by two expatriot advisors, one from International Development Research Centre and the other from Environmental Research Projects. The current fisheries program includes development of management plans for conch and spiny lobster fisheries; assistance to fishermen's groups in the form of workshops, assistance with gear supply and outboard engine repair (through funding provided by Inter American Foundation); inventory of critical coastal habitats; and investigation of fish aggregating devices and habitat enhancement as means for improving local fishery landings.

Duty-free concessions are provided for importation of fishing equipment, including outboard engines. The loan scheme for fishermen has been described above. Government is negotiating with the Caribbean Development Bank for a pre-investment fisheries project.

8. Government Priorities

The national plan of St. Kitts/Nevis includes a variety of fisheries-related activities: investigation of the feasibility of a deep-sea fishing fleet; provision of storage facilities for fishermen, including freezers and ice machines; assistance to cooperatives for repair shops; development of shark fishing; development of mariculture; investigation of the feasibility of establishing a processing/canning facility. At present, efforts are directed toward existing fisheries and to the development of appropriate exploratory projects to determine the optimum direction for future development efforts.

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(1) Anderson, et al., 1985
(2) Caribbean Group, 1984
(3) Dalhousie Ocean Studies Programme, 1984
(4) Olsen, 1984
(5) Vidaeus, 1970

Country Profile -- St. Lucia

1. General Descriptors

Population (1985): 131,400 (2)
Land Area: 609 sq km
GNP per capita (1982): US$ 621 (2)
GDP Growth Rate (1982): 2.1% (1)

[Except as otherwise noted, the following data are from Murray, 1983]

2. Characteristics of the Fishing Fleet

There are an estimated 2,000 fishermen in St. Lucia, roughly half of whom are employed in the industry full-time. An estimated 600 fishing vessels are in operation, most of which are narrow wooden canoes 5 - 7 m in length powered by 25 - 40 hp outboard engines.

Four types of fishery are distinguished: trolling, beach seine, handline/trap, and black fish (porpoise). The troll fishery for pelagic species (gill nets are also used occasionally) accounts for 67 - 70% of the annual catch which in 1980 was estimated to be about 1,772,700 kg (6).

3. The Fisheries Resource Base

St. Lucia has a coastal shelf of 522 sq km. Fish catch is at a maximum during the first six months of the year. Migratory pelagic stocks are undoubtedly the primary fishery resource being exploited at this time. Coral habitats in St. Lucia are not extensive, and reef fisheries have been heavily exploited. There is a substantial shelf on the southeast coast which is reported to support useful quantities of queen conch. Coral rubble, seagrass, and occasional expanses of mangrove characterize the shallow waters between between Moule a Chique and Port Praslin. These offer ideal habitat for juvenile fishes and spiny lobster post-larvae. Fishermen in this area have been observed to harvest several hundred pounds of adult spiny lobster in less than two hours by free diving in depths less than 12 m; the spiny lobster resource in this area appears to be a promising candidate for controlled development.

4. Handling, Processing and Marketing

Until recently, fishermen sold their catch, without any processing, directly to consumers, either from the beach or roadside vending points. During periods of glut, excess catch might be sold to independent vendors. Intermediate cold storage and refrigerated transport have not been available for island-wide distribution or to accommodate excess catch during periods of glut. In the spring of 1985, a new fish landing complex opened in Castries, offering a guaranteed market for fishermen's catch. Fish sold through the facility are cleaned whole, steaked, and fileted. Current reports suggest that

supply of fish exceeds the plant's capacity, and that disputes over pricing have led some fishermen to revert to traditional marketing practices. It is emphasized that these may well be "growing pains" associated with initial operation of the facility, and are probably not accurate indications of the long-term potential of the facility.

5. Infrastructure

Nine fisheries cooperatives are established in St. Lucia. The Goodwill Cooperative in Vieux Fort is particularly active in providing outboard repair facilities and gear supplies to its members. Similar services are provided in varying degrees by the other cooperatives.

6. Market Analysis

Despite an apparently adequate natural supply of fish (if optimum use could be made of the pelagic fishery and the resource is stable), St. Lucia annually imports an average of EC$ 2 million worth of fish and fish products (about 60% of this is salt cod). If imported quantities are converted to equivalent landed weight and added to domestic landings, a rough estimate is obtained of minimum demand (minimum because if fish were readily available at a competitive price, local consumption would probably increase). On this basis, demand for fish in St. Lucia is estimated to have been 3,656,332 kg in 1968 (5) and 2,422,000 kg in 1978 (2). The apparent decrease in consumption is probably a reflection of the enormous increased cost of imported fish (average increase = 389%, 1968 - 1978), and the availability of cheaper substitutes, especially imported chicken. In 1980, traditional demand for salt cod was still heavy, but price increases had led to a new demand equilibrium at much reduced levels of consumption (2).

Population of the island is expected to increase to 137 - 147,000 by 1990 (4). If per capita consumption remains constant at the 1980 level of 20.6 kg, demand in 1990 will be roughly 2,822,200 - 3,028,200 kg. This would call for a supply roughly two million kg in excess of current landings; if this is met through imports, the cost will be in excess of EC$ 10 million. Again, it is probable that per capita demand for fish would increase with an improved local supply of fish at reasonable prices.

Prices are difficult to predict given the current dislocations caused by the opening of the Castries market, but it seems unlikely that these will fall below the current yearly average which is influenced by periods of considerable glut (consequent price fluctuations would presumably be reduced by improved marketing).

7. Government Services

The Fisheries Management Unit of the Ministry of Agriculture is the largest fisheries division among the RDO/C countries, with a total staff of 26, including two fisheries officer, two biologists, four fisheries assistants, 12 statistics collectors, and 6 support staff. Regular assistance is provided to local cooperatives with training, engine maintenance, and gear supply activities. Vessel and gear demonstrations are being arranged with fishermen as part of an overall effort to increase production through use of larger, more stable fishing platforms and better techniques. Introduction of new vessels into the fishery is hampered at present by a history of inappropriate vessels. Fiberglass vessels

currently being promoted are in regular use by Martinique fishermen, and are probably quite suitable for St. Lucia's fishery. These boats cost over EC$ 10,000, however, compared to less than EC$ 5,000 for a traditional canoe. Despite the greater longevity of the fiberglass boats, there is a reluctance on the part of some fishermen to make such an investment until the basic problem of marketing is solved.

The Fisheries Management Unit undertakes regular monitoring of sea turtle nesting sites and selected coral areas in support of general conservation objectives. In addition, a marine algae cultivation project has been in operation for several years. Following a successful experimental phase, techniques are now being extended to interested fishermen as a means of augmenting income during the latter half of the year.

Government has also participated in the construction of the Castries fisheries complex discussed in section III, and plans to provide similar facilities in other major landing sites.

8. Government Priorities

The fundamental strategic objectives of St. Lucia's National Plan are:

- sustained and balanced economic growth
- sustained improvement in human welfare
- conservation of natural resources

In pursuing these objectives, emphasis is being placed on rural development (including reserves for industrial sites in selected villages) as a means of limiting population drift into the Castries region. The inclusion of resource conservation among development objectives is encouraging, and support to the Fisheries Management Unit (which amounted to EC $555,500 in FY 1982/83) may reflect a genuine commitment to this goal.

References

(1) Caribbean Group, 1984
(2) Carleton and Wirth, 1980
(3) Mitchell and Gold, 1982
(4) St. Lucia National Plan, 1977
(5) Vidaeus, 1969
(6) Walters, 1984

Country Profile -- St. Vincent

1. General Descriptors

Population (1980): 110,000 (2)
Land Area: 388 sq km
GNP per capita (1982): US $539 (2)
GDP Growth Rate (1982): 2.3% (1)

2. Characteristics of the Fishing Fleet

There are an estimated 5,000 - 6,000 fishermen in St. Vincent and the Grenadines, of whom roughly half are employed in the industry full-time. In addition about 2,500 persons work in related sectors. In the Grenadines, 85 - 95% of adult males are engaged in fishing or related activities. Many fishermen make only a subsistence living and cannot cover depreciation costs of their equipment. An estimated 537 fishing vessels are in operation, most of which are open or partially decked whalers or sailing dinghies. Most bottom and reef fishing is done in the Grenadines, and many fishermen camp in the Tobago Cays. Fishermen may range 50 miles or more from shore when trolling for pelagic fishes.

The fishermen of the Grenadines, in particular, are typically independent, have a history of poor relations with the St. Vincent government (though the current administration is much more sympathetic to the needs of the Grenadines), and frequently respond violently (i.e., by burning boats) to policies or individuals perceived as acting against the fishermen's interests.

Annual landings are estimated to be at least 1,700 tons, including 800 - 850 t from the Grenadines. Comprehensive data on catch composition are not available.

3. The Fisheries Resource Base

Except as otherwise noted, the following description is based on data in (2).

St. Vincent (including the Grenadines) has one of the largest coastal shelves in the Eastern Caribbean; in excess of 1800 sq km. There are numerous habitats for spiny lobster and conch, and if properly managed this could be one of the most productive areas in the region for these species. At present these resources are probably overexploited. In general, declining catches and small size of captured fish suggest that many of the shallower portions of this area are almost certainly overfished. On the other hand, pelagic fisheries, the shelf edge and portions of the windward shelf are probably underexploited. It has been estimated that overall fisheries production could be increased by a factor of three, primarily through increased landings of pelagic species.

4. Handling, Processing and Marketing

About 60% of the catch is sold within the country. Many fishermen sell their catch directly to Martinique or via intermediaries aboard trading schooners. In 1983, exports to

the French market were estimated at 500 tons. This trade with Martinique and to a lesser extent with St. Lucia has stimulated communication and exchange between the islands at the fishermen's level, and much of the gear currently used in St. Vincent was purchased in Martinique.

Fish are landed for local sale at multipurpose jetties or on the beach; there are no established fish landing or processing facilities. Fish are normally sold without any preparation, though larger fish may be divided into smaller pieces. Cold storage facilities in St. Vincent consist mainly of small freezers owned by individuals and shops. Several freezer and ice facilities are available in the Grenadines. Often, fish are stored in these facilities after unsuccessful vending efforts. As a result, the fish are far from fresh when frozen. Ice boxes are used on a few boats, mostly those used to transport fish to Martinique. Salting and drying (mostly in fishing camps in the Grenadines) is rudimentary.

Most locally landed fish is marketed at the point of landing or in nearby villages. In some areas there are customary roadside sales points. The supply to remote areas is sporadic due to the difficulty and cost of transportation which cannot be offset by a higher price. The St. Vincent Marketing Corporation has nominal responsibility for fisheries, but receives little cooperation from fishermen. Fish vendors in Kingstown are licensed by the Town Board, but this policy is applied only to vending within the central market. Retail prices range from EC $0.50 for reef fish to EC $3.00 for grade A fish (e.g., tuna, snapper, etc.).

5. Infrastructure

As previously noted, landing, storage, processing, and marketing facilities are minimal or absent.

Credit for fishermen is theoretically available from the Agricultural Bank, the Cooperative Bank, and the National Commercial Bank. Only the latter, however, is willing to accept financed boats and engines as collateral, placing these facilities generally beyond the reach of most fishermen. Fishermen can obtain duty free concessions for the import of boats and engines, and fuel subsidies are available to cooperatives. There are no fishermen's cooperative organizations, however, with a single exception in Fancy. Bequia fishermen have evidenced interest is some sort of association if benefits can be demonstrated.

The St. Vincent Grenadines are noted for the quality of their artisanal shipwrights. A small fiberglass boat building facility has been in operation for several years near Blue Lagoon (St. Vincent). There are a number of outboard repair mechanics in St. Vincent and the Grenadines, but availability of spare parts are frequently a problem. Repair services for diesel engines, electronic equipment, and hydraulic fishing gear are inadequate or non-existent.

6. Market Analysis

Data on local consumption and imports are virtually non-existent. Local consumption has been estimated at 10 kg per year, but this extremely low figure does not

include consumption of imported fish reported to be "considerable" (2). Residents of St. Vincent have reported chronic shortages of fish, particularly in remote villages. Considering the quantities of fish imported to Antigua and Grenada, it seems likely that fish imports to St. Vincent are at least 1000 mt.

7. Government Services

The Fisheries Division of the Ministry of Agriculture has responsibilty within Government for fisheries affairs. Some data on fish landings are compiled by the Division. Manpower shortages severely limit planning and programming capabilities. Experimental freshwater aquaculture projects for Tilapia nilotica and Macrobrachium rosenbergii are underway under supervision of a Peace Corps volunteer.

8. Government Priorities

A major fisheries development program has recently been recommended by an FAO consultant (2). The Canadian International Development Agency has agreed to implement portions of the program concerned with infrastructure and modernization of the fleet, but support for resource management components appears uncertain.

Historically, Government has not evidenced strong support for fisheries development. This situation is likely to change, however, as the newly-elected Prime Minister has a history of deep personal interest in the marine environment and fishing communities. Most of Government's current plans appear tied to the proposed CIDA project, and it is not clear how, or if, additional activities (such as those suggested by the FAO Consultant which will not be funded by CIDA) will be integrated into an overall development plan.

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APPENDIX A

Aquaculture/Mariculture Project Evaluation System

A proposal for a major aquaculture development (not research) project should include the following analyses. Proposals which fail to address at least the major questions or issues should be rejected or returned for revision.

A. Market Analyses -- Can you sell what you want to grow?

1. General Questions

a. What seafood products are in greatest demand domestically and in export channels (i.e., for what products is demand rising more rapidly than supply?)

b. What seafood products are imported in significant quantities to meet the demands of domestic tourist and restaurant industries, where do these imports come from, and what is the magnitude of expenditures for these imports?

c. What import substitution opportunities are there?

2. Questions Pertaining to Specific Products

a. Are there established domestic and/or export markets for the product and how are these markets currently supplied?

b. How large are the domestic and export markets?

c. Does demand (expressed in toto or on a per capita basis) appear to be growing, and if so, at what annual rate for both domestic and export markets?

d. Is there unsatisfied demand? If so, where?

e. In the domestic market, is the product sold principally through institutional outlets (e.g., restaurants), retail seafood stores, at point of production (e.g., fish dock or pond site), or other?

f. How much of the domestic demand for the product is met by domestic production and how much by imports?

g. Is domestic production stable, growing, declining, or non-existent?

h. What is the recent 10-year price history for the product domestically and in target export markets? Are any trends evident?

i. Are there major seasonal or annual fluctuations in supply, demand, price, and if so, why?

j. What are the preferred product forms in the domestic and export markets?

k. Who are the major suppliers to the domestic and export markets, what are their current market shares (if available), and what interest do they have in handling your product?

l. How accessible are the preferred markets from standpoints of geography (transportation), production (amount of production, frequency, and regularity of supply, ability to supply especially desirable product sizes, forms, etc.), and price-cost relationships?

m. What are the realistic possibilities, advantages and disadvantages of selling the product via pre-production contracts?

n. What products will be the major competitors in domestic and export markets and what are their recent price and production histories?

B. Technology Analysis -- Can You Grow What You Can Sell?

1. What is the current state-of-the-art culture technology, who has it, and how available is it?

2. Has the life cycle of the target organism been completed in captivity on a repeated, dependable basis?

3. What are the important environmental and culture requirements for each major life history stage?

4. Are brood stock and seed stock of the organism readily available? If so, where and on how regular and dependable a basis?

5. Are there native species that appear suitable for culture or will exotic species have to be introduced?

6. Are the nutritional requirements of the organism well enough known that useful formulated feeds can be obtained commercially at a reasonable cost? Are the feeds available locally, will they have to be imported, can they be manufactured domestically (or on the farm) from locally available raw material?

7. Does the organism exhibit important behavioral or disease problems?

8. What is the current status of disease diagnosis and treatment technology?

9. What are the growth and survival characteristics of the organism in culture, based on the best available data? Indicate best, worst,

most likely cases based on current data, and point out limitations of the data. Note especially whether the organisms have been reared to commercial size in any numbers and in any systems approximating a commercial-type grow-out unit, and also if any product from such trials has been test-marketed.

10. What are the accepted industry practices and state-of-the-art technology for processing and handling the product?

11. Who and where are the leaders in technology development for this organism? What are their forecasts for technology improvements over the next 3 - 5 years and how do they rate the liklihood for commercial successes at this time?

12. What if any pilot projects have been conducted? What were the scales of these projects, their major results, and problems?

13. Who is currently growing or attempting to grow this organism commercially, where, what has been the production record to date, and are the operations profitable now or likely to be in the near future?

14. What have been some of the major commercial failures with this organism? Why did these operations fail and how much money was lost? What lessons are to be learned from these failures that will improve your chances of success?

15. What kinds of labor are required for each step in the production process and how available is such labor?

16. How available and who are the technical experts who will be involved in designing, reviewing, and implementing the project plan?

C. Environmental Analysis -- Are the physical, biological, economic, and socio-political climates suitable for the proposed aquaculture project? Information needs are outlined below, based in large part on Webber (1977).

1. Physical Environment

a. Hydrological factors
(1) Temperature -diurnal and seasonal variations
(2) Salinity - tidal and seasonal variations

(3) Solutes
  (a) dissolved nutrients
  (b) dissolved gases (e.g., oxygen, carbon dioxide, hydrogen sulfide, ammonia)
  (c) toxic or deleterious materials
(4) Bacteriological and viral content
(5) Turbidity and light penetration - variation
(6) Suspended solids (total and settleable)
(7) Detritus concentration
(8) pH - variation and buffering system
(9) Total alkalinity (freshwater only)
(10) Total hardness (freshwater only)
(11) Chloride, sodium and divalent cation concentrations (freshwater only)
(12) Watershed characteristics
(13) Ground water supply
  (a) aquifers
  (b) water table depth
  (c) history of wells in area (if any)
(14) Tidal flushing
(15) Wave action -- average, storms, etc.
(16) Currents

b. Meteorological Factors
(1) Wind
  (a) prevailing direction
  (b) velocities
  (c) seasonal variations
  (d) storms
(2) Light -- total annual solar energy impingement
(3) Air temperature -- mean, range, seasonal variation
(4) Relative humidity -- mean, range, variation
(5) Precipitation
  (a) total amount annually
  (b) rainfall annual distribution
  (c) storm rainfall
(6) Evaporation rates

c. Edaphic Factors
(1) Soil type -- subsoil profile to depth (frequently to water table); clay content
(2) Percolation rate -- coefficient of hydraulic permeability
(3) Particle size and shape
(4) Angle of repose -- wet and dry
(5) Topography
(6) Fertility
(7) Microbiological population
(8) Leachable toxins (e.g., pesticides, heavy metals, petroleum)
(9) Soil bearing strength and compactibility

2. Biological Environment

a. Biotic Resources
(1) Primary productivity of waters -- seasonal variations and major algal species
(2) Secondary productivity
(3) Natural production of "feed" for target culture organism
(4) Eutrophication
(5) Response(s) of water to fertilization
(6) Availability of feed raw materials

b. Availability of natural seed and brood stock
(1) Geographic availability
(2) Seasonal availability
(3) Likely range of harvest densities (i.e., CPUE for seed or adult animals)
(4) Ease/difficulties in transporting seed or brood stock to farm site

c. Occurrence of disease organisms, predators, competitors, and pollution
(1) Geographic and seasonal variation in distribution and abundance of disease and predator organisms
(2) Availability of prophylactic measures to prevent and treatments to eradicate infections
(3) Ability to avoid contaminated areas

3. Economic Environment

a. Land
(1) Amount, availability, and accessibility of land suitable for development
(2) Costs (purchase, lease)
(3) Ownership restrictions
(4) Use (zoning) restrictions

b. Labor
(1) Availability of skills needed and unskilled labor and proximity to development site(s)
(2) Costs for labor (various levels), including all benefits, any necessary t raining, housing if necessary, etc.
(3) Union rules (if any) and government labor regulations
(4) Liability laws
(5) Availability of professional management
(6) Availability of engineering skills
(7) Necessity for specialized education/training

c. Infrastructure
(1) Transportation
(a) accessibility of facilities and length of haul to port or market
(b) road system for trucking
(c) railroad service

(d) shipping ports, cargo handling facilities
(e) airports, cargo handling
(f) frequency and dependability of road, rail, and air transport systems

(2) Communications
(a) telephone, telex, cable
(b) language problems

(3) Energy supplies
(a) availability and cost of gasoline and diesel fuel delivered to project site
(b) availability, dependability, and cost of electricity delivered to project site
(c) cost for on-site power production via diesel/gas generators as main or emergency supply; potential for hydroelectric power generation at project site

(4) Materials and services
(a) availability and cost of feed
(b) availability and cost of fuel
(c) availability of major equipment items
(d) service and maintenance of equipment
(e) availability of spare parts and replacement machinery
(f) availability of competent design, engineering, and construction services
(g) availability and quality of processing facilities and costs of processing product
(h) availability and cost of seed and brood stock
(i) availability of extension, disease diagnosis, and technological services from the public sector

(5) Construction costs
(a) earth moving
(b) piping
(c) wells and/or water intake system
(d) buildings
(e) equipment acquisition and installation
(f) construction permits
(g) construction supervision

(6) Financial considerations
(a) sources and availability of capital
i. commercial banks
ii. development banks
iii. venture capital groups
iv. public offering
v. limited partnerships
vi. personal or corporate resources
(b) operating credit
(c) financial controls
(d) constraints on movement of investment capital and earnings
(e) currency stability
(f) taxes
(g) insurance costs
(h) investment incentives
i. low-interest or interest-free government loans
ii. tax reductions, holidays or credits

(i) import duties and restrictions
(j) interest rates
(k) potential returns from competing investments
(l) markets (see Market Analysis) and marketing costs

4. Socio-Political Environment

a. Government
(1) Type
(2) Stability
(3) Economic development policies and services
(4) Natural resources policies

b. Legal Framework
(1) Incentives to private investment
(2) Ownership or local participation requirements (equity limits)
(3) Import-export restrictions
(4) Permits for construction, use or destruction of natural resources
(5) Fishing policies and restrictions
(6) Water rights -- riparian, ownership, and lease conditions
(7) Policies concerning importation of exotic species
(8) Legal protection for private property resources

c. Social factors
(1) Cultural characteristics
(a) tradition of cultivation
(b) local attitudes toward product to be produced
(c) attitudes toward risk
(d) cultural access to loans
(e) attitudes towards property rights and poaching
(f) customs, habits, religious beliefs
(g) potential for displacement of artisanal fisheries, etc.

(2) Competing uses of the environment
(a) urbanization and industrialization
(b) waste disposal
(c) power generation
(d) recreational uses
(e) mineral and petroleum extraction
(f) dredging
(g) navigation
(h) irrigation
(i) farming
(j) sport fishing
(k) commercial fishing
(l) other

(3) Community services
(a) schools

(b) medical care
(c) housing
(d) protection
(e) cultural resources

(4) Labor
(a) traditional pursuits
(b) adaptability
(c) availability of specialized labor

(5) Local interest in development projects
(a) degree of interest
(b) degree of participation
(c) degree to which locals have say in channelling development in specific directions

D. Economic Analysis -- Will projected revenues from the proposed project exceed estimated costs in a reasonable time period (i.e., will the project make a profit, and how soon)?

All costs and revenues to be associated with the project should be estimated. The following lists are not meant to be all-inclusive, but rather to serve as examples.

1. **Investment Costs**
   a. legal services to establish company
   b. land -- purchase or lease plus any closing costs
   c. architectural, engineering and consulting services
   d. earthmoving -- clearing, pond and road construction
   e. buildings
   f. water intake(s), wells, and water distribution piping
   g. dike stabilization
   h. road graveling
   i. equipment
      (1) pumps and spares
      (2) intake screens
      (3) pond drain structures with screens
      (4) tanks (various)
      (5) transport tanks
      (6) vehicles (e.g., truck, jeep, ATV cycle)
      (7) tractor plus mowing attachments, blade and backhoe
      (8) feed storage and distribution equipment
      (9) boat, motor and trailer
      (10) nets
      (11) emergency aerators
      (12) welding tools
      (13) fuel tanks
      (14) laboratory equipment, including microscopes, balance, scales, dissolved oxygen meter, pH meter, refractometer, water quality kits, etc.

(15) office equipment, including desks, chairs, lamps, calculator, microcomputer and printer
(16) water filtration system (if needed)
(17) emergency generators
(18) contingencies and miscellaneous

j. operating capital

2. Variable and annual costs

a. seed stock
b. feed
c. fertilizer
d. management
e. labor
f. fringe benefits
g. insurance (accident, property, crop)
h. property and other taxes
i. electricity
j. fuel
k. business fees
l. maintenance and repairs
m. equipment rental
n. waste removal
o. potable water
p. travel
q. marketing and sales (including advertising)
r. legal -- recurring
s. accounting -- recurring
t. communications -- telephone, telex, postage
u. supplies (farm and office)
v. depreciation
w. interest on borrowed funds

3. Projected revenues and assumptions

4. Financial feasibility -- Data from items 1 - 3 should be used to prepare a pro forma financial statement showing estimated expenditures and returns (internal rate of return or net present value) from the project over a period of several years (usually up to 10). Projected expenditures (costs) to be incurred during the developmental phase of the project (usually the first two years) should be indicated on a quarterly basis. Costs, time requirement, and evaluation criteria for any pilot project should be clearly specified. Also, the type of business structure (e.g., corporation, limited partnership, etc.) should be described.

E. Warning Signs to Look For in Evaluating Proposals for Aquaculture Development and Demonstration Projects

The following are suggested as indicators of a lack of thoroughness and sound planning for projects that are expected to lead, over a relatively short term, to commercially

successful enterprises. They are not meant to be applied to research projects, although some could be useful in such evaluations. The indicators are listed in no particular order of priority.

1. Lack of production, survival, cost, and problem data from pilot-scale trials.

2. Projected (extrapolated) growth, survival, or biomass curves based on data from only part of a grow-out cycle.

3. Projected production for large grow-out units based entirely on laboratory experiments or other very small-scale studies.

4. Projected results based on very few experimental trials, especially where these wereat small-scale and/or lacked replication.

5. Projected production, survival, feed conversions, etc. based on best, rather than average, results achieved in laboratory experiments, pilot-scale trials, or other commercial operations.

6. Projected production based entirely on results from very different environments, without appropriate modifications and cautions to take into account local conditions.

7. A nebulous marketing plan -- this should be among the more specific parts of the proposal. At the very least, the marketing plan should include a discussion of (a) current markets for the specific product to be produced, (b) current prices and historical price trends for the product, (c) where the markets are, (d) exactly what the operation expects to produce (product forms), where it expects to sell it and for what price, (e) other products for which it might be a competitive subsitute, and (f) a realistic assessment of how much market development work will be necessary.

8. Lack of substantive technical and/or business track record by the principals involved in the project and failure to specify and present credentials for the key technical, marketing, and management personnel.

9. An obvious lack of appreciation for and knowledge of local conditions, situations and customs.

10. A lack of any appreciable local involvement in the project.

11. Unusually high cost projections, obvious lack of familiarity with local costs for construction, labor, materials, etc., and extremely heavy reliance on outside, temporary consultants.

12. Unrealistically low cost projections and failure to include major costs (e.g., for insurance, taxes, housing, transportation, contingencies) in economic planning.

13. Lack of, or inadequate, contingency planning and budgeting.

14. Failure to appreciate and plan adequately for time and financial requirements and difficulties in successfully transferring an aquaculture technology to a new environment -- each site is different, with site-specific characteristics and obstacles to be accommodated or overcome. Start-up usually takes much longer than initially anticipated; start-up delays, problems, and costs should be planned for.

15. Oversimplification of the technology necessary for success of the project and gross overstatement of the level and reliability of current technology.

16. Lack of references to support statements concerning the level of available technology, production estimates, project development costs, potential returns, etc.

17. References to "secret" or "advanced" proprietary technology which is critical to thesuccess of the project but which has not been independently evaluated. Some reasonable proof of the reliability of such technology should be required prior to making an investment decision.

18. Failure to include a pilot phase, at least for what ultimately are proposed to be large projects, with clear evaluation criteria, go/no-go decision points, and a realistic scale-up plan.

19. Basing revenue projections on retail, rather than producer prices, or on unusually high prices rather than several year averages, or on unrealistically high production levels.

20. Lack of appropriate facilities necessary to do proposed demonstration work.

21. Failure to identify major weak points in project plan and how t hey are to be compensated for (e.g., there may be only one hatchery within reasonable distance of the project site).

22. Lack of specific focus -- How big is the operation to be, what product and product form will it produce, how much product will it produce and at what frequency, where will it sell the product, and what selling price is expected?

23. If the project does not appear feasible on paper, it is unlikely to be feasible when implemented.

APPENDIX B

Evaluation Criteria for Projects Proposed for Implementation under the Fisheries Development Program

Originally, it was desired to prepare a matrix of probable outcomes for potential project activities. In the course of preparing this report, however, it has become apparent that the inadequacy of site-specific information combined with the unique characteristics of fisheries in the RDO/C countries would make such a matrix highly speculative and of little predictive value. Recognizing these constraints, it is vital that Phase II projects include provisions for making forecasts of the following impacts, and that Phase III projects do not proceed before reliable information is available to complete such forecasts. Impacts which should be considered include, at the minimum, impact upon

(a) local capabilities for optimum sustained use and management of fishery resources
(b) local income
(c) self-sufficiency
(d) food availability
(e) employment
(f) social structure
(g) resource management

Past history of fishery development efforts and major constraints suggest the following evaluation points. One of two options at most stages is to reject or reformulate the project. This may appear unduly rigorous, but number of projects which are marginally successful or outright failures indicates that fishery development projects require greater attention to the areas subjected to evaluation by the following points.

General Evaluation Points for all Projects

A. Characterization

1. Has the project been successful or beneficial anywhere?
   YES -- Project may be Phase II
   NO -- Project must be Phase I
2. Has a prototype project been succesful in the intended implementation locale?
   YES -- Project may be Phase III
   NO -- Project must be Phase II
3. Is adequate information available for site-specific feasibility and impact analyses?
   YES -- Project may be Phase III
   NO -- Project must be Phase II

B. Acceptibility of Approach

1. Does the project address local objectives?
   YES -- Continue evaluation
   NO -- Reformulate or reject project

2. Have local personnel participated in the formulation of the project?
   YES -- Continue evaluation
   NO -- Reformulate or reject project
3. Does project team have demonstrated expertise in the specific project theme area?
   YES -- Continue with evaluation
   NO -- Reformulate or reject project
4. Phase II or III projects: Are provisions made to monitor environmental, social, and economic impacts, and to modify project activities in response to the information generated?
   YES -- Continue with evaluation
   NO -- Reformulate or reject project
5. Phase II or III projects: If external expertise is involved, is there a training/transfer component to the project, and local opportunity to put such training to use?
   YES -- Continue with evaluation
   NO -- Reformulate or reject project
6. Phase II or III projects: Is there a reasonable indication that natural resource capacity is favorable to the project?
   YES -- Continue with evaluation
   NO -- Reformulate or reject project

Additional Evaluation Points for Specific Project Areas

A. Training

1. Does the project offer opportunities which are distinct from those already available in the region?
   YES -- Continue with evaluation
   NO -- Reformulate or reject project
2. Is there an existing local program or concrete opportunity to put the training to use?
   YES -- Continue with evaluation
   NO -- Reformulate or reject project
3. Are necessary materials and supplies available to trainees when training is completed?
   YES -- Continue with evaluation
   NO -- Reformulate or reject project
4. Is provision made for follow-up support to trainees and skills up-grading?
   YES -- Continue with evaluation
   NO -- Reformulate or reject project

B. Technology Innovation

1. Is the innovation a major departure from currently used technology?
   [In general, the probability of undesirable dislocations in fishery systems increases with greater departure from existing technology; incremental innovations are the alternative]
2. Will the innovation increase dependence upon purchased (particulary imported) inputs?
   [this is not desirable, because it reduces the control which the fisherman can exercise over his operations and their profitability]

C. Resource Assessment or Management

1. Is there are provision for long-term acquisition of key information (particularly, MSY and catch-effort)?
   YES -- Continue with evaluation
   NO -- Reformulate or reject project
2. Is there provision for ongoing analytical capabilities?
   YES -- Continue with evaluation
   No -- Consider reformulation

D. Credit

Should be provided only when training, technical support, and market opportunities are being improved to such an extent that repayment is likely

E. Subsidies

Not advisable