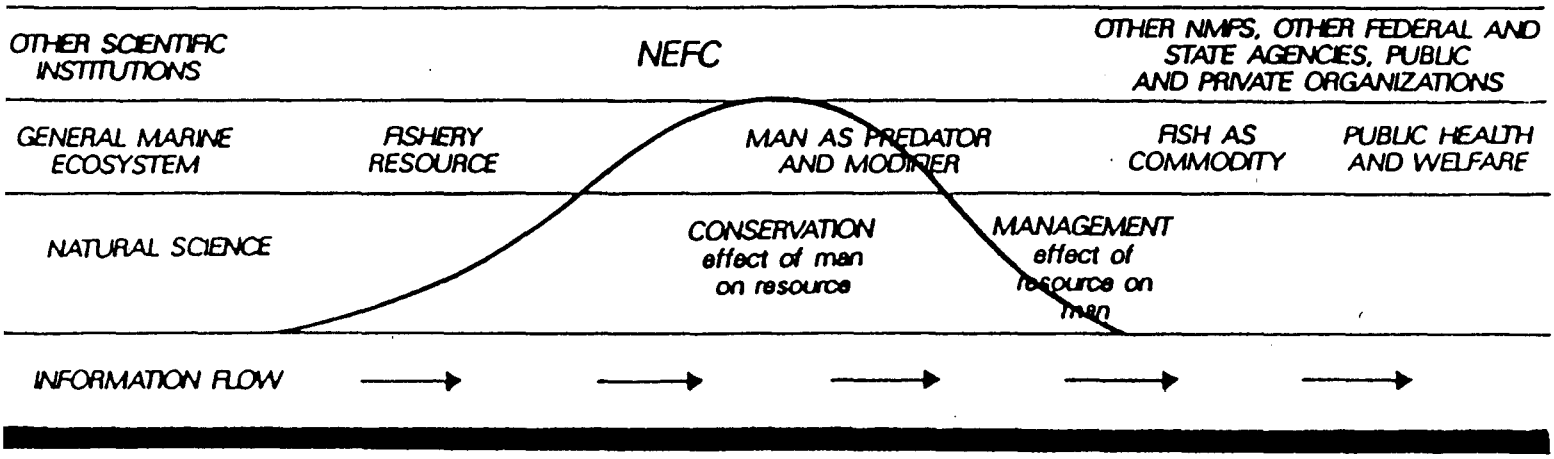
NEFC

CORE

RESEARCH PROGRAM



RESEARCH PLANNING AND COORDINATION STAFF

June 1986

DRAFT

THE PURPOSE AND DIRECTION OF THE NORTHEAST FISHERIES CENTER RESEARCH PROGRAM

Research Planning and Coordination Staff

Woods Hole, MA

27 June 1986

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EXECUTIVE SUMMARY

The Core is defined as the central and most important part; in this context we are seeking the essence of a program of research in marine fisheries. Beyond this, experience has shown a wide divergence as to what is important. A consensus would be that most everything done by the Northeast Fisheries Center (NEFC), and more, is important and central to the needs of conservation and management of living marine resources. However, it is difficult for any one program to provide enough information to satisfy all the various needs, and accommodate all the concerns. It is necessary, therefore, to define both the role that NEFC is to play and the Core emphasis for the research program that will enable NEFC to meet its primary responsibilities.

In examination of the range of possible options for a Core emphasis that lies with the role of NEFC, one factor is clear--NEFC has an obligation to develop an understanding of the productivity of living resources of the Northwest Atlantic, and to predict the effects of natural and man-induced changes to the ecosystem on fishery yield. In meeting its obligation, NEFC must immediately, or ultimately, respond to the information requirements of fishery managers. To realize the full potential of the Nation's fishery resources within their limits of productivity, fishery managers must develop strategies, impose management regimes and regulations, and monitor progress. As an integral part of this process, the NEFC Core emphasis must, at a minimum, be able to determine the limits of resource productivity. Therefore, the Core emphasis can be stated as:

> Define the limits to which the habitat and living resources of the Northwest Atlantic can be modified and still assure that the living resource populations can sustain themselves at levels consistent with prevailing fishery management policies and goals.

This Core emphasis is consistent with the stated goals of the US Department of Commerce, NOAA, NMFS, and prevailing management authorities. It also represents, collectively, the mandates under which the NEFC exists and operates. The statement implies a need to understand the variability and interactions among biological, chemical, and physical processes that affect productivity of living resources, in order to predict how modification of the processes by man ultimately affects abundance of fishery populations. It is from this understanding that benefits of modification can be assessed by managers. The statement also implies a need to understand the relationship between population abundance and subsequent recruitment, and to apply this knowledge to determine (with some degree of confidence) the level of risk associated with the ability of a population to sustain itself under a given modification scheme. Within the continuum of research activities dealing with fishery science (Figure 0.1), the Core emphasis would be located between effects of man as a predator and modifier of the marine ecosystem, and the directed scientific research needed to provide information to determine those effects.

The statement of Core emphasis for the NEFC research program should lead to the establishment of a revised system of research programming and accountability (Figure 4.4). Steps to arrive at this system involve ranking research priorities and associated activities in a manner that is consistent with the Core emphasis, relating the ranking to the current research program and program planning system, and determining what modifications to the current program are necessary to align it with the Core emphasis. Research activities should address the immediate needs of fishery managers and contribute to the information base specified by the Core statement.

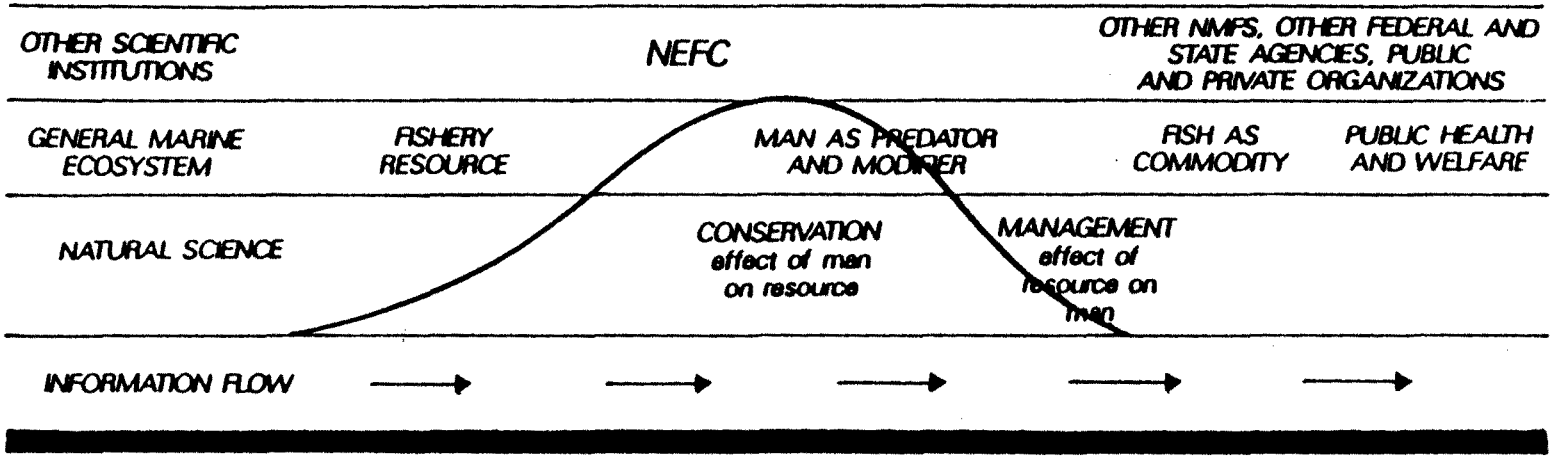

Figure 0.1. Relationship of the recommended CORE emphasis to the continuum of activities associated with a research program in marine fisheries.

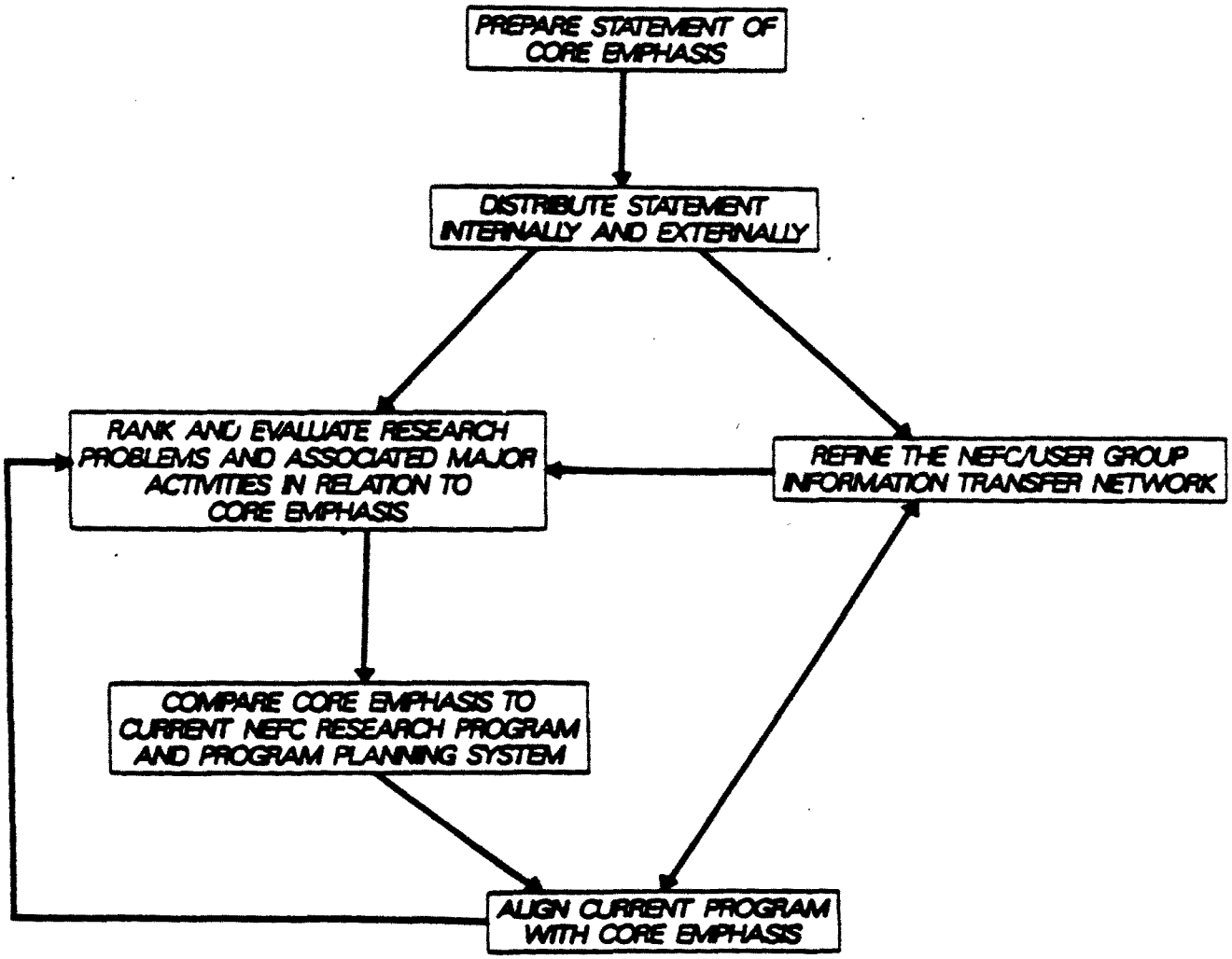

Figure 0.2. Framework for alignment of NEFC research program with the Core statement.

INTRODUCTION

As stated in the April 1985 strategic plan for the National Marine Fisheries Service (NMFS), the mission of the agency is to:

> "Achieve a continued optimum utilization of living marine resources for the benefit of the Nation."

This mission is derived from the more than 100 Federal laws administered by the NMFS which relate to living marine, anadromous, and commercial fresh water fisheries resources and their habitats. Significant among these laws are the American Fisheries Promotion Act of 1980 (AFPA), the Magnuson Fishery Conservation and Management Act of 1976 (MFCMA), the Fish and Wildlife Coordination Act of 1956, the Endangered Species Act of 1973 (ESA), the Marine Mammal Protection Act of 1972 (MMPA), the Saltonstall-Kennedy (S-K) Act, and Titles V and XI of the Merchant Marine Act of 1936 (financial assistance programs). The mission is also derived from over 20 NOAA policies that have been published in the Federal Register or that have appeared in official memoranda or presentations by NMFS and NOAA administrators. The policies most pertinent to the NEFC research program include the Fisheries Development Policy, the Marine Recreational Fisheries Policy, the Habitat Conservation Policy, and Guidelines for Fisheries Management Plans.

The NMFS mission recognizes the living marine resources within the Fishery Conservation Zone/Exclusive Economic Zone (FCZ/EEZ) of the United States as valuable renewable National resources. The renewable nature of these resources means that substantial benefits to the Nation can be realized through assuring their continued biological productivity and their optimum utilization by the multiple, often competing, users. Achieving optimum utilization of the living marine resources includes protecting and conserving

the habitat which is the foundation of resource productivity. It also involves the creation of a business climate conducive to the production of economic benefits and the guardianship of basic resource values. This mission would change only if the basic legislative authorities were to change.

Under the NMFS mission the Regional Offices are responsible for management, enforcement, and conservation. The Fisheries Centers are responsible for planning, developing, and managing multi-disciplinary programs of basic and applied research designed to: (1) better understand the living marine resources and the environmental quality essential for their existence and continued productivity; and (2) describe and provide to management, industry, and the public, options for the utilization and conservation of living marine resources and maintenance of environmental quality which are consistent with national and regional goals and needs, and international commitments.

The current Northeast Fisheries Center (NEFC) program evolved in response to increasing demands for information and scientific inquiry. This process has caused an expansion away from the more traditional fisheries science investigations of major species to that of a more fundamental study of ecosystems on the one hand, and utilization factors on the other. This redirection or transformation has been forced to some degree by the demands for information to deal with the changing nature of the fisheries and changing policies, and increasing habitat alterations caused by accelerated industrial activities. Additionally, other studies have been initiated, which are designed to provide information for future needs, as well as to provide a leadership role in studies of the more basic processes of marine resource productivity.

Thus, the scope, complexity, and logistic support of NEFC's activities have increased, with a predilection to maintain them in the face of decreasing resources. In adopting an expanded approach, it has been necessary to maintain many of the previous program activities because of a continuing demand for the traditional information. NEFC scientists have responded rather well in attempting to balance supply against demand. The last few years of reduced funding and restricted administration, however, have demonstrated that it is not feasible to continue activities in the expanded scope.

In 1985, NEFC implemented a general reorganization and redirection designed to better meet changing information needs and Center resources. As part of the process, the Research Planning and Coordination Staff (RPAC) was formed to identify the major concerns relating to conservation and management of the living marine resources, determine the research program which will provide the information about the resources needed to deal with these concerns, and assure that the elements of the research programs are effective and working together to achieve the mission of NEFC.

One of the major tasks of RPAC in 1986 is to develop a "Core" to NEFC's research program which would permit reasonable adjustment of activities while maintaining integrity and consistency in NEFC's research efforts. This document responds to this objective, and provides a basis for a continuing process of research for planning and evaluation.

The dictionary defines the core as the central and most important part; in this context one is seeking the essence of a fisheries research program. Beyond this, experience has shown a wide divergence as to what is important; a consensus would be that nearly everything done by NEFC (and more) is important and central to the needs of conservation and management of living marine resources. This may be correct in that it is difficult for any one program to

provide enough information to satisfy all the various needs, and accommodate all the concerns. It is necessary, therefore, to define both the role that NEFC is to play and the emphasis within the research program that will enable NEFC to meet its primary responsibilities.

In addition to conforming to the mandates and mission that govern the research activities of NEFC, the Core should have an identifiable purpose that satisfies the information needs of resource managers and advances them toward achieving continued optimal use of living marine resources and their habitat. The Core should incorporate a recognition that there exists a need to address issues of current concern to managers, which require a quick turnaround between problem identification and resolution. The Core must also recognize the a need to build an information base upon which future decisions can be made regarding the living resources and their habitats. The information base should also allow for advancement in the field of fishery science. The Core should be capable of providing guidance during program expansion and contraction, and be flexible enough to change as issues change and the information base grows.

This document begins with a discussion of the marine fisheries system within which the NEFC conducts its research program. Users of the system are identified, along with their needs for research information. The types and interrelationship of activities that could be associated with a research program to address those needs are presented, leading to formulation of a Core emphasis. A framework for alignment of the current NEFC program with the Core emphasis is then presented.

1.0 THE HABITAT, LIVING RESOURCES, AND FISHERIES OF THE NORTHWEST ATLANTIC

The level of continuing harvest that finfish and shellfish populations can support depends on the annual renewability of the populations. This renewability is, in turn, affected by habitat, other living resources, and by the fisheries themselves. The following overview of the status of those elements and their interactions in the Northwest Atlantic provides a basis for understanding the context within which NEFC conducts research.

1.1 THE HABITAT AND LIVING RESOURCES OF THE NORTHWEST ATLANTIC

The Northwest Atlantic has been divided into six regions as part of the Regional Action Plan (RAP) process (Figure 1.1), which was established to strengthen the NMFS research/management interface in the Northeast. Each region has relatively consistent physical and chemical characteristics; the regions include coastal drainage basins because they significantly influence those characteristics.

1.1.1 Coastal Gulf of Maine

The coastal Gulf of Maine area extends approximately 30 nm seaward and is influenced by such coastal processes as estuarine plumes and coastal upwelling. The area is marked by a steep underwater terrain, a rockbound coast, and relatively small estuaries. Six major rivers, the St. Croix, Penobscot, Kennebec, Androscoggin, Saco, and Merrimack, provide input from a drainage area of over 44,000 sq km. In addition, the Bay of Fundy outflow through the Grand Manan Channel influences the northern section of this region and creates an area of mixing in which right whales congregate each summer to feed, nurse their young and mate. Water circulation is generally to the southwest, then southerly along Stellwagen Bank, and finally easterly and offshore at Cape Cod.

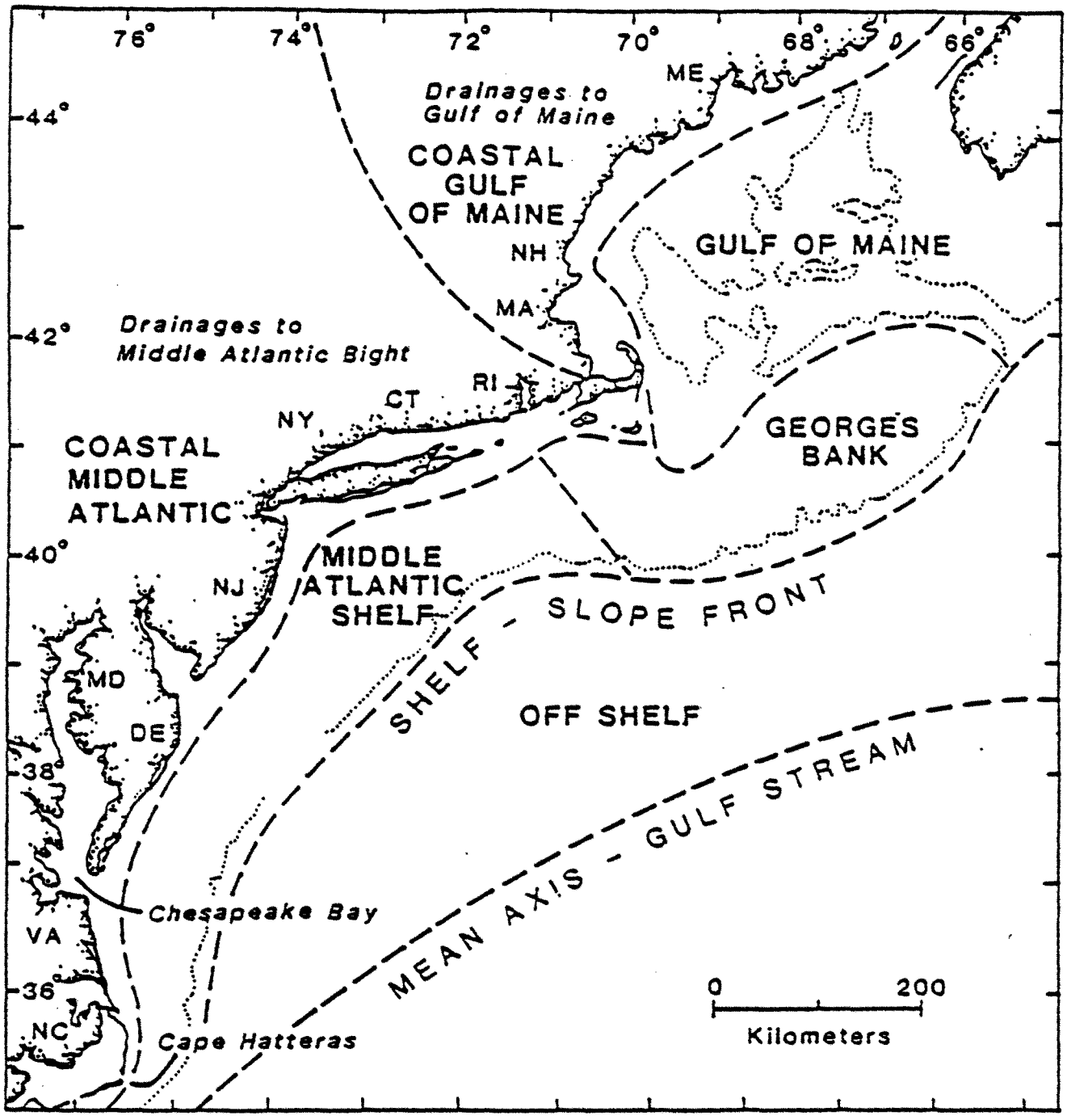

Figure 1.1. Northeast Regional Action Plan Regions

The coastal Gulf of Maine provides habitats for important fish (Atlantic herring; Atlantic cod; haddock; cusk; winter, summer, and yellowtail flounder; Atlantic halibut; bluefish; redfish, and scup), shellfish (American lobster, hard and soft clams, ocean quahog, bay and sea scallop, and northern shrimp), anadromous fish (shortnose sturgeon, alewife, American shad, and Atlantic salmon), marine mammals (harbor seal, dolphin, harbor porpoise, and humpback, fin, minke and right whales), sea turtles, and significant birdlife. The habitat in various portions of the region is affected to one extent or another by ocean disposal of waste and by effluents from urban areas located between Eastport, Maine, and Boston, Massachusetts. There is also a significant amount of non-point source pollution carried by the rivers. Coastal development is continuing in most parts of the region and threatens to further reduce already-depleted marsh and shallow-water areas.

1.1.2 Gulf of Maine

The Gulf of Maine is a semi-enclosed sea of 90,700 sq km separated from the Atlantic Ocean below 50 m by Browns Bank and Georges Bank. Three narrow passages exist below 50 m in depth, the largest of which is the 230-270 m deep Northeast Channel between Georges Bank and Browns Bank. The two smaller openings are Great South Channel between Nantucket Shoals and Georges Bank, and a trough between Browns Bank and Nova Scotia. Within the Gulf of Maine, the bottom is characterized by numerous basins which are relatively flat with steep sides. The maximum depth is 377 m in Georges Basin just inside the mouth of the Northeast Channel.

The circulation in the Gulf of Maine is characterized by a seasonal clockwise gyre which swings around the Gulf and joins the clockwise gyre on the northern edge of Georges Bank. Above 50 m in depth, input to the Gulf of Maine is from the Scotian Shelf and the various rivers emptying into the coastal Gulf of Maine region. The Northeast Channel provides the majority of input below 50 m in depth.

The Gulf of Maine offers significant deepwater habitat for fish (Atlantic cod, haddock, pollock, redfish, winter flounder, and Atlantic halibut), shellfish (American lobster and northern shrimp), and pelagic species (Atlantic herring, Atlantic mackerel, swordfish, and bluefin tuna). Significant populations of marine mammals (dolphins, harbor porpoise, and humpback, fin, minke, and right whales) occur seasonally. Presently, threats to the area are from non-point source pollution entering from the Scotian Shelf and the coastal Gulf of Maine, and from pollutant discharges by ships transiting the area.

1.1.3 Georges Bank

Georges Bank is located east of Massachusetts and is bounded on the north by the Gulf of Maine, on the east by the Northeast Chann , and on the south by the front between shelf water and slope water at the shelf margin (i.e., shelf-slope front). Much of the region is a shallow, sandy bank with numerous shoals along its northern half, which slopes off gently to the shelf break on its southern and eastern half. The edges are characterized by steep slopes descending to greater than 200 m in the Gulf of Maine, the Northeast Channel, and at the continental slope. The southern edge is intersected by numerous submarine canyons that provide significant habitat for important fishery resources.

Strong rotary tidal currents keep the water relatively homogeneous on Georges Bank; salinities are stable and temperatures reflect seasonal warming and cooling. Overlying this, a clockwise gyre brings Gulf of Maine water around Georges Bank and along the shelf-slope front. This gyre is instrumental in determining the distribution and survival of the eggs and larvae of the species spawning on Georges Bank.

The southern edge of Georges Bank is an area of strong thermal front activity. The Gulf Stream generates warm core rings, which separate from the Gulf Stream and sometimes approach closely enough to the Bank to entrain water masses

from it. Severe storms, particularly in winter, significantly alter the water column structure. The variability of the hydrographic processes and meteorologic events affect future recruitment to the fishery.

The Great South Channel lies between Georges Bank and Nantucket Shoals. It is a broad, sandy break with numerous rock piles and a sill depth of 75 m that is a major route for large baleen whales migrating into the Gulf of Maine to feed in the summer. The Nantucket Shoals area is another major feature of the Georges Bank complex. These shoals extend southward from Cape Cod, along the western edge of the border between the Great South Channel and the Gulf of Maine, in a series of sand ridges that rise to 3-10 m deep with troughs of 10-30 m in depth. They diminish offshore around the 40-m contour and form into a gently sloping plain to the continental shelf break. The area has significant diurnal tidal currents along the troughs that keep the water constantly overturned. These areas, together with Jeffreys Ledge and Stellwagen Bank, are major summer feeding areas for large numbers of humpback and fin whales.

Overall, Georges Bank is a highly productive area and heavy fishing pressure is exerted on its numerous fish and shellfisn populations (Atlantic cod; haddock; pollock; yellowtail, winter and summer flounder; gray sole; silver, red and white hake; butterfish; redfish; cusk; wolffish; tilefish; Atlantic mackerel; Atlantic herring; American lobster; sea scallop; surf clam; and squid). Several types of marine mammals frequent the area (dolphins; harbor porpoise; and humpback, fin, minke and right whales). This area is potentially affected by exploratory oil drilling, non-point source pollution, and shipping activities.

1.1.4 Coastal Middle Atlantic

The Coastal Middle Atlantic is the area inshore of the 30-m contour extending from Cape Cod southwest to Cape Hatteras. The area is characterized by a series of sounds, broad estuaries, and large river basins (Connecticut, Hudson, Delaware, and

Susquehanna). A relatively smooth bottom gently slopes from the offshore rim of the sounds and estuaries out to the 30-m contour and beyond.

The waters of the region have a complex and seasonally dependent pattern of circulation. Seasonally varying winds and irregularities in the coastline result in the formation of a complex system of local eddies and gyres. Currents tend to be strongest during the peak river discharge period in late spring and during periods of high winds in the winter. In late summer, when winds are light and estuarine discharge is minimal, currents tend to be sluggish and the water column is generally stratified by temperature.

This region provides major habitats for shellfish (American oyster; hard, soft, and surf clams; ocean quahog; bay scallop; blue crab), fish (menhaden; striped bass; bluefish; mackerel; scup; spot; croaker; weakfish; tautog; black sea bass; butterfish; silver hake; summer, yellowtail, and winter flounders; American shad; alewife; blueback herring; Atlantic herring; shortnose sturgeon), loggerhead and leatherback turtles, and marine mammals (harbor and gray seals; dolphins; and fin and minke whales). Estuaries provide major spawning and nursery areas for many of the species of this region. The estuaries are presently threatened by pollution from rivers, agriculture drainage basins, and urban areas (New York, Philadelphia, Baltimore, Washington, and Norfolk), as well as by direct loss of habitat caused by filling of wetlands, damming and diversion of rivers, mosquito ditching in marshes, and dredging of channels.

1.1.5 Middle Atlantic

The Middle Atlantic region covers an area from the vicinity of Block Island southward to Cape Hatteras. The inshore boundary lies approximately 45 km from the coast. The offshore boundary is the shelf-slope front, generally located 17 km seaward of the 200-m depth contour. The shelf width varies from 24 km at Cape Hatteras to 190 km southeast of New York.

Much of the region is a sandy plain which increases in slope seaward of the 100-m isobath. Numerous submarine canyons intersect this area. Hudson Canyon, in particular, extends into the shelf as the Hudson Shelf Valley and effectively sections the area into two zones, southwest and northeast of the shelf valley. Surface circulation is divided into two zones as well; the northern cell has a general westerly drift and the southern cell has a general southwesterly drift, due to the influence of the inflow of coastal water from rivers and estuaries.

The Middle Atlantic Shelf has a different faunal composition than the Gulf of Maine or Georges Bank. Most of the fish populations are migratory and species composition varies with season. As water temperatures rise in spring and summer, there is a large influx of warm-water species from the south (drums, bluefish, and jacks), and several cold-water species migrate north (Atlantic cod, Atlantic herring, alewife, Atlantic mackerel, spiny dogfish, and American shad). In the fall, warm-water species (summer flounder, butterfish, longfin squid, hakes, and black sea bass) move offshore and/or migrate south. Cold-water species move south into the Mid-Atlantic area again in winter. Other seasonal inhabitants include loggerhead and several other species of sea turtles, dolphins, baleen whales (fin, humpback, and minke) and sperm whales. The area supports a major fishery for surf clams and ocean quahogs. It is threatened by exploratory drilling, by non-point source pollution from shipping activities and by ocean disposal of sewage and industrial wastes.

1.1.6 Offshelf

The offshelf area can be generally described as the area between the shelf-slope front and the Gulf Stream. At its inner boundary, the shelf-slope front characteristically joins the shelf at the 100-m isobath and intersects the surface 50-70 km seaward. It is an area that is rich in commercially valuable fish and shellfish (bluefin tuna, other tunas, swordfish, marlin, Atlantic mackerel,

tilefish, lobster and red crab). Sperm whales, other marine mammals, sea turtles, and large numbers of seabirds also frequent this area.

Offshore, the Gulf Stream undulates as it moves to the northeast, forming a dynamic eastern boundary for the area. Rings of warm water about 80-160 km in diameter break off from the Gulf Stream at a rate of about eight per year and transit to the southwest, eventually coming in contact with the shelf at southwestern Georges Bank. The passage of each of these warm core rings marks a major event in the hydrographic regime and may significantly affect the biota of the shelf-slope front and possibly of the shelf itself. Other than ring passages, impacts on the offshelf waters are primarily from pollution generated by atmospheric fallout, shipping, and from ocean dumping of wastes at Deepwater Dumpsite 106.

1.2 THE COMMERCIAL FISHERIES OF THE NORTHWEST ATLANTIC

The exploited finfish and shellfish stocks in the Northwest Atlantic between Cape Hatteras and Nova Scotia number over 100 species. About 30 finfish, 10 shellfish, and two squid species annually contribute about 80% of the catch of the foreign and domestic commercial fisheries in the area. In 1984, the commercial nominal catches (live weight equivalents and excluding discards) totalled approximately 1,250,000 mt (Table 1.1), of which about 560,000 mt were finfish and 690,000 mt were invertebrates. In the same year, the US recreational fishery is estimated to have taken approximately 75,000 mt of finfish.

The traditionally exploited finfish and squid stocks have an estimated long-term annual yield of about 1,000,000 mt. The menhaden resource along the Atlantic coast represents an additional 500,000 mt potential. Swordfish, tunas, and other large oceanic pelagics, for which long-term potential yield estimates are unknown, are not included in the above estimates. Two species which have not been fished to

Table 1.1 USA commercial and foreign nominal catches (mt) from the marine finfish and invertebrate resources off the northeastern United States (Gulf of Maine - Mid-Atlantic) in 1984. All catches are expressed as live weight and are provisional. Recreational catches are not included.

Species	Foreign	USA Commercial	Total
Principal Groundfish	15,387	100,539	115,926
Atlantic cod	8,849	43,721	52,570
Haddock	2,708	11,603	14,311
Redfish (Ocean Perch)	71	4,721	4,792
Silver hake (Whiting)	412	21,020	21,432
Red hake	57	2,273	2,330
Pollock	3,290	17,201	20,491
Flounders	219	65,481	65,700
American plaice	8	10,135	10,143
Witch flounder	14	6,532	6,546
Yellowtail flounder	4	17,815	17,819
Greenland halibut	0	0	0
Atlantic halibut	62	74	136
Winter flounder	5	14,680	14,685
Summer flounder	0	14,197	14,197
Windowpane flounder	0	1,830	1,830
Flatfishes (unknown)	126	218	344
Other Groundfish	2,199	23,240	25,439
Cusk	477	1,710	2,187
Scup	0	7,781	7,781
White hake	1,013	6,491	7,504
Atlantic wolffish	82	1,042	1,124
Groundfish (not specified)*	627	6,216	6,843
Principal Pelagics	9,477	37,977	47,454
Atlantic herring	0	33,447	33,447
Atlantic mackerel	9,477	4,530	14,007

Table 1.1 (cont'd)

Species	Foreign	USA Commercial	Total
Other Pelagics	446	271,577	272,023
Bluefish	0	4,279	4,279
Atlantic butterfish	432	11,993	12,425
Atlantic menhaden	0	251,788	251,788
Pelagics (not specified)*	14	3,517	3,531
Other Finfish	795	31,288	32,083
River herring	16	4,088	4,104
Spiny dogfish	2	4,390	4,392
Skates	5	4,129	4,134
Finfish (not specified)*	772	18,681	19,453
Invertebrates	28,925	660,363	689,288
Short-finned squid (Illex)	676	9,307	9,983
Long-finned squid (Loligo)	11,031	10,825	21,856
American lobster	267	19,887	20,154
Shrimp (Pandalid)	0	3,227	3,227
Crab	1	57,921	57,922
Surf clams	0	168,038	168,038
Ocean quahogs	0	149,120	149,120
Sea scallops	16,950	64,468	81,418
Invertebrates (not specified)*	0	177,570	177,570
Grand Total	57,448	1,190,465	1,247,913

*Not specified indicates there are other species in this category which are not listed in the table.

any extent are the saury and the sand lance. At times, these species appear to have a standing stock of about 1,000,000 mt. Both species are very important ecologically as food for larger species.

1.2.1 Pelagic Finfish

Demersal (bottom-associated) and pelagic (free-swimming) species of finfish have some distinct differences which affect their availability to the fisheries. Pelagic species (such as tunas, herring, mackerel, swordfish, and menhaden) are more migratory than demersal species, and some (e.g., herring) are vulnerable to fishing at reduced levels of abundance because of their schooling behavior.

Herring, mackerel, butterfish, and bluefish have a combined long-term annual yield of about 370,000 mt. Bluefish, with a predominantly recreational catch, is probably being fished close to its potential, and there is a developing fishery for butterfish. Herring and mackerel dominate both the historic and potential yield of this group. Both species were heavily fished and depleted by foreign fleets prior to the 1976 Magnuson Fisheries Conservation and Management Act (MFCMA). The mackerel resource has recovered significantly and could support the development of a domestic fishery. However, the Georges Bank herring stock has not yet recovered.

1.2.2 Demersal Finfish

Demersal species of major commercial importance include cod, haddock, redfish, pollock, silver hake, red hake, yellowtail flounder, American plaice, winter flounder, and summer flounder. Collectively, this group of species represents a long-term annual potential yield of 400,000-450,000 mt. The 1984 foreign and domestic commercial catch for these species totalled about 207,000 mt or about half of the long-term potential. All of these species, except

silver and red hake, are currently subjected to intense fishing pressure, and the stock biomass for many is at reduced levels, most notably for haddock and redfish.

The Georges Bank haddock population showed significant signs of recovery during the late 1970's, immediately following the implementation of MFCMA. However, two larger-than-average recruiting year classes in that period were heavily exploited and population abundance is now declining toward the low levels which followed the heavy fishing during the 1960's.

In the redfish fishery of the Gulf of Maine, recruitment has been poor and there is no evidence of improvement. On the other hand, cod resources of Georges Bank and the Gulf of Maine have remained abundant in spite of near record high yields during the past several years. Spiny dogfish is a species with significant potential yield (estimated to be 65,000 mt annually) which is presently being fished very lightly (1984 domestic landings were 4,400 mt).

1.2.3 Squid

Long-finned and short-finned squid, the two traditionally exploited squid species, have an estimated potential yield of 74,000 mt per year. The 1984 total of joint venture (US and foreign) and domestic catches was 31,839 mt. Although squid resources are particularly variable as a result of their short life-span (one or two years), there is significant potential for expansion of the domestic fishery.

1.2.4 Shellfish

The major shellfish species include sea scallops, surf clams, ocean quahogs, and lobsters. This group has a combined long-term potential yield of about 70,000 mt (meat weight for scallops, clams, and quahogs; live weight for lobsters). The 1984 landings for these species totalled 81,000 mt. With the possible exception of ocean quahogs, all of these species are presently being

fished at or above their long-term potential. Moreover, many of these species and their processed products are particularly subject to the effects of habitat degradation and contaminants.

1.2.5 Stock Variability

All of the fish and squid species of the Northwest Atlantic are highly variable in their distribution, abundance, and yield. Most of the variability in the yield in exploited stocks is due to variability in the abundance of year classes entering the fishery. Variability in abundance may be greater than twenty-fold for some stocks. The problem of determining the source of this variability in abundance is compounded by the difference among stocks in the pattern of the variability over time, which tends to obscure cause and effect relationships.

1.3 AN ECONOMIC OVERVIEW OF KEY COMMERCIAL FISHERIES IN THE NORTHWEST ATLANTIC

1.3.1 New England

The trend in the economic status of the New England fishing fleet over the period 1978 through 1984 has been the reverse of that of the national economy. Over the period many fish stocks declined, fuel and interest costs rose steeply, the number of vessels in the fisheries jumped sharply, and the level of imports increased. Although many costs of fishing have begun to stabilize, insurance costs recently have accelerated in many ports and access to an important fishing area, a rich portion of the Georges Bank, was lost in 1984 as a result of the World Court settlement.

The total[1] revenue received by vessels of five gross registered tons (GRT) or more has remained at approximately $150 million over the last seven

[1] All value amounts--prices, revenues, costs, earnings, etc.--have been adjusted for inflation ("deflated") using 1977 as the base year. In this way the purchasing power of a dollar is comparable between years.

years. Total landings (live weight), which increased by over 46,252 mt to 324,073 mt between 1978 and 1982, fell to 300,478 mt in 1984. The number of vessels in this category increased by almost 50% between 1978 and 1981, but has since remained fairly constant at approximately 1,350 vessels. Consequently, landings-per-vessel and revenue-per-vessel have, with minor fluctuations, shown a downward trend over the period following implementation of the Magnuson Act (MFCMA). The larger-than-normal profits to individual fishing vessels, which were made possible after enactment of the MFCMA, have been diluted to a large extent by the growth in the fleet, increased operating costs, and stock declines.

1.3.1.1 Otter Trawls and Scallop Dredges

For the 990 otter trawl vessels operating in 1984, total landings and total revenue were 162,702 mt and $92 million, respectively, down slightly from the 1983 level. Deflated revenue-per-trawler has fluctuated around $94,000 in the 1980s after a steep decline from the 1978 figure. Landings-per-trawler have likewise declined but less steadily. Both revenue and landings-per-trawler were at their lowest point in 1984 for the seven year period.

The New England scallop dredge fleet is comprised of approximately 210 vessels. The fleet harvested 37,549 mt (live weight) of sea scallops and a small quantity of Icelandic scallops in 1984. This figure is significantly lower than the 67,181 mt brought on board in 1981. The 1984 landings brought $32 million to the fleet, $10 million less than in 1983, and a low for the period. The average individual vessel received $150,000 for 176 mt (live

weight) of sea scallops dredged that year. This was the lowest total value received and quantity landed in the seven year period.

In general, the decline in landings has not brought about an increase in prices paid to fishermen. In some cases the size of the average fish decreased as stocks came under stress from increased fishing effort. For some species, imports helped prevent prices from rising. The prices of most major species caught have been relatively stable over the period. Cod and redfish prices have changed very little. Those of pollock, whiting and the hakes have declined since 1979. Haddock, yellowtail flounder, and winter flounder prices declined through 1981, but have risen slightly in the recent past. Scallop prices, which were stable through 1982, increased by almost 50% the following year but fell by 10% in 1984.

The increase in foreign imports of cod, other groundfish, and flatfish--principally from Canada--has helped to moderate the potential rise in fish prices resulting from declining US catches. The major increase in imports has been in cod, especially in the fresh product. Although 1984 imports to New England were less than those of 1983, Canadian cod imports were fully seven times the quantity of cod landed by the New England fleet. The mix of the different cod product forms has also changed and now competes more directly with New England landings.

Total scallop imports have been fluctuating but have shown a generally downward trend. Imports of sea scallops from Canada declined by about 2 mt (meat weight) between 1983 and 1984, and by 7.8 mt since 1977. Some of this slack has been taken up by other countries, most notably Iceland and Japan. Domestic supplies of presumably close substitutes for sea scallops--bay scallops and calico scallops from the South--have had a moderating impact on prices paid to New England sea scallopers. The jump in the 1983 average price

was apparently influenced less by a small decline in total scallop supplies than by the general economic turnaround.

The costs of the various inputs used in fishing--fuel, labor, and interest on capital--have, with the exception of insurance costs, stabilized in the last two years after having risen sharply in 1979-1982. Currently, substantial and, in some cases, prohibitively expensive hull and liability rates exist in particular ports and for vessels in particular fisheries because of abnormally large numbers of sinkings, large liability settlements, or because of the advanced age of a fleet.

The landings per unit of capital and labor used in fishing have been declining, reflecting changes in the state of the fish and scallop stocks. On the basis of man-days-at-sea or vessel-days-at-sea, otter trawl landings have declined since 1977 and were at a low for all tonnage classes of trawlers in 1984. For example, the landings per vessel-day-at-sea for the largest class of trawler (greater than 150 GRT) were 65% of what they were in 1978. For all but the smallest scallop dredges, the decline in returns to vessel-days-at-sea has been even more severe. The landings per vessel-day for the largest scallop dredges in 1984 were only 28% of its 1978 level. By the end of 1983 a selection of New Bedford scallop dredge vessels showed that the earnings of the captain, an individual crew member, and the owner gave them less than half the purchasing power they had received in 1978. For a selected group of trawlers, the impact of these trends in the fishery have been similar. In 1984 the average trawl or scallop dredge firm was operating much closer to the point where its financial returns from fishing would not exceed what could be earned elsewhere. The surplus profit or resource rent has been severely diminished as a buffer to the effects of resource variability, increasing costs, imports and other domestic market competition.

1.3.1.2 The Lobster Fishery

Approximately 95% of lobster catches in the Northeast are landed in New England, of which over 47% are caught in Maine. New England landings grew from 14,889 mt in 1978 to a peak of 19,086 mt in 1983, and fell slightly in 1984 to 18,827 mt. Total revenue from these catches has risen only slightly over the period, from $56.7 million in 1978 to $62.4 million in 1984. Prices initially fell, reached a low in 1982 and gained only slightly in 1984.

The inshore lobster fishery accounts for over 87% of the landings and slightly less than 84% of the revenue generated by this species. It is carried out by boats of less than 5 GRT in the territorial waters of each of the New England states. No total count of the number of boats or traps in the region is available. A few states, most notably Maine, keep detailed records on the fishery. Maine landings have declined somewhat since the high in 1982 of 10,841 mt. The 1984 landings, 8,845 mt, are similar in magnitude to those of 1978.

The offshore lobster fishery involves vessels of over 5 GRT principally out of ports in Massachusetts and Rhode Island. These vessels use traps, pots and lobster trawls. Many otter trawl vessels also land lobsters as incidental catches in the groundfish fishery. Since 1979 reported New England offshore lobster catches have risen from 1,678 mt to 2,404 mt.

Since 1981, the nation's principal source of lobster meat has been foreign imports. The vast majority of this imported product comes into New England. New England imports of live lobsters increased from 5,515 mt to 10,590 mt between 1978 and 1984. Almost all of the live lobster imports come from Canada. Imports of fresh and frozen lobster meat have increased over

six-fold in the seven year period from 474 mt to 3,045 mt. Since 1980 over 90% of this flow has come from Canada with the majority of the remainder from Iceland.

1.3.2 Mid-Atlantic

1.3.2.1 The Surf Clam and Ocean Quahog Fishery

The Mid-Atlantic surf clam and ocean quahog fishery is conducted principally by a fleet landing in New Jersey, Maryland and Virginia. These vessels, which contribute the majority of U.S. supplies of these products, has been relatively stable in number over the past four years. In 1984, 138 vessels of 5 GRT or more received $24 million for combined catches of 278,201 mt live weight. Both revenue-per-vessel and landings-per-vessel for 1984 were at a six year high of $172,000 and 2,016 mt live weight, respectively.

Significant quantities of ocean quahogs were not landed until 1977. Since then, quahog landings have stabilized the total combined yield and compensated for the declining surf clam catch which peaked in the mid-1970s. In 1975, surf clams were 99% of combined landings, while in 1984 they were 66%. The ex-vessel price per pound of surf clam meats reached a peak of fifty-two cents in 1977 and has since been on a slow and steady decline. The average price per pound of meats in 1984 was twenty-nine cents. Ocean quahog prices have been relatively constant for several years at about eighteen cents per pound of meats.

Landings per man-day-at-sea and vessel-day-at-sea have risen significantly since 1979; an average 1984 man-day returned 415% and a vessel-day 438% of the yield they produced in 1979. With fishing costs, especially fuel costs, having leveled out recently, the variable costs of landings have decreased. However, the age of the mid-Atlantic surf clam fleet has put

upward pressure on insurance premiums. Consequently fixed costs of production are quite high. The disparity between quahog and surf clam prices and the trend toward increased landings of quahogs is expected to continue.

1.4 THE RECREATIONAL FISHERIES OF THE NORTHWEST ATLANTIC

The marine recreational fisheries of the Northwest Atlantic have been surveyed by NMFS using the same methodology each year since 1979. For purposes of the survey, the Northwest Atlantic region is divided into the North Atlantic and Mid-Atlantic Subregions, and data is compiled for the beach/bank, private/rental boat, and party/charter boat modes of fishing.

The latest year for which survey data are available is 1984. From 1979 to 1984, survey results show few significant changes in the total number of fish caught in any species group in the region. Summer flounder, bluefish, spot, Atlantic croaker, scup, winter flounder, and spotted seatrout were the most frequently caught species each year. Bluefish, which ranked first in the catch over the period 1979-1983, was replaced by summer flounder in 1984. Large changes in the total catch among the six years for a species group were generally due to changes within a single state, and often within a single fishing mode within a state. Relatively small sample sizes used in relation to the total fishing population, and their effect on ratio estimators, may have contributed to these changes.

The total number of recreationally caught fish along the northwest Atlantic (Maine-Virginia) was 168.4 million fish in 1984. Approximately 37% of the catch in the region was released alive. Over 70% of the catch in number of fish was taken in inland waters (e.g., rivers, sounds, bays) or in the ocean within three miles of shore. The private/rental boat mode accounted for the highest percentage of the 1984 catch (67%) of any fishing method.

1.4.1 North Atlantic Subregion (Maine-Connecticut)

Bluefish, winter flounder, and scup dominated the marine recreational fishery in the North Atlantic Subregion during 1984, as they did in 1979-82. These species accounted for over 50% of the total catch in numbers in the subregion. Other frequently caught species in 1984 were Atlantic cod, tautog, cunner, summer flounder, Atlantic mackerel, and pollock. The private/rental boat mode - ocean three-mile or less area combination accounted for the largest proportion of the total number of fish caught (35%).

For all areas of fishing combined, the private/rental boat mode alone accounted for 65% of the total number of fish caught in 1984, and accounted for an average of 61% of the catch over the period 1979-1983. In 1984, the ocean three-mile or less area accounted for the greatest proportion (47%) of the catch in number. This represented a change from 1979-82 when the inland area was the most productive, accounting for an average of 52% of the total catch in numbers.

Approximately 1.3 million New England residents participated in marine recreational fishing in the North Atlantic and made an estimated 5.0 million fishing trips in 1984. The 1979-82 mean is 1.2 million participants and 5.4. million trips. Fishing activity was greatest during the July/August wave in 1984; approximately 9% of the coastal county residents of the North Atlantic states participated in marine recreational fishing during these months. Out-of-state residents made an additional 1.6 million fishing trips in 1984 in the subregion.

Average catch per trip increased for all fishing modes between 1983 and 1984 but was still below 1979-82 mean values. The private/rental boat mode had the highest average catch rate with 6.9 fish/trip in 1984. The beach/bank mode had the lowest average catch rate with 2.4 fish/trip in 1984. Bluefish

was both the most sought after and most numerous species caught during 1984, and winter flounder ranked second in both categories. Although Atlantic cod ranked third among the species sought after, it ranked fourth behind scup in numbers caught. Since the intercept interviews are conducted at the completion of a fishing trip there is probably some response bias introduced that correlates the species sought with what was actually caught.

1.4.2 Mid-Atlantic Subregion (New York - Virgina)

Spot, bluefish, and summer and winter flounder comprised over 60% of the total catch in numbers in the Mid-Atlantic in 1984. These same species dominated the 1979-82 catches. Catches of spot and black sea bass were considerably lower in 1984 than in 1983.

Eighty-one percent of the catch in the Mid-Atlantic Subregion in 1984 was from inland waters or within three miles of shore. As in the North Atlantic Subregion, private/rental boats are the most productive mode of fishing, accounting for approximately 68% of the total number of fish caught in 1984, and an average of 55% of the catch over the period 1979-82. In 1984, the private/rental boat mode - inland area combination lead all other combinations of mode and area, with 33% of the total number of fish caught in the subregion.

Participation in marine recreational fishing by residents of the Mid-Atlantic states declined from 3.1 million fishermen in 1983 to 2.9 million fishermen in 1984. Residents of the subregion made an estimated 16.4 million marine fishing trips in 1984; an additional 4.7 million trips were made by out-of-state residents. Fishing activity was greatest in July/August, with approximately 10% of the sampled residents of the coastal counties having participated in the fishery during the period.

Catch rates in all fishing modes in 1984 were higher than the 1979-82 average catch rates. Bluefish and summer flounder were the most sought after individual species during 1984 with approximately 35% of the respondents indicating a preference for one or the other of the species. Winter flounder (14%) was the only other species that accounted for more than 10% of the preference responses during that year.

2.0 ISSUES AND INFORMATION NEEDS OF THE LIVING MARINE RESOURCE USERS

The current NEFC research program has evolved in response to requests for the federal government to provide information related to the status and utilization of living marine resources of the Northwest Atlantic and their habitats (Figure 2.1). NMFS/NOAA/Commerce policies and research mandates have been shaped to some extent by these requests, and NEFC's programs have further been determined by direct Congressional legislation and appropriations. The research program at NEFC has also been formed by the types of information requested directly from NEFC researchers by other NMFS/NOAA programs, outside federal and state agencies, private organizations, and individuals. The priority with which the various requests and mandates are addressed is not fully under NEFC control, and necessarily changes from time to time to reflect changes in public policies and issues.

2.1 NEFC RESEARCH INFORMATION RECIPIENTS

Information produced by NEFC research is provided to all sectors of society that have an interest in the well-being of the living marine resources of the Northwest Atlantic (Table 2.1). The commercial and recreational fishing industries, their associated support industries (e.g., net and tackle manufacturers, bait dealers, fuel distributors, and hotels), and fishery development foundations use NEFC research information to make decisions concerning products, marketing, investments, and fishing/processing techniques. Management councils, fisheries commissions, state and local governments, Congress, and NMFS/NOAA use the information to develop policies and to administer the management of the resources. Other federal agencies,

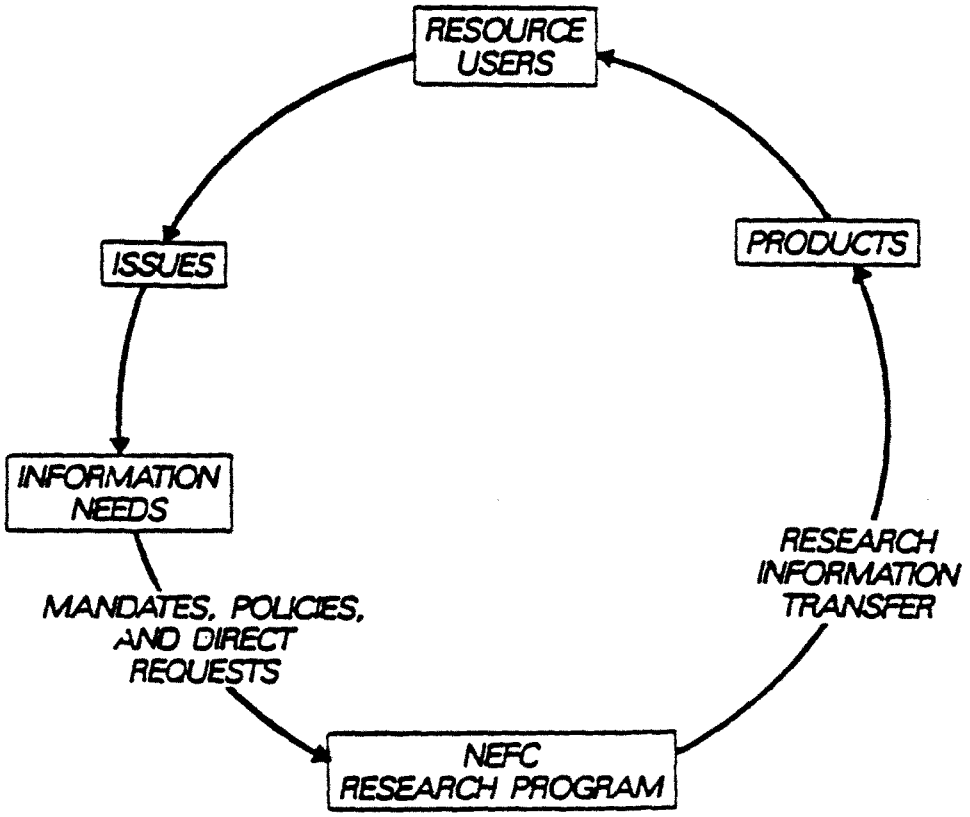

Figure 2.1. Process for incorporation of information needs of users of marine fisheries resources into the NEFC research program.

Table 2.1 Recipients of Information Generated by the Northeast Fisheries Center.

Recipients	Purpose
Councils and Commissions	Management and Fisheries Policy Development and Implementation
State and Local Governments	Management, Policy, Investment, and Regulation
NMFS, NOAA, and Department of Commerce Administrators	Planning, Policy, Information, Review of Management, Need for Management, Regulation, Adminstration, and Litigation
Congress	Management, Budgetary Investment, Legislation, and Policy
Educational Institutions	Research and Information
Fishing Industry	Fishing and Processing, Aquaculture, Production, and Marketing
Fishing-Supported Industries	Marketing, Investment, and Production
Fishery Development Foundations	Research, Education, and Application
Conservation Groups	Lobbying
Scientific Organizations	Research, Management, and Education
Consulting Firms	Impact Analyses
Marine Advisory/Extension	Information and Communications
Media	Communication
Office of Management and Budget	Budgets and Regulations
Other Federal Agencies	Research, Litigation, Regulatory Decisions, Negotiations, Policy, and Enforcement
Recreational Fishing Interests	Investment, Information, and Communication
Consumers	Safety, Storage, Preparation, Nutritional Value
International Science and Development Organizations	Information, Research, Application, and Education

consulting firms, educational institutions, and scientific organizations use information produced by NEFC to supplement their own information bases. Conservation groups and the media use NEFC information to influence regulatory agency decisions and keep the public informed of the status of living marine resources, as well as safety and nutritional aspects of fishery products.

To address the information needs of these user groups, NEFC's research products have assumed several forms (Table 2.2), some of which are difficult to measure in a quantitative sense. The variety of products reflects the varying level of technical detail that is necessary to satisfy the information needs of the diverse user groups. The success of NEFC's research program should be related to both the quality of the science and usefulness of the products to promote the public welfare. However, the perception of success is often more narrowly focused on the usefulness of the information to achieve management goals and direct benefits returned to fishermen.

2.2 ISSUES AFFECTING MARINE FISHERIES RESOURCES

The information needs of resource user groups arise in response to current and anticipated issues that need resolution (Table 2.3). For the commercial and recreational fisheries sector, the issues are generally related to the maintenance of an adequate and stable supply of fishery resources. Managers and legislators are primarily concerned with obtaining the maximum benefits from the marine fisheries resources on a sustained level within a multiple-use framework. The general public is primarily concerned with issues related to stock availability, aesthetics, product safety, nutrition, and the general health of the marine ecosystem. Often, a particular issue is of concern to more than one sector.

Table 2.2 Products of NEFC Research.

PUBLIC PRESENTATIONS
-seminars, symposia -organization meetings -media interviews
PRESS RELEASES
SCIENTIFIC PUBLICATIONS
-review articles -journal articles -technical reports -books
STATUS REPORTS
-fisheries statistics -state of environment -state of fisheries
IMPACT ANALYSES
-fisheries -other resource uses
ADVICE
-fishery management plans -legislation -regulations -education
PRODUCT TEST RESULTS
-contaminants -pathogens -species composition
DEMONSTRATIONS
-technology transfer -fishing techniques -product handling, storage, preparation -training

Table 2.3 Issues Associated with Utilization of the Living Marine Resources.

Abundance and Availability
- Productivity
- Abundance of Desired Target or Alternate Species
- Prediction of Future Abundance and Stability
- Access to Species
Fishing
- Gear Selectivity
- Gear Technology
- Expenditures
Product Quality and Safety
- Palatability
- Pathogens and Contaminants
- Handling, Processing, and Storage
Socieconomics
- Price
- Demand
- Product/Marketing
- Imports/Exports
- Substitution of Alternative Food Items
Planning and Policy
- Defining Policy and Setting Objectives
- User Conflicts
- Effectiveness of Management Measures
- Mitigation of Fishery and Habitat Losses
Stock Assessment
- Prediction of Yield
- Evaluation of Management Options
- Multispecies Impacts of Fisheries
- State/Federal/International Cooperation
Habitat Degradation
- Waste Disposal and Ocean Dumping
- Coastal Urbanization
- Energy Production and Transport
- Port Development and Utilization
- Estuarine Watershed Development
- Agriculture
- Mineral, Oil, and Gas Extraction
Consumption
- Safety
- Nutrition
- Preparation Techniques
Aesthetics
- Endangered Species
- Non-fishing Recreation
- Shoreline Development

2.2.1 Fisheries Sector Issues

Availability of fish and shellfish is the key issue for the commercial and recreational fisheries sector. Recreational opportunities become limited when the availability of preferred target species or their alternates has declined (due either to a decline in abundance or a shift in distribution), when access to the species is limited, and when the species caught are unpalatable or unsafe to consume (or perceived to be when they are taken from obviously degraded, unaesthetic habitats). For some species, the availability of large trophy-size fish is a major factor. Participation in marine recreational fishing activities may also be restricted because of conflicts with competing users of the same fishery resources or their habitat.

Competition with other users also affects commercial fishing. In order to ensure the availability of a stable and sustained supply of fishery products, the resources must be accessible to US fishing vessels. In addition, the fishery resources themselves must be sufficiently abundant, and this abundance must be as stable and predictable as possible. Costs of commercial fisheries operations generally need to be minimized; they cannot increase at a rate faster than the increase in price paid for their products. The demand for US fisheries products depends on consistent quality products which are free of pathogens and toxic contaminants, and a price that is competitive with alternative food items.

2.2.2 Conservation and Management Issues

Among the most difficult issues facing fisheries managers are the establishment of fishery policy and the identification and implementation of meaningful management objectives for the fisheries resource. These issues require decisions concerning how the resource will be divided into manageable units, how the units will be allocated among the various users, how conflicts

among these users can be resolved, and how stocks can be kept at fishable levels. Management agencies must be able to predict the potential yield which can be obtained from the resources and the effects of habitat degradation and fishing on the yield. These agencies must also have the means to monitor and measure the effectiveness of their policies and associated objectives, and the means to determine when to alter them if the situation warrants. Predicting the impacts of attempts to mitigate the loss of fishery resources and habitat adds to the complexity of the agencies' decision making processes.

The fishery management process in the northeast is complicated further by the division of jurisdiction among two countries, eleven states, and two regional fishery management councils. Some resources, such as striped bass, are caught within state waters but traverse many state boundaries and often reside in shelf waters. Others are fished predominantly in state waters (Atlantic salmon, shad, alewives; bluefish), although significant portions of the resource reside outside of state waters. Thus, one of the strategic issues is state/federal/international cooperation in the collection and analysis of required biological and environmental data, and in conservation and management.

2.2.3 Public Sector Issues

In addition to the issues of product safety and nutrition, the public in general is concerned with issues such as: (1) aesthetics (including whale watching, noxious blooms of phytoplankton, fish kills, unpleasant visibles, and noxious odors); (2) endangered species; (3) shoreline development; (4) oil spills from offshore drilling or shipping; (5) hazardous dumping and discharges, and (6) closures of beaches or shellfish beds due to contamination. The relative priorities of public sector issues appear to

change more often and to a greater extent than priorities for the other sectors; they also tend to be more diffuse. The public sector, however, still expects the government to respond to their needs for information concerning the issues that are, at least for the moment, of prime concern; examples are outer continental shelf oil development and ocean dumping.

2.3 INFORMATION NEEDS

The information needed to address living marine resource issues is used to describe: (1) how use of the resources and their habitat affects the state of the marine fisheries system and its function; and (2) how these effects alter the basic ability of the resource to supply and sustain yields. The system, diagrammed in Figure 2.2, centers around the biomass available for harvest in the northwest Atlantic. The biomass is increased by reproduction and growth, and decreased by fishing mortality, removals by man for other purposes (e.g., research sampling, exhibition, or population control), non-harvest fishing mortality, and habitat degradation. Natural mortality may be the result of biotic factors (e.g., predation, pathogens, or unavailability of prey items) or abiotic factors (e.g., temperature or salinity stress, contaminants, or habitat loss).

The primary NEFC response is to the fishery managers: regional fishery management councils, states, commissions, and NMFS Regional Office and Washington Office. A list of their information needs is presented in Table 2.4, adapted from the information requirements established by NMFS for fishery management plans prepared by the regional fishery management councils. The needs cover descriptions of the fishery stocks, their habitats, and socioeconomic profiles of their user groups. The needs also require

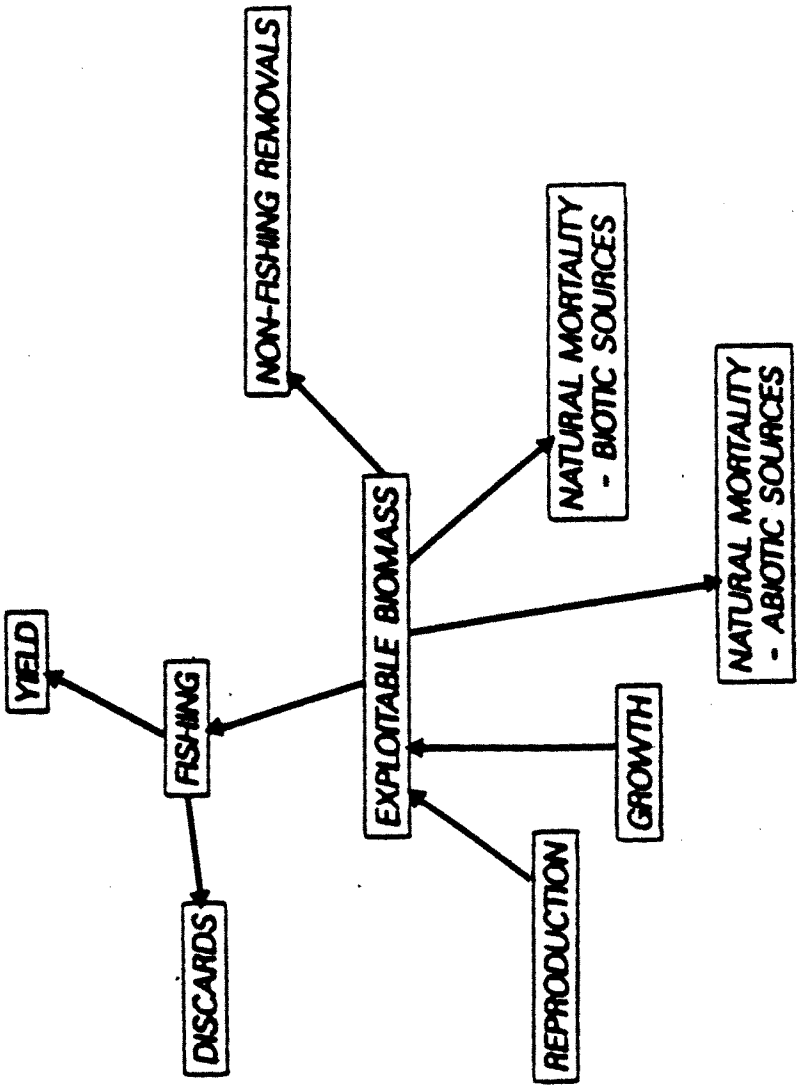

Figure 2.2. The Marine Fisheries System.

Table 2.4 Information Needs of Marine Fisheries Resource Users, Adapted from Requirements for Fishery Management Plans Prepared by Regional Fishery Management Councils.

1. STOCK DESCRIPTION

   1.1. Stock Definition
   1.2. Distribution
   1.3. Abundance and Present Biological Condition
   1.4. Trophic Relationships
   1.5. Estimate of Maximum Sustainable Yield (MSY)
   1.6. Probable Future Condition

2. DESCRIPTION OF STOCK HABITAT

   2.1. Condition of the Habitat
   2.2. Probable Future Condition
   2.3. Habitat Areas of Particular Concern ("Critical")
   2.4. Relationship Between Habitat Condition and Stock Effects
   2.5. Habitat Mitigation Programs and their Effects on Stocks

3. DESCRIPTION OF FISHING ACTIVITIES

   3.1. History of Exploitation
   3.2. Domestic Commercial and Recreational Fishing Activities
      3.2.1. Participating user groups
      3.2.2. Vessels and fishing gear
      3.2.3. Employment
      3.2.4. Fishing and landing areas utilized
      3.2.5. Conflicts
      3.2.6. Amount of landings/catch
      3.2.7. Assessment and specification of U.S. harvesting capacity
      3.2.8. Extent to which U.S. vessels can harvest optimal yield (as defined by managers) on an annual basis
   3.3. Foreign Fishing Activities
      3.3.1. Participating nations
      3.3.2. Vessels, harvesting and support, and fishing gear
      3.3.3. Fishing and landing areas
      3.3.4. Enumeration of landings and value as distributed among the stocks
   3.4. Interactions between Domestic and Foreign Fishing Participants
      3.4.1. Description of interaction
      3.4.2. Tonnage transferred
   3.5. Domestic Processing Capacity

Table 2.4 (cont'd)

4. DESCRIPTION OF THE ECONOMIC CHARACTERISTICS OF THE FISHERY

   4.1. Value of the Catch in Domestic Harvesting Sector
   4.2. Processed Products and their Value
   4.3. International Trade in Processed Products

5. DESCRIPTION OF THE BUSINESSES, MARKETS, AND ORGANIZATIONS ASSOCIATED WITH THE FISHERY

6. DESCRIPTION OF THE SOCIAL AND CULTURAL FRAMEWORK OF DOMESTIC FISHERMEN AND THEIR COMMUNITIES

   6.1. Ethnic Character, Family Structure, Community Organization
   6.2. Employment Opportunities and Unemployment Rates
   6.3. Recreational Fishing
   6.4. Economic Dependence on Commercial and Recreational Fishing and Related Activities

7. DESCRIPTION OF NON-FISHING ACTIVITIES

   7.1. Types
   7.2. Extent and Distribution
   7.3. Trends - Past, Future
   7.4. Conflicts with Fishing Activities

projections of the future status and biological condition of the stocks, forecasts for habitat quality and quantity and estimates of fishing mortality that would lead to a maximum sustainable yield or optimum yield. Fishing or other factors may severely depress stocks to a point where they cease to provide desired yields. Reduction in stock sizes may also occur as a result of changes in the structure of the marine ecosystem caused by fishing, by natural phenomena, or by degradation resulting from human activities. Therefore, it is necessary to know the causes, extent, and effects of these changes.

Information is also needed on the effects of increasing concentrations of human population, urban development, and industrial and port development on the coastal marine ecosystem. Amidst these dynamic and intense pressures, which tend to result in the loss or degradation of the remaining habitat upon which fisheries resources depend, managers must continue to adapt and update their strategies to conserve the marine resources and promote their wise use based on the multiple-use principle.

The quality and extent of marine habitat affects not only the condition of the fishery stocks, but also the wholesomeness and quality of fisheries products. The introduction of non-native species and the transfer of infectious disease entities such as viruses, bacteria, fungi, and protozoans into the ecosystems has resulted in the existence of "living pollutants" which create public health hazards. Controlling these hazards requires inspection systems; the nature, extent, and impacts of these hazards also need to be examined.

The list of information requirements for management also includes items related to the conduct of the fisheries, including many social and economic

issues. One may further extend this list as the needs for information concerning fishery development, product quality, and public health are included in fishery management by the Fishery Management Councils.

The NMFS Northeast Regional Office (NER) is responsible for responding annually to literally thousands of license and permit applications for proposed habitat alterations along the coast. These alterations range from small-scale projects such as marinas, to very large projects such as the Westway Project in New York City. NEFC is expected to provide NER with the resource information base necessary to evaluate the license and permit applications in terms of their potential effects on the living marine resources. In many cases, the ecological information needed to allow a credible review (or in some cases an active assessment of impact) greatly exceeds that which is available in the Center, or which can be provided within the usually short response time provided in the review process. Generalized knowledge is difficult to utilize because of the site-specific nature of most of the projects, but is needed to justify final decisions on application requests.

The mandates governing the Department of Commerce, NOAA, and NMFS which relate to living marine resources, environment, and fisheries encompass all of the described information needs. Meeting all of these needs requires a wide range of research activities and staff expertise in the natural and artificial environments. Balancing these activities with limited resources is a major challenge facing NEFC into the foreseeable future.

3.0 A GENERALIZED MARINE FISHERIES RESEARCH PROGRAM

Fishery science has evolved from zoology, ichthyology, limnology, and oceanography to encompass and depend on a wide range of related sciences. Fishery science may be viewed as the study of the interactions of man and the aquatic living resources, or it may be viewed in the practical sense as research in support of fisheries management. Since the 1920s, the concept at the heart of both theoretical and applied fishery science has been that for each fish species or stock, there is a rate of removal which produces the maximum sustainable biological yield. It remains so today. The purpose of fishery research is to find out how fishing affects the stocks so that the rate of removal can be regulated to achieve desired yields. The ability to manage the fisheries hinges not only on the knowledge of natural events, but also on the knowledge of social, economic, and political factors involved. A modern marine fisheries research program must include a mix of research from a number of categories, including studies at different biological levels within the ecosystem such as organism studies, population studies, and community studies, as well as utilization studies (fishery-related, habitat-related, socioeconomic).

The basic foundation from which the fisheries scientist proceeds is more often than not dictated by the identification of a socioeconomic problem and how fishery research may contribute to its solution. Application of the science requires an understanding of the biological or environmental basis of the problem and the ability to predict the outcome of taking various courses of action.

Management of the marine fisheries system for optimum use was brought to the forefront in 1976 when the US Congress enacted the Magnuson Fishery

Conservation and Management Act (MFCMA). The MFCMA represented interests, of state governments, the commercial fishing industry, recreational fishermen, and interested members of the public. The principal objectives of MFCMA were to achieve and maintain, on a continuing basis, an optimum yield from the marine fisheries through management of domestic fisheries. Optimum, with respect to the yield of a fishery, is defined by the MFCMA as the amount: (a) which will provide the greatest overall benefit to the nation, with particular reference to food production and recreational opportunities; and (b) which is prescribed as such on the basis of the maximum sustainable yield (MSY) from such fishery as modified by any relevant biological, socioeconomic, or ecological factors.

The federal standards for implementation of the MFCMA place great emphasis on having scientific information available for use in making fishery management decisions. The mandates of this Act require NEFC to provide scientific information and advice related to the status and potential of marine fisheries resources of the Northwest Atlantic. Further, as a government research entity responsible to the public, NEFC is often called upon by multiple user groups to respond to questions that require short-term answers, but which draw upon information at hand produced from multiyear research programs (Table 2.1). Demands for up to date answers lead to a mode of operation that requires an annual process of data collection, processing, analyses, and presentation of results. There is not a clear distinction between short-term and long-term studies. Short-term studies lead logically to continuing them to accommodate the long-term research endeavors, which eventually result in products needed to answer future questions posed. NEFC, as a based funded government agency is responsible for maintaining and making available quality information to the general scientific community and the public.

3.1 ELEMENTS OF A GENERALIZED RESEARCH PROGRAM

A necessary first step in defining the NEFC Core Research Program is to identify the ingredients of a generalized research program in marine fishery science from which the core program in part arises. The elements that are fundamental to such a program may be grouped into physical/chemical environmental studies; biotic research at the organism, population, and community levels within marine ecosystems; and studies of man as a unique predator on the living marine resources from that system (Table 3.1). Organism, population, and community studies are all subsumed under the more encompassing ecosystem studies which cut across all levels of biological organization. The eclectic nature of the field of fishery science is intrinsic to this approach to classifying a generalized research program. In addition, this approach avoids the immediate imposition of constraints on the structure of a research program due to the current NEFC organization and associated institutional activities. No attempt is made to arrange the elements in Table 3.1 sequentially or into a hierachy of importance.

Table 3.1 is not presented as an outline of a proposed or operating research program with all of its activities down to the least divisible level. Rather, the categories of this generalized outline are to be viewed as containing elements of fishery science and supporting disciplines, from which the NEFC Core Research Program can be selected.

Table 3.1 Components of a Marine Fisheries Research Program.

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1. Ecosystems studies: Fundamental unit of study which cuts across all levels of biological organization

   1.1 Abiotic

      1.1.1 Physical/Chemical Environment studies: Physical and chemical mechanisms and processes that determine productivity of aquatic ecosystems

- Water characteristics
  - Water movement
    - Currents
    - Water mass characteristics
    - Circulation patterns
  - Salinity
  - Temperature
    - Bathymetric profiles: Temperature-depth profile
  - Chemical composition: Nutrients, metals, synthetics, organics, etc.
    - Natural
    - Anthropogenic
  - Light penetration: intensities
  - Dissolved oxygen
    - Biological oxygen demand
- Substrate characteristics
  - Bottom topography
  - Sediment type/composition
    - Sediment chemistry
    - Contaminants
    - Sediment transport

   1.2 Biotic

      1.2.1 Organism studies: Organization, responses, and related mechanisms governing an organism's role in its environment

- Classification and systematics of marine organisms
- Ontogeny: Course of development in an individual organism
- Physiological mechanisms
  - Metabolism
    - Feeding energetics
    - Growth and developmental rates
    - Locomotion: Bioenergetics
  - Sensory mechanisms: Internal and external reaction to stimuli
    - Migration, mating
    - Toxic responses
  - Reproduction
    - Effects of age/size on egg viability
    - Endocrinology
  - Toxicity
    - Biochemical/genetic effects

Table 3.1 (cont'd)

- Behavior mechanisms
  - Feeding
  - Movement: Vertical, horizontal, seasonal, diel
  - Predator avoidance
  - Stress responses: Response to physical and chemical gradients
  - Schooling
  - Larval locomotion abilities and behavior
- Pathobiology: Cytologic and histologic studies of the health of larvae, juveniles, and adults
  - Disease
    - Intermediate vector
    - Mortality
  - Parasites
  - Abnormalities
    - External morphology
    - Cells, tissues, organs

1.2.2 Population studies: Population structure and the underlying factors governing its temporal and spatial variations

- Population distribution and abundance of all life stages
  - Temporal
  - Spatial
    - Vertical
    - Horizontal
  - Density aggregation
  - Stock identification
    - Geographic
    - Genetic
    - Fishing units (Georges Bank, Gulf of Maine, etc)
- Recruitment: Addition of new members to a population
  - Physical and biological mechanisms controlling the recruitment process
  - Reproduction: Gaining knowledge of spawning habits and habitats
    - Fecundity: Annual potential productivity
    - Maturity: Age and size
    - Spawning seasons/patterns
- Age and growth: Gaining knowledge of age composition of a population
  - Longevity
  - Growth rates
  - Age and size distribution
  - Age when habitat requirements change
- Mortality: Removal of members from a population
  - Fishing
    - Age specific fishing mortality
    - Discards

Table 3.1 (cont'd)

- Natural
  - Predation
  - Catastrophic environmental events
  - Disease
  - Density-dependent mechanisms
- Habitat alteration
  - Physical loss and modification
  - Chemical contamination
- Genetics
  - Selectivity due to man's activity
  - Impacts of artificial propagation on gene pool

1.2.3 Community studies: Interactions among populations
- Habitat requirements
  - Availability
  - Selectivity (limitations)
  - Type
  - Suitability
- Food web interactions
  - Predation
  - Competition
  - Nutrient cycles and energy flow
  - Fluctuations in productivity

2. Utilization Studies: Studies relating to exploitation of marine fishery resources

2.1 Biological studies: Focus on examining human influence on the marine fisheries system

2.1.1 Fishery-related studies
- Optimum use
  - Biological, economic, social factors
- Stock enhancement
- Effects of management measures and regulations
- Food technology: Contaminant monitoring, product quality, product safety, etc.
- Fishing technology
  - Performance and efficiency of gear
    - Operations
    - Development
  - Gear Selectivity
  - Relationship between catch and effort

Table 3.1 (cont'd)

2.1.2	Habitat-related studies - Use conflicts: Oil drilling, dredging, ocean dumping, etc. - Effects of degradation and loss - Enhancement and mitigation: Artificial reefs, marsh creation, etc. - Anthropogenic sources: Fates and effects
2.2	Socioeconomics: Economic and social information pertaining to fisheries and the human communities that depend on them
2.2.1	Economic factors - Catch value - Costs, revenues, profits - Imports, exports - Product profiles - Market characteristics - Factors controlling market demand - Habitat valuation
2.2.2	Social factors - Fishing community profiles - Job mobility - Cultural influences

3.1.1 Physical/Chemical Environmental Research

Physical and chemical characteristics of water which affect productivity are water movement, salinity, temperature, chemical composition, light penetration, and dissolved oxygen. Characteristics of the marine substrate which affect productivity include bottom topography, and the type, composition, and transport of sediments. The periodicity of change in these characteristics may range from hours to decades. Many of the characteristics are amenable to measurement with remote sensing technology (e.g., satellites, aircraft, automatic recorders).

3.1.2 Organism-Level Research

Populations and communities are composed of individual organisms which express the population's morphological and physiological characteristics. Variations among the individual organisms express the genetic variation in the population. Research at the organism level is aimed at understanding the organization and response of an organism to its environment. Studies are focused on organism identification and description, as well as all aspects of life history. Additionally, the researcher seeks to understand the importance of fluxes of energy and nutrients to individual organisms. Behavior, which is intrinsic to the ecology of fish and other marine animals, is mediated through the responses of individuals to their environment. The photoperiodic responses of individuals, for example, determine the timing of daily and seasonal activities (e.g., feeding, migration, spawning) of the population. Behavior of the individual is a mechanism that, in part, controls population densities and distributions through such things as the success of the animal in caring for itself and the survival of offspring.

3.1.3 Population-Level Research

A population is a group of interbreeding organisms occupying a particular space. It is a demographic unit characterized by density, a certain age structure, a birth rate, and a death rate. Resource concerns relate to understanding spatial and temporal variations in population abundance. Populations experience additions of individuals into the unit through birth and immigration and losses of others through emigration or death. A population may be a self-regulating system. The regulatory mechanisms within the population may be related to the population's density (density-dependent), the environment (density-independent), or the interaction of both. Since a population (or stock) is composed of interbreeding organisms (individuals) it can also be considered a genetic unit, a collection or pool of genes rather than a group of individual fish. Populations are constantly changing adaptive characteristics because of changing environmental influences.

3.1.4 Community-Level Research

Biological organization at the community level is characterized by assemblages of one or more populations occupying a common area (co-ocurring in time and space). Within the marine ecosystem in general, and in particular with regard to fishes, a diversity of species is the overriding characteristic at the community level of organization. Multispecies interactions resulting from the effects of harvest and variability in the environment thus become important at the community level. The research concern here may take two different routes. Studies may relate to the pattern of interactions among individuals of a species, interactions among species within a community and interaction between a community and its non-living (abiotic) environment at the ecosystem level, as well as the utilization of both by man. The second research approach is concerned with communities of organisms in terms of total

biomass and productivity with emphasis on the causes of variability (dynamics), both natural and anthropogenic.

3.1.5 Utilization Studies

Research concerning utilization of living marine resources seeks to understand the impact of man on those resources and the habitat that sustains them. The primary emphasis of research in this area is to determine the effects of fishing and other uses of the marine environment on fish stocks, so that these uses may be regulated to achieve social and economic goals. Utilization studies must also examine issues such as product quality, marketability, and safety; and the development of fishing/processing technology.

A wide array of socioeconomic information is also required to understand utilization and the effects of regulation. Studies must include: (1) fleet and port profiles, (2) demand and supply at all market levels and for all user sectors, (3) expenditures by the fisheries, (4) production and supply by support industries, (5) value added and product flow, (6) employment in fisheries and associated sectors, and (7) sociological factors associated with the fishing communities.

3.2 INFORMATION FLOW

The outline presented in Table 3.1 does not reflect the fact that the elements of a marine fisheries research program are interdependent. The program depends on information flow, from basic research elements to data synthesis and the development of research products that are provided to users and managers of the living marine resources and their habitats. Basic research elements encompass those research activities conducted to develop a long-term information base. On the other end of the scale are applied

research elements, which are those research activities conducted to answer specific questions about resource utilization. Information generated by basic research activities is generally useful for a longer period of time and requires less frequent updating than applied research information.

One approach to expressing interdependency in a marine fisheries research program is to arrange the activities listed in Table 3.1 into a flow diagram (Figure 3.1). In this diagram, information flows from a basic understanding of the physical and chemical processes in the marine environment to optimum use of the biota in that environment. At each step, information from previous steps is combined and further refined to answer more specific questions concerning the marine fisheries system and the influence of human activity upon it. Each set of research activities contains basic and applied elements, with an emphasis on basic elements on the left end of the diagram and applied elements on the right. It is not necessary to wait until the final step to provide research products to user groups. Products are generated at all steps, and range from raw data to summary documents. In a sense, no set of research activities identified in Figure 3.1 can exist without the research activities that precede it.

Associated with information flow are numerous feedback loops, where decisions made and actions taken affect the continuing collection and interpretation of the types of information upon which those decisions and actions were based. For example, a change in the fishing mortality rate to achieve the desired fishery yield will alter abundance of the population being fished, which may in turn affect its age structure and reproductive capacity; it may also affect the abundance, age structure, and reproductive capacity of other populations with which it interacts. Similarly, a decision to alter habitat to satisfy a need for development may immediately affect the behavior

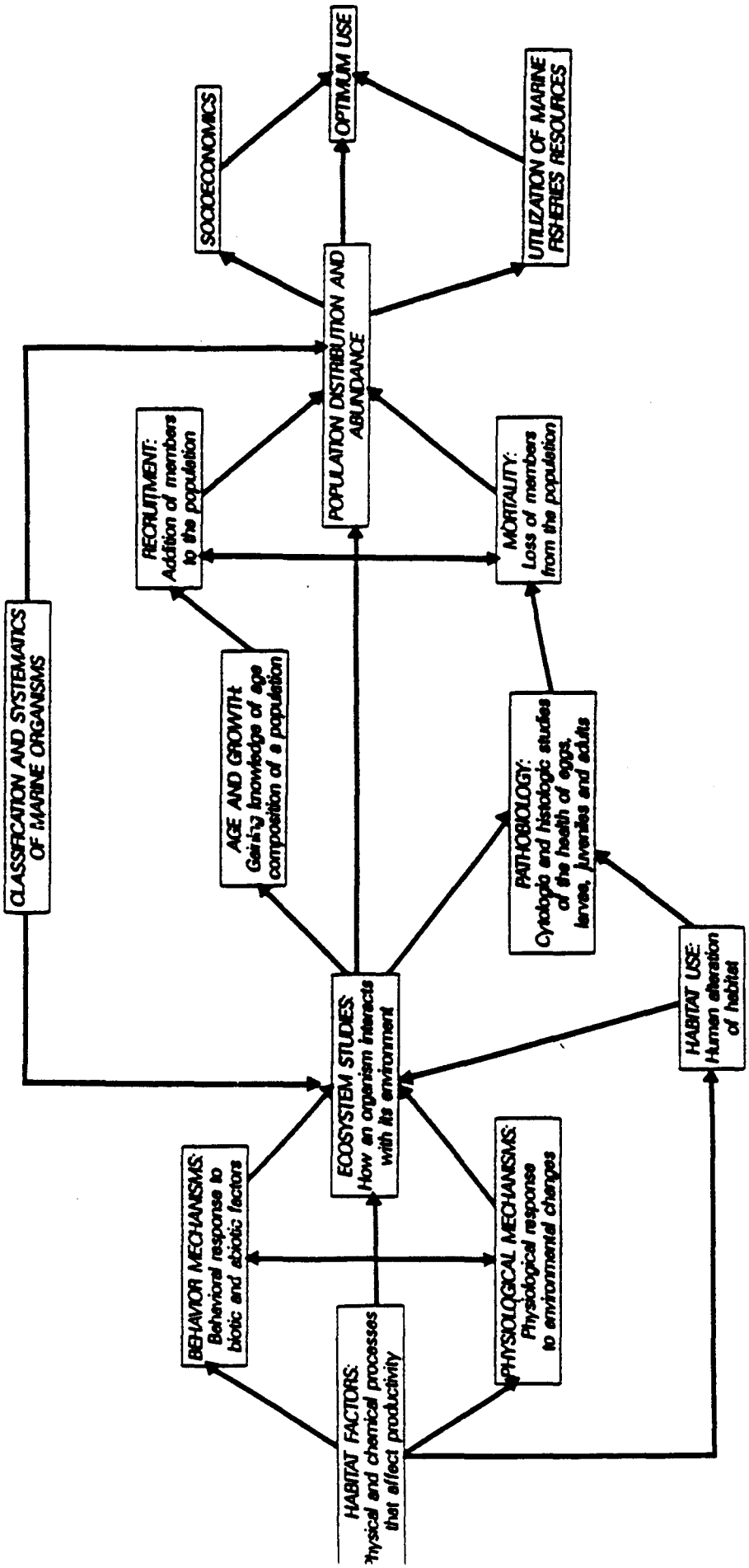

Figure 3.1. Information flow in a generalized program of marine fisheries research.

and physiological balance of certain organisms, and ultimately affect the distribution, abundance, and reproductive capacity of their populations and other populations associated with them.

3.3 RESEARCH QUESTIONS

The types of information that flow from one set of research activities to the next in a program of marine fisheries research depends, at least in part, on the research questions being asked regarding the marine fisheries system. These questions are generated by issues of concern to the users and managers of the resource, as addressed in Section 2. In a general sense, the current issues can be subsumed under four questions:

1) What are the physical and chemical processes that affect abundance of living marine resources? This question addresses the basic habitat requirements of living resources. Variability in the physical-chemical marine environment affects the biological productivity of the marine ecosystem and the abundance and distribution of living marine resources; however, the mechanisms involved are poorly understood. Physical and chemical variables that are likely to be responsible include salinity, temperature, turbulence, transport, sediment type, and dissolved oxygen.

2) What factors control, limit, and cause variability in abundance, recruitment, and utilization of living marine resources, and how can they be predicted? Annual variability in the number of animals that enter the harvestable resource (recruitment) is the primary determinant of its potential magnitude (biomass). Understanding the process that results in this variability, which usually occurs during the first year of life, is one of the principal problems in fishery science.

There are several aspects of the recruitment process that require special attention because of the relationships of the harvestable biomass to its utilization: (1) effects of the state of the spawning stock on subsequent success of recruitment to harvestable stock, where the state may be defined as weight, number, age composition, fecundity, genetics, or physiology; (2) effects of other species (predators, competitors, and prey), as well as other members of the same species, on survival of eggs, larvae, and juveniles; (3) effects of habitat availability and water quality on the parents, gametes, viability of fertilized eggs, and survival at subsequent life stages.

One would expect that without fishing the magnitude of the individual species in the harvestable biomass would vary over time, but that the total biomass would be relatively stable. Any change would be caused primarily by predation and competition, and would be influenced by the relative magnitude of the various species and the abiotic and biotic environmental factors. Fishing currently seems to be the most pervasive force of mortality on the havestable biomass of many exploited species, especially offshore forms. It is also a source of mortality that has at best a weak negative feedback to the fishery.

Fishing mortality is highly selective and disturbs the natural balance and composition of populations and communities. The extent to which fishing modifies the natural succession or replacement of species affects predictions of the composition of future harvestable biomass.

3) What are the effects of pollution and habitat degradation and loss on living marine resources and their utilization? Evidence that uses of the marine environments are having adverse effects is manifested in clues that are directly observable (e.g., fish and shellfish kills, noxious blooms of plankton, fin rot disease, carcinoma), as well as through changes that are

only immediately detectable with the use of sophisticated measuring equipment. Such events include contamination of fish flesh with toxic substances (PCBs, dioxins, PAHs, etc.), and damage to genetic material within the organism's cellular structure. To many people, the "health" of the environment may be measured by the quality and quantity of fishery products obtained from it. To others, it may be measured in terms of general aesthetics. In any event, there is a need to measure and evaluate the condition of the environment with respect to human health, ecosystem structure and function, commerce, and the aesthetic and recreational needs of society.

4) What are the methods of achieving optimal utilization of living marine resources, given that the system within which they exist is used for a variety of purposes? Utilization of living marine resources depends on capabilities to develop fishery products, socioeconomic conditions that dictate the demand for those products, and biotic and abiotic factors that control the magnitude of the harvestable biomass from which those products are obtained. Decisions affecting utilization also influence the manner in which the marine environment is used for other purposes (e.g., whale watching, mineral extraction, sand and gravel mining, port development, ocean disposal).

4.0 FORMULATION OF A CORE EMPHASIS

The preceding sections have established the context for determining the Core emphasis of NEFC. The Introduction presents the mandates, policies, and mission of DOC/NOAA/NMFS, and a philosophical definition of the Core. In Section 1, the habitat and living marine resources of the Northwest Atlantic, and the importance of these resources and their habitat to society have been identified. Resource use issues, as identified in Section 2, serve to define the information needs to which NEFC is asked to respond.

In Section 3, a historical perspective of the evolution of fisheries research is presented, moving from the basic study of natural history issues to a complex and multidisciplinary scientific profession. An effort is made in this Section to develop and present an objective, generalized marine fisheries research program. This program contains the basic ingredients researchers might select to integrate specialized knowledge into a larger view of fisheries problems in order to contribute towards their solution. Additionally, Section 3 portrays the interdependence of various research activities and further identifies and defines the scope and flow of research activities that can be applied to satisfy user needs. Finally, Section 3 presents the most important questions currently facing marine fisheries scientists who are studying the Northwest Atlantic.

Now it is necessary to draw the preceding sections together into a meaningful framework and form a Core emphasis within the NEFC research program. The limits of the framework are largely defined by NEFC's role in the study of fishery science. These limits are broad enough to include a number of options for a Core research emphasis; therefore, choice of the emphasis must be predicated upon how best to meet the needs of the primary

users of NEFC's research information and advice, and which of the various needs are most important to meet. Once the choice is made, a process should be established to align the current NEFC research program with the Core emphasis. The organization and conduct of the current NEFC research program was not a driving factor in the development of a framework for formulation of a Core research emphasis. The intent has been to minimize biases in the selection of a research emphasis that might result from consideration of existing NEFC expertise, facilities, and budget. These factors will be an important consideration in the process of implementing the Core emphasis.

4.1. NEFC'S ROLE

The Core program represents as narrow a focus as is compatible with its purpose. It is recognized that short-term exigencies and the diverse user community present a broad spectrum of needs for scientific information. Thus, while the "Core" will undoubtedly be broadened, it does not suit the value of this document to do so.

4.1.1 Mandates, Policies, and Mission

The guidance provided by the various mandates and policies of DOC/NOAA/NMFS is a hierarchy of succeedingly specific responsibilities. Topics identified in this manner include habitat, marine mammals and endangered species, anadromous fish, international fisheries, and commercial and recreational fisheries. Perhaps the most specific and appropriate of the mandates with respect to providing guidance on the conduct of research is the MFCMA, as previously discussed in Section 3. This Act directs the Secretary of Commerce to initiate and maintain a comprehensive program of fisheries research to carry out and further the purposes, policy, and provisions of the Act in order to conserve and manage the fishery resources for the optimal

benefit of the Nation. Elements of the research program identified include biological research concerning the interdependence of fisheries or stocks of fish, the impact of pollution on fish and shellfish, the impact of wetland and estuarine degradation, and other matters relating to the abundance and availability of fishery stocks. The NMFS strategic plan of 1985 provides a framework within a set of regional fishery objectives. The objectives, however, do not define what fisheries research is required.

4.1.2 NEFC as a Research Entity

The studies at one end of the continuum of research activities associated with the marine environment (Figure 4.1) focus on understanding the natural phenomena which determine the variability and sustainability of the resources. This leads into fishery science, which is more concerned with limited abstractions of the complex realities which apply to fishery resource productivity and yield. Next along the continuum are conservation and fisheries management, which are the meeting point between the artificial (man-made) system and the natural environment within which they operate. Fisheries management is accomplished primarily through public institutions because the fishery resources are a common property. The purpose of management is to balance a wide range of public and private interests, many of which are conflicting; it is concerned with attaining this purpose by adapting the artificial system to the natural environment. It is important to note that if the two are not compatible with one another, the practice may not serve the purpose. Finally, the continuum leads to issues of utilization of the resources (i.e., fish as a commodity which provides employment food, recreation) and consumption of fish as a public health and welfare issue.

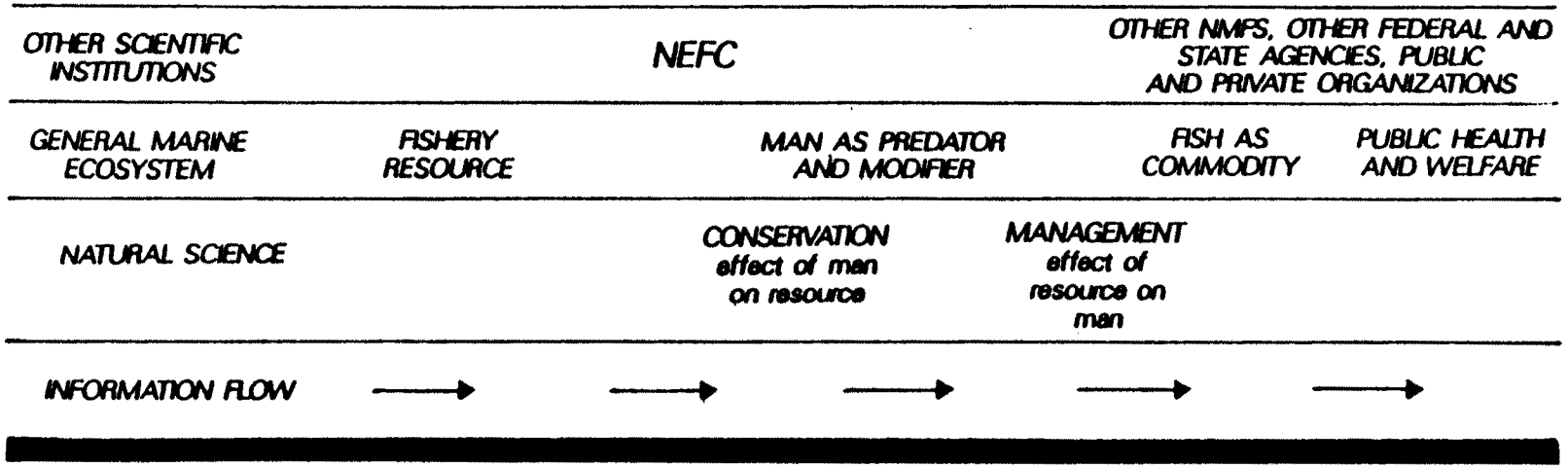

Figure 4.1. NEFC's role in the continuum of research activities to study the marine system.

4.2 OPTIONS FOR A CORE EMPHASIS

The Core emphasis should define the sets of activities that are to receive priority based on current information needs. It is also necessary to consider possible future changes in emphasis. The Core program must, therefore, not exclude options for reasonable and measured change. This requires that we balance the specific and generalized studies which will provide the flexibility to meet future needs.

Options for Core emphasis within the NEFC research program range from conducting natural science to providing advice and services to the fishery managers to promoting utilization and associated benefits. Between these bounds, a number of options exist, including a Core emphasis that has multiple foci. However, under the premise of multiple foci, the intent of the Core emphasis may not be clear, leading to diffused and possibly ineffective research effort.

4.2.1 Emphasis on Natural Science

Given NEFC's responsibilities, activities under this emphasis would address causation, or the factors which affect the state and productivity of the living marine resources. Fisheries and habitat uses would be viewed as perturbations to the natural environment (Figure 4.2A). Primary objectives of research would be understanding the overall variability of resource productivity and state, attempting to determine what and how biotic and abiotic factors (natural and man-induced) cause the temporal changes, and predicting the future state of the resource. Organism-level studies would involve classification of organisms and their diversity, and any and all relationships between them. Also involved at the organism level would be the examination of the effects of ontogeny, physiology, behavior, and pathology on mortality, growth, and reproduction of fishery resources. Responses of

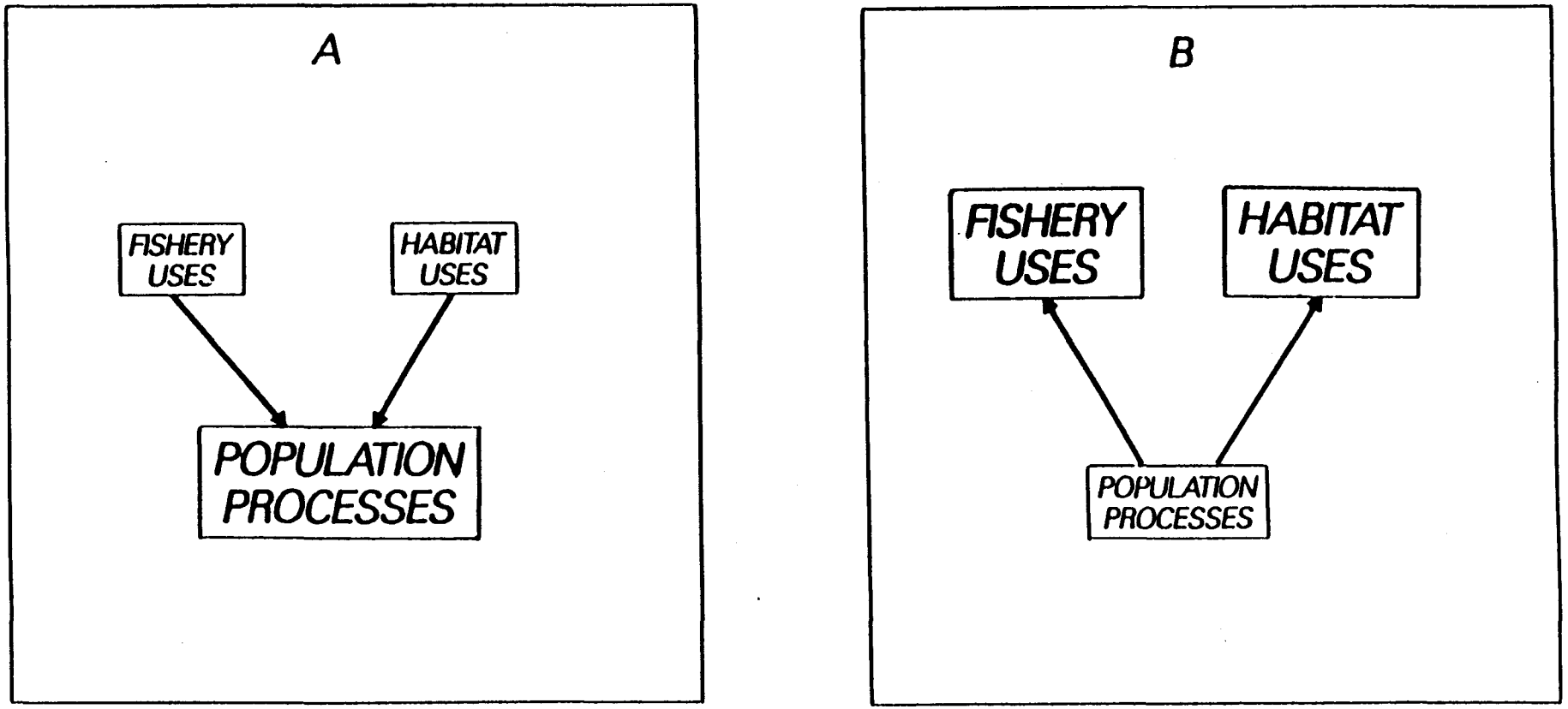

Figure 4.2.a. The marine fisheries system viewed as fishery and habitat uses acting as perturbations to the natural environment.

Figure 4.2.b. The marine fisheries system viewed as optimizing utilization of living marine resources and their habitat.

individual organisms to environmental stimuli would be measured and evaluated, as, for example, useful data for understanding migratory patterns.

Population-level studies would focus on identifying and evaluating the sources of variation in the distribution, abundance, mortality, age, and growth of fishery resources. The major issues affecting marine fisheries research (see Section 3.2) that would be addressed include the recruitment process, the long-term effects of selective fishing and pollution, and the mechanisms by which environmental variability affects fishery resource productivity.

Food web interactions and the linkages between habitat and fishery resources would be the central activities of community-level research under this emphasis. Research at the level of use-related studies would focus on examination of factors affecting catchability of fishing and sampling gear. These factors include gear avoidance behavior, and distribution of species within the water column.

An emphasis on natural science research would mean that scientists would be specialists rather than generalists, would have a greater control over the establishment of research hypotheses, and have more freedom in deciding which type of research product best suits their needs. However, the resulting research products may not be suitable for the needs of fishery managers, and may lead to criticism that NEFC is an ivory tower institution. The ability of NEFC scientists to provide quick responses to resource use issues may also be compromised with this research emphasis.

4.2.2 Services and Advice

At the other end of the range of possible research emphases for NEFC is the conduct of research activities to provide services and advice directly to fishery managers. Optimizing utilization of living marine resources and their

habitat would be viewed as the primary purpose for studying the marine fisheries system (Figure 4.2B). Products generated by NEFC with this emphasis would directly apply to fishery management and regulation, conservation, and use of the fishery resources. Information would be provided for use by decision-makers with little, if any, additional synthesis.

Organism-level studies would result in products such as: (1) definitions of fishery management units; (2) criteria for habitat and water quality; (3) recommendations for area and season closures for fisheries and other human activities to protect critical life stages or habitats; and (4) analyses of the socioeconomic impacts of pathogens on fishery utilization. Studies at the population level with emphasis on services and advice would involve providing information leading to a definition of optimum yield and monitoring individual stocks, assessing the impact of various management measures on the stocks, and developing artificial and natural methods for stock enhancement. Community-level studies would result in the definition of critical habitats, and lead directly to development of specifications for multispecies fisheries. These specifications might include allocations, optimum yield, allowable biological catch (ABCs), allowable limits for foreign fishing (TALFFs), and information and data necessary for fishery management plans as they are related to the conservation of the resources.

Use-related research activities would involve estimating the socioeconomic values and benefits of harvesting fishery resources, relating those values and benefits to domestic and world supply and demand, and evaluating the socioeconomic impacts of management measures. Methods for restoration and mitigation would also be developed and evaluated. Techniques for handling, preserving, and preparing fish products would be developed, as would techniques for improving the efficiency and selectivity of fishing gear

and resolving gear conflicts. Research activities would also include the study of product quality, marketability, and safety, and the development of fishing/processing technology.

The primary advantage of an emphasis on services and advice would be the ability to quickly respond to the information needs of managers as they address current issues. The research products would be in a form ready or nearly ready to essentially drop into the decision-making process. However, due to the lack of a defined focus for management issues, information needs tend to be diffuse. As such, research cadres would have to be maintained in a number of areas (e.g., recruitment, habitat impact, socioeconomics, product safety), and they would need to act more as generalists than specialists. Furthermore, over a period of time the issues of importance to fishery managers may change, and NEFC may run the risk of not being prepared to address new issues as they arise. Investment in the long-term information base may be forfeited in favor of "firefighting" activities. Given this scenario, NEFC scientists would have little input regarding the research undertaken.

4.2.3 A Combination of Natural Science and Services/Advice

Maintaining a research emphasis somewhere between natural science and the provision of services and advice on utilization would imply a program centered around information transfer. Natural science research would be conducted with conservation and management implications in mind. A major activity would be to synthesize and present interpretations of scientific information required for conservation and management. Modelling would probably be a common technique used by NEFC scientists under this option. Stock assessments would be conducted, from which managers could draw implications regarding potential

methods for optimizing yield. Time series data related to status and abundance of important fishery resources would become the mainstay of the NEFC information base.

This emphasis would lead to a research program with greater flexibility than could be achieved under the other options. However, there would be a risk of diluting research effort because of the wide scope of potential research that has management implications. Attempting to respond to many issues may cause precision and accuracy to suffer. The research program may also lack an identifiable focus.

4.3 RECOMMENDED CORE EMPHASIS

Based on the preceding discussion one factor is clear--NEFC has an obligation to develop an understanding of the productivity of living resources of the Northwest Atlantic, and to predict the effects of natural and man-induced changes to the ecosystem on fishery yield. In meeting its obligation, NEFC must immediately, or ultimately, respond to the information requirements of fishery managers. To realize the full potential of the Nation's fishery resources within their limits of productivity, fishery managers must develop strategies, impose management regimes and regulations, and monitor progress. As an integral part of this process, the NEFC Core emphasis must, at a minimum, be able to determine the restraints which resource productivity impose on management. Therefore, the Core emphasis can be stated as:

> Define the limits to which the habitat and living resources of the Northwest Atlantic can be modified and still assure that the living resource populations can sustain themselves at levels consistent with prevailing fishery management policies and goals.

This Core emphasis is consistent with the stated goals of the US Department of Commerce, NOAA, NMFS, and prevailing management authorities. It also represents, collectively, the mandates under which the NEFC exists and operates. The statement implies a need to understand the variability and interactions among biological, chemical, and physical processes that affect productivity of living resources, but emphasizes how modification of the processes by man's interaction ultimately affects fishery yield. It is this understanding that enables managers to assess the costs and benefits of modification. The statement also implies a need to understand the relationship between population abundance and subsequent recruitment, and to apply this knowledge to determine the level of risk (at some level of confidence) associated with the ability of a population to sustain itself under a given modification scheme. In reference to the continuum of research activities presented in Figure 4.1, the recommended Core emphasis would be centered between the effects of man as predator and modifier in the marine ecosystem, and the directed scientific research necessary to provide the information to determine those effects (Figure 4.3).

4.4 IMPLEMENTATION

The statement of Core emphasis for the NEFC research program should lead to the establishment of a revised system of research programming and accountability (Figure 4.4). Steps to arrive at this system involve ranking research priorities and associated activities in a manner that is consistent with the Core emphasis, relating the ranking to the current research program and program planning system, and determining what modifications to the current program are necessary to align it with the Core emphasis. Research activities

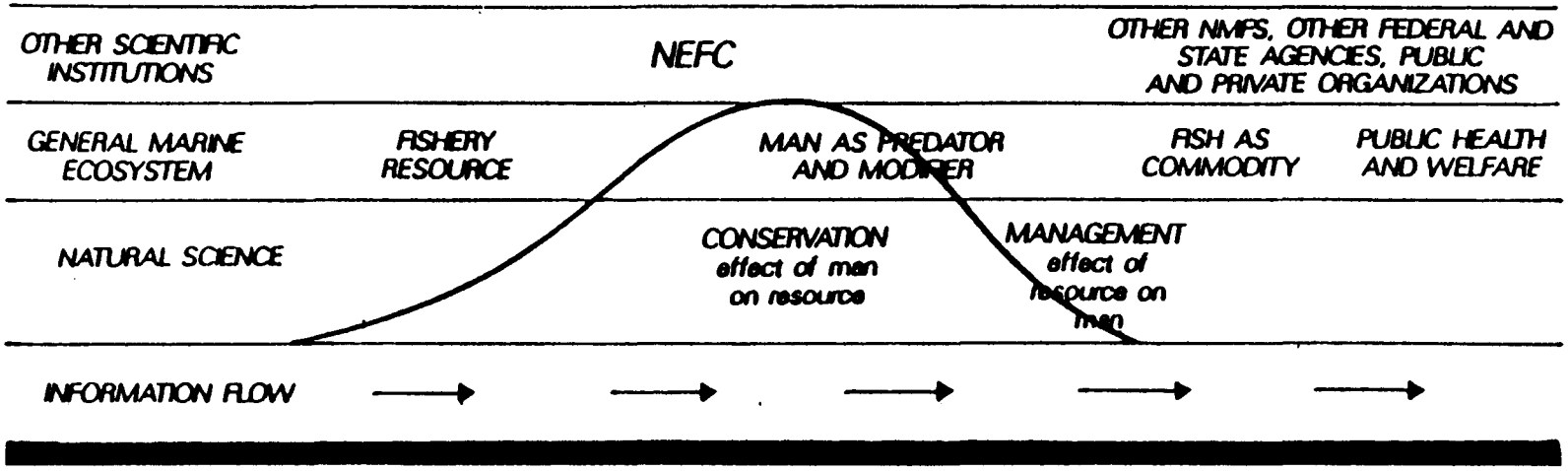

Figure 4.3. Relationship of the recommended CORE emphasis to the continuum of activities associated with a research program in marine fisheries.

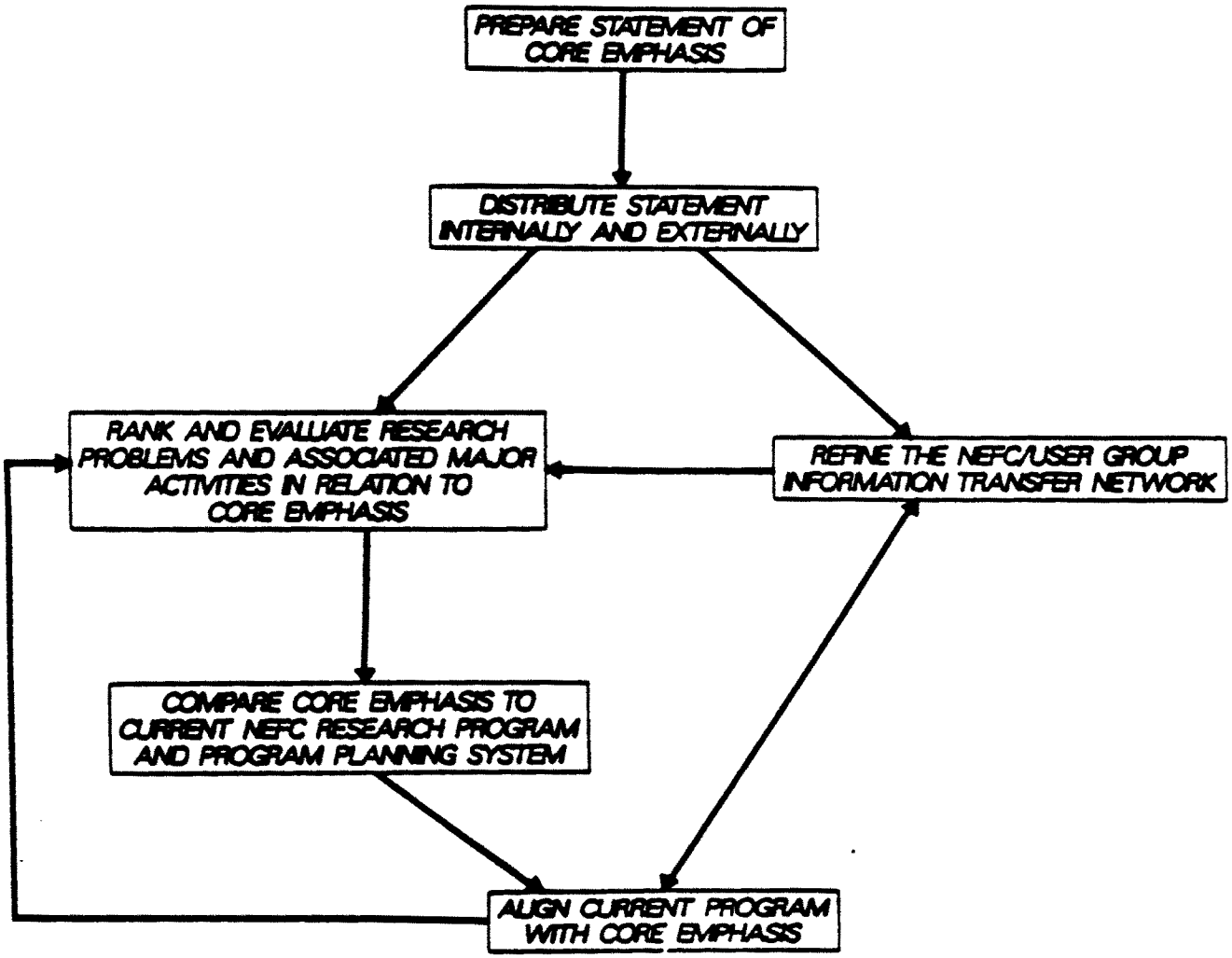

Figure 4.4. Framework for alignment of NEFC research program with the Core statement.

should address the immediate needs of fishery managers and contribute to the information base specified by the Core statement.

Incorporated in the review and ranking of research problems and associated activities is the determination of the value of information versus the cost of obtaining it. Some activities may drop out or receive low priority because the technology required to accomplish them is inadequate or too expensive. Other activities may receive higher priority because they need to be accomplished before additional activities can be undertaken. This exercise can lead to refinement and improvement in research surveys and monitoring, making them more cost-effective and responsive to information needs.

The development of a program planning model, analogous to the hypothetical model presented in Figure 4.5, may prove to be a valuable product of the process of ranking research problems and associated activities. The model can provide the framework for discussions of research priorities, and eventually serve as a research funding guide. The model should possess the following characteristics: (1) recognition of a minimum funding level below which the program cannot maintain its Core emphasis; (2) incorporation of research activities that are within the capabilities of technology and expertise (not necessarily within NEFC at the present time); and (3) identification of research activities that are necessary within NEFC's perceived role, but not within the problems and activities that receive Core emphasis.

The available budget during a given funding period establishes the number of research activities that NEFC can undertake; it also limits the level of their sophistication. There also exists a minimum budget level below which the research program cannot meet its mandates and mission. The budget does

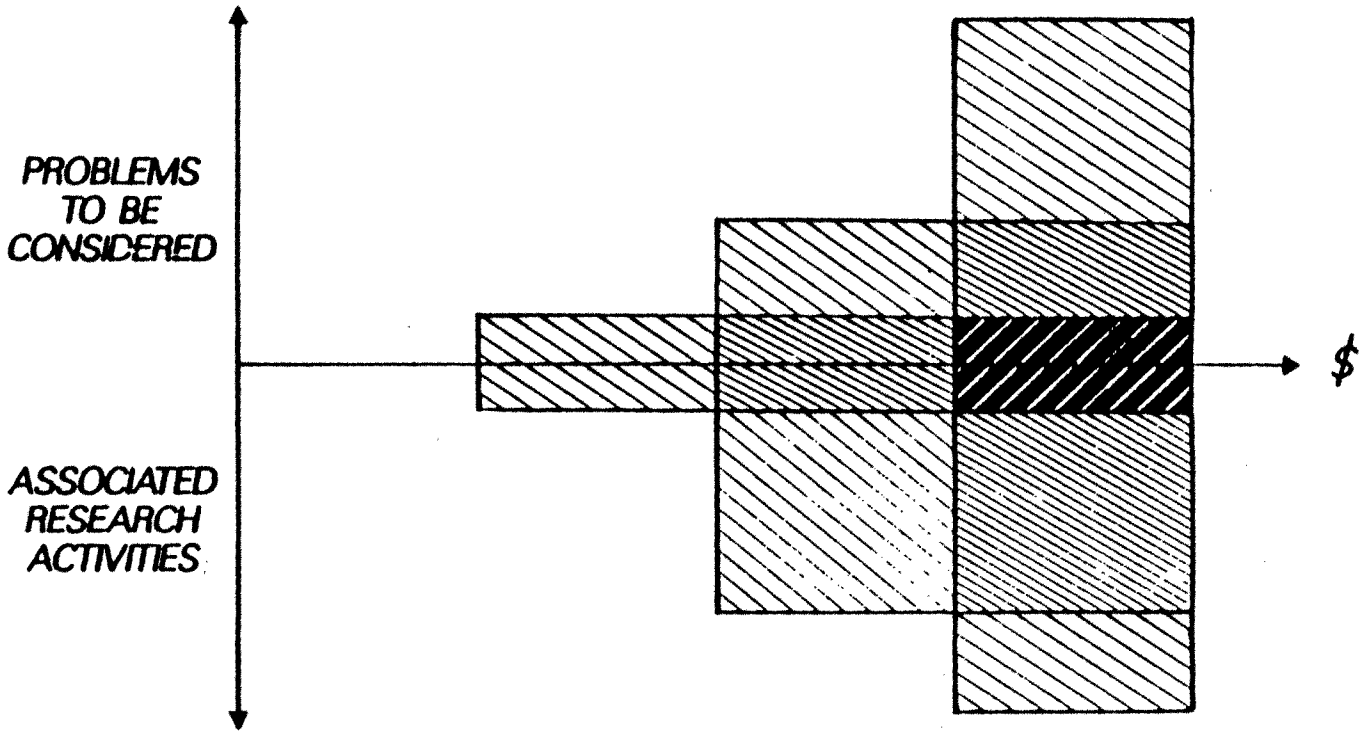

Figure 4.5. A hypothetical research planning model indicating distribution of research effort (directly related to density of shading) for each budget increment above a minimum level.

not necessarily relate to the precision or accuracy of information that can be obtained within these bounds. That is controlled, in part, by the instrumentation used to measure the environmental variables, the allocation of expertise and facilities among the various research activities, and the research design. With a given budget level choices need to be made concerning the trade-off between maintaining minimum effective size of research activities, and emphasizing those activities where immediate information needs and/or accuracy and precision in measurement are greatest at the current time. The Core should be viewed as something that the research program should build towards, and decisions on replacement of expertise, facilities, and equipment should all be made with the Core emphasis in mind.

Another important step in the establishment of a revised system of research planning and accountability is to distribute the Core emphasis statement to users of NEFC research information (Table 2.1), and ensure that their needs are addressed in the research planning and budgeting process. The NEFC should work closely with its research information users in the development of an information transfer network. Feedback from primary user groups will also be valuable in the ranking of research problems.

Development of the revised system of research planning accountability will take several years, and will involve NEFC Division, Branch, and Investigation Chiefs, the NEFC Research Council, the NMFS Regional Office, the Fishery Management Councils, the marine recreational fishing community, other federal agencies, and state agencies (Table 4.1). The Research Planning and Coordination Staff (RPAC) will assume a lead role in development and operation of the program planning system. The Research Planning and Evaluation Section of RPAC will assume lead responsibility for development and execution of the planning model, and the Research Coordination Section of RPAC will establish and operate the information transfer network.

Table 4.1 Tasks Associated with Implementation of the Core Emphasis

Task	Lead Responsibility	Others Involved
1. Prepare statement of the Core Emphasis	NEFC RPAC	NEFC Executive Board NEFC Research Council
2. Distribute statement internally and externally 2.1 Perform final editing and prepare graphics 2.2 Compile a document distribution list 2.3 Print and mail	NEFC RPAC	NEFC Public Affairs Office
3. Refine the NEFC/User Group information transfer network 3.1 Conduct user needs workshops for formal feedback 3.2 Improve informal communication network 3.3 Develop a research product distribution plan	NEFC Coordination Section	NEFC Chiefs NMFS Regional Office NMFS Headquarters NEFC Library Services
4. Rank and evaluate research problems and associated major research activities in relation to the Core emphasis 4.1 Identify problems and activities 4.2 Develop a program planning model 4.3 Relate problems and activities to user groups' schedules of information needs 4.4 Develop information value/cost functions for each activity 4.5 Evaluate program efficiency to reduce cost of information	NEFC Chiefs NEFC Research Council NEFC Research Planning & Evaluation Section NEFC Coordination Section	NMFS Regional NMFS Headquarters Primary Outside User Groups
5. Compare Core Emphasis to current NEFC research program and program planning system 5.1 Compare current ranking of problems and activities to ranking based on Core emphasis and identify inconsistencies 5.2 Evaluate how the Core emphasis relates to the current program planning system (MBOs, CYOPs) and recommend changes, as appropriate	NEFC Chiefs NEFC Research Council NEFC Research Planning & Evaluation Section NEFC Coordination Section	NMFS Regional NMFS Headquarters Primary Outside User Groups
6. Align current program with Core emphasis	NEFC Executive Board	