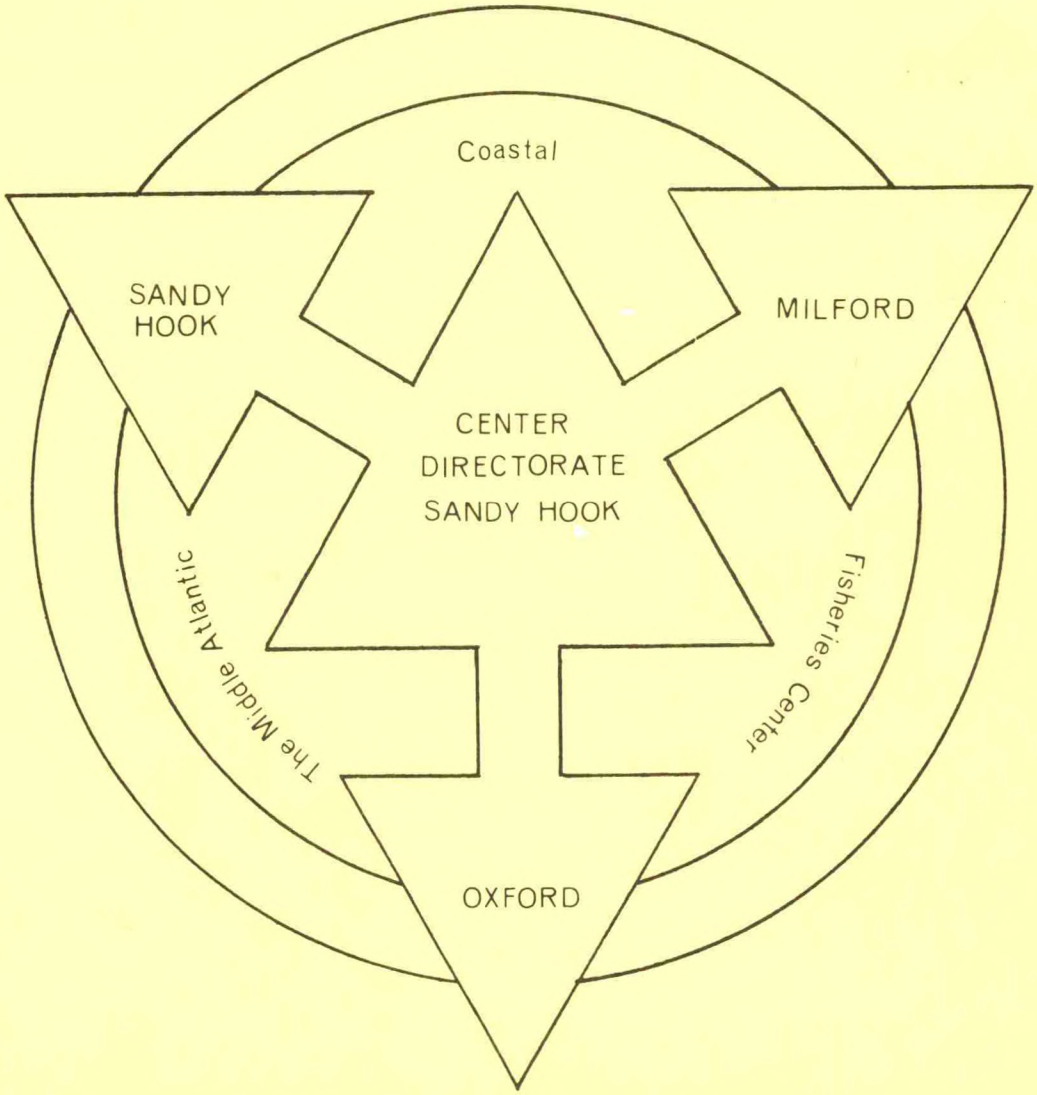
SPORT FISH EMPHASIS DOCUMENT
MIDDLE ATLANTIC COASTAL FISHERIES CENTER

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region

MIDDLE ATLANTIC COASTAL FISHERIES CENTER



Informal Report No. 15

SPORT FISH EMPHASIS DOCUMENT

National Marine Fisheries Service "

MIDDLE ATLANTIC COASTAL FISHERIES CENTER

Prepared under the direction of the Center Director

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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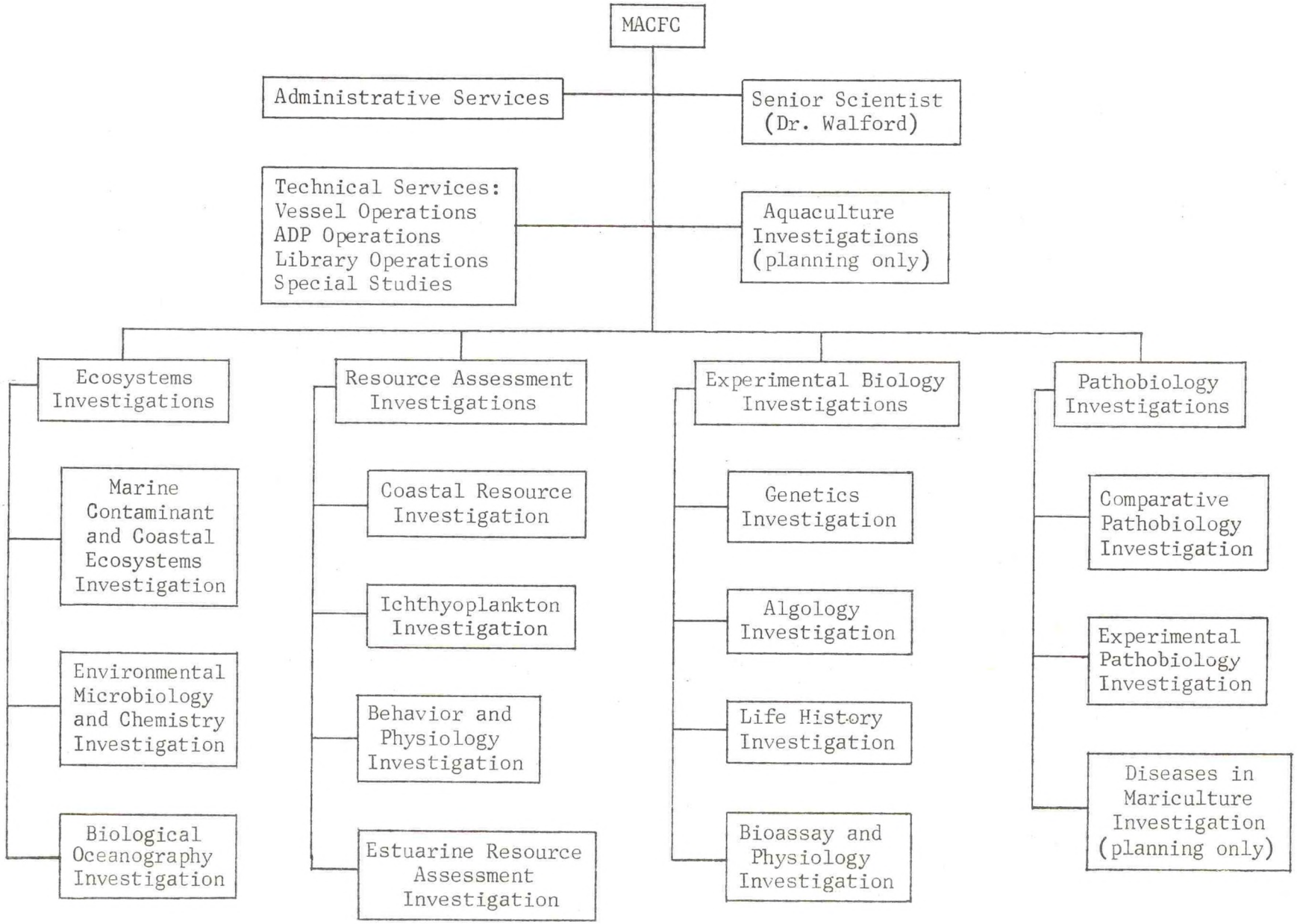
SPORT FISH EMPHASIS DOCUMENT

I. INTRODUCTION

The sport fishery of the Middle Atlantic Bight is of substantial proportions. Over 2.7 million fishermen spend 36 million fishing days annually in estuarine and marine waters pursuing this sport. The total volume of the recreational fish catch in the New York Bight is estimated to equal the volume and exceed the value of the commercial fisheries. The monetary value of sport fishing in the upper Atlantic coast area has been estimated at $850 million annually, considering time spent as a part of expenditures for the sport. A better understanding of the impact of the sport fisherman upon the marine ecosystems of the middle Atlantic coast and the resources which serve his long-term interests is needed. His impact on the industries which serve him and on the commercial fisheries must be resolved.

Traditionally, the Sandy Hook Laboratory has been the leader in Federal research on the Atlantic coast marine game fish. Today, the saltwater sport fishing program of the Middle Atlantic Coastal Fisheries Center (MACFC) derives much of its information from more extensive activities conducted by its component laboratories at Milford, Conn., and Oxford, Md., as well as Sandy Hook (Table 1). The broader spectrum of activities contributes to improved management information. As part of their research objectives, Resource Assessment surveys, Ecosystems

Table 1. Organization Chart for MACFC.



Investigations, Experimental Biology Investigations, and Pathobiology Investigations are all responsible to contribute relevant information beneficial to the sport fishermen (cf. Appendix Fig.). Such information supports competent management of the biota and the environment.

Size of the Middle Atlantic Coast Sport Fishery

It has been estimated that the number of fishermen in the middle Atlantic region has increased from about 13 to over 17 million, an approximate growth of 27% from 1960 to 1970. The volume of the catch has fluctuated regionally (Table 2). Twelve species comprised the majority of the catch (about 80%) from over 150 significant sport fish species caught. These are listed in Table 3 for 1960 and 1970. Major changes over the 10-year period were decreases in catch of flounder, fluke and cod, and increases in mackerel, weakfish, spot and puffer.

Relationship of Sport to Commercial Fishery

A comparison of the list of species which comprise the commercial catch along the middle Atlantic coast with the list of sport fish species demonstrates the extent of overlap between the two. Most of the species are, therefore, multiple-use resources. The extent of overlap between the two is subject to the unpredictability of the socioeconomic situation and natural abundance. A commercial resource today may be unacceptable or unobtainable tomorrow, while today's sport fish may be tomorrow's commercial catch. The extent of overlap between the two fisheries and some of the types that may be considered unique to a particular fishery

Table 2. Change in Angler's Harvest and Participation: 1960-70.*

	1960	1965	1970
		Number of Fish (×1000)	
Middle Atlantic	114,502	92,126	168,209
		Pounds of Fish (×1000)	
Middle Atlantic	178,000	128,288	246,267
		Anglers (×1000)	
Middle Atlantic	1,344	1,375	1,767

*Source: 1960, 1965, 1970 Saltwater Angling Surveys, BSFW and NMFS.

Table 3. Weight Ranking of Sport Fish Species Harvest: 1960-70.*

Rank	Middle Atlantic		South Atlantic	
	1960	1970	1960	1970
1	Bluefish	Bluefish	Jacks	King mackerel
2	Striped bass	Atlantic mackerel	Groupers	Jacks
3	Tunas	Striped bass	Snappers	Dolphin
4	Flatfishes	Spot	Red drum	Grunts
5	Red drum	Puffer	Black drum	Groupers
6	Black sea bass	Weakfish	Spanish mackerel	Spotted seatrout
7	Tautog	Winter flounder	Seatrouts	Porgies
8	Croaker	Perches	Grunts	Yellowtail snapper
9	Spot	Summer flounder	Porgies	Bluefish
10	Spearfishes	Sea robins	Kingfish	Snook
11	White perch	Black sea bass	Tarpon	Catfishes
12	Cod	Catfishes	Mullets	Kingfish

*Sources:

1960 - Saltwater Angling Survey, John Clark. Circular 153. BSFW. Dept. Interior.

1970 - Saltwater Angling Survey, David Deuel. Unpublished ms. NMFS. Dept. Commerce.

are suggested in Figure 1. The relative impact of the two groups is shown in reported catches of 1970 (Fig. 2).

Similarly, a latent resource today may be tomorrow's popular target. Latent resources here are defined as (1) resources about which insufficient data are known to determine the characteristics of the population, (2) resources which are not exploited for socioeconomic reasons, or (3) resources for which harvesting techniques have not yet been adequately developed. For example, at present, mackerel, tilefish and sharks could withstand far more sport fishing pressure, while the black sea bass, by virtue of habitat improvement, can be made available to the sportsman in far greater quantities.

Satisfying the Needs of Sport Fishing in the Mission Profile of MACFC

Fulfillment of MACFC's responsibilities to sport fisheries is accomplished by two basic approaches: (1) investigations are handled as major but general research foci with spinoffs of information to specific uses or users; (2) they are undertaken on the basis of need for a specific mission-oriented use. For example, species are assigned study priorities on the basis of optimum commonality of use rather than to maximize expected return from sport fishing. As another example, research either is conducted on a cradle-to-grave basis for limited numbers of species (i.e., species-intensive studies) or is concentrated at one life stage across a wide set of species (i.e., ichthyoplankton investigations). One may also argue that, since the accomplishment of marine animal research is a facilities-intensive activity, any program

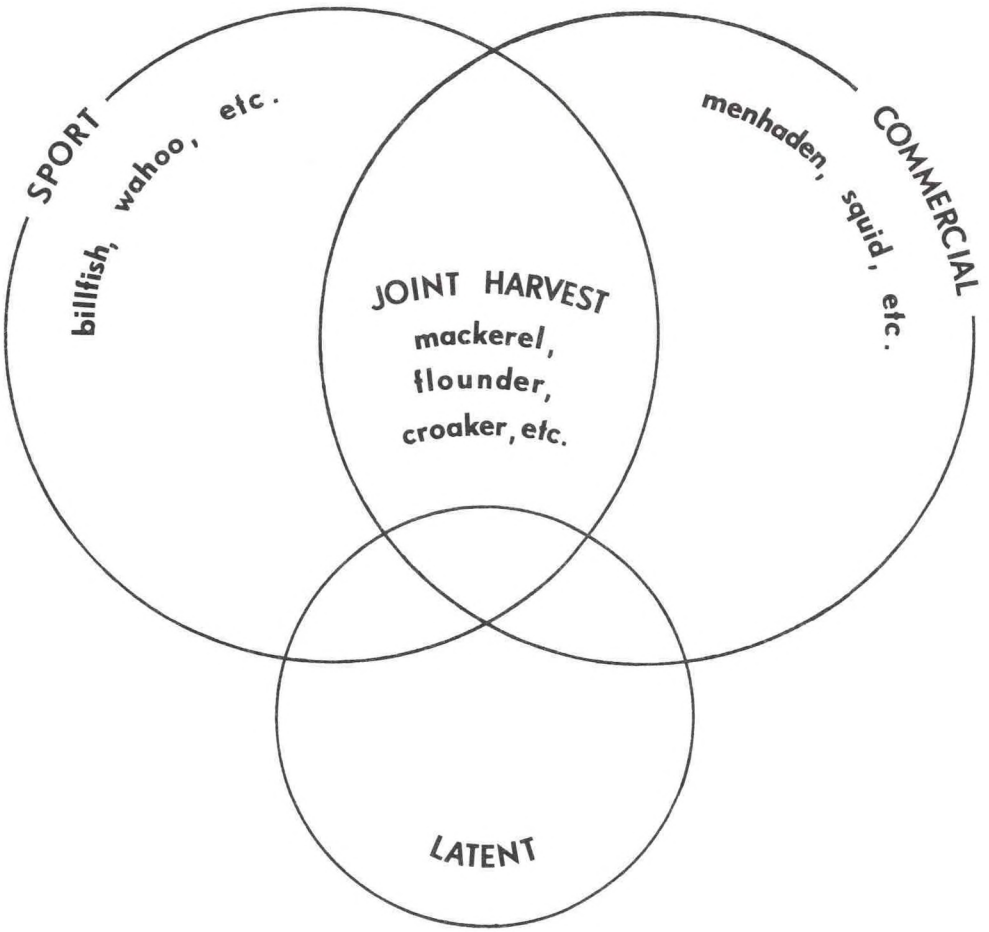


Figure 1. The relations of fisheries and fish stocks -- functions of location, density, and socioeconomic factors.

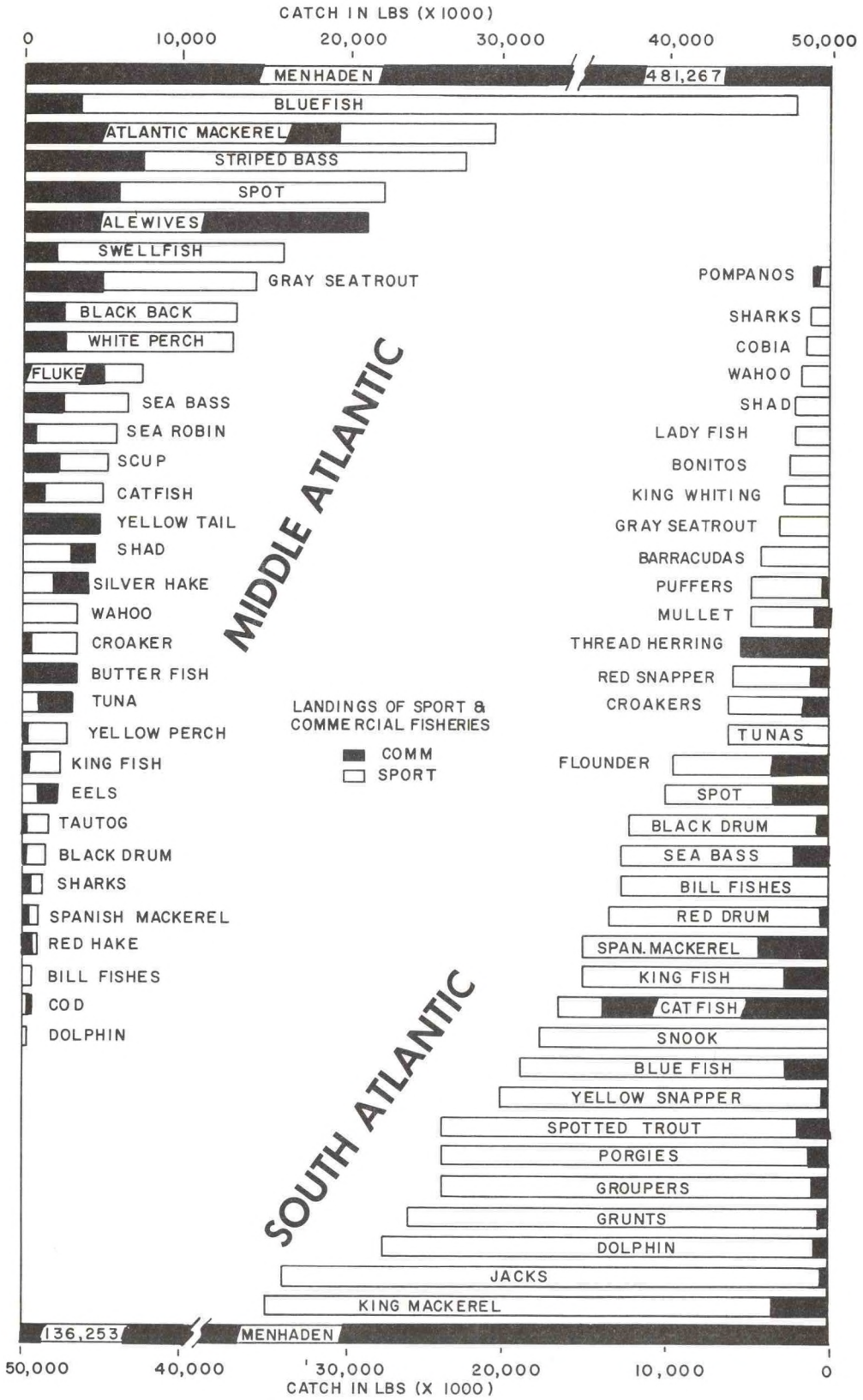


Figure 2. Landings of sport and commercial fisheries in 1970.

conducted by MACFC must have in its scheme of priorities the goal of maximizing the information captured per dollar of investment. An equally cogent-sounding argument would contend that, with limited manpower and facilities budgets, available effort should be sharply focused to conserve resources. Since the major source of information is survey, and ships are costly to procure and operate, it is the first consideration which prevails, and this is reflected in the conduct of the broad scope of the MACFC sport fishing program. Species-intensive research is only pursued to provide more complete answers concerning species of unusual significance to the users.

II. OBJECTIVES OF SPORT FISHERY PROGRAM

The objectives of the sport fishery program can be simply stated as follows:

(1) To provide the user of marine sport fishery resources with answers to questions, and information concerning:

  (a) The seasonal presence of sport fish species;

  (b) The most likely location of the species;

  (c) Effective means for catching the species;

  (d) Limits of fishing pressure conducive to good conservation practices.

(2) To provide natural resource management personnel with answers to questions, and information concerning:

  (a) The status of sport fish stocks;

  (b) Species migration patterns;

(c) The role and importance of various habitats in the life cycle of species of interest;

(d) The significance of mortality through natural predation, disease, and fishing pressure throughout the life cycle;

(e) The effect of man and his institutions on the species of interest.

(3) To provide the research community with information that can be used to expand existing knowledge of species comprising the sport fishery.

Milestones and accomplishments relevant to satisfying these objectives are measured in terms of:

(1) Completion and publication of sport fishing atlases and research papers;

(2) Completion of information base lines for specific geographical areas;

(3) Completion of information system programs; and

(4) Implementation of monitoring programs for following changes in selected species.

In each case, species is an independent variable.

Table 4 indicates recent accomplishments and those scheduled for early completion. Continuing activities are indicated, as well as future objectives.

Table 4. Some MACFC Targets or Sport Fish-Related Activities.

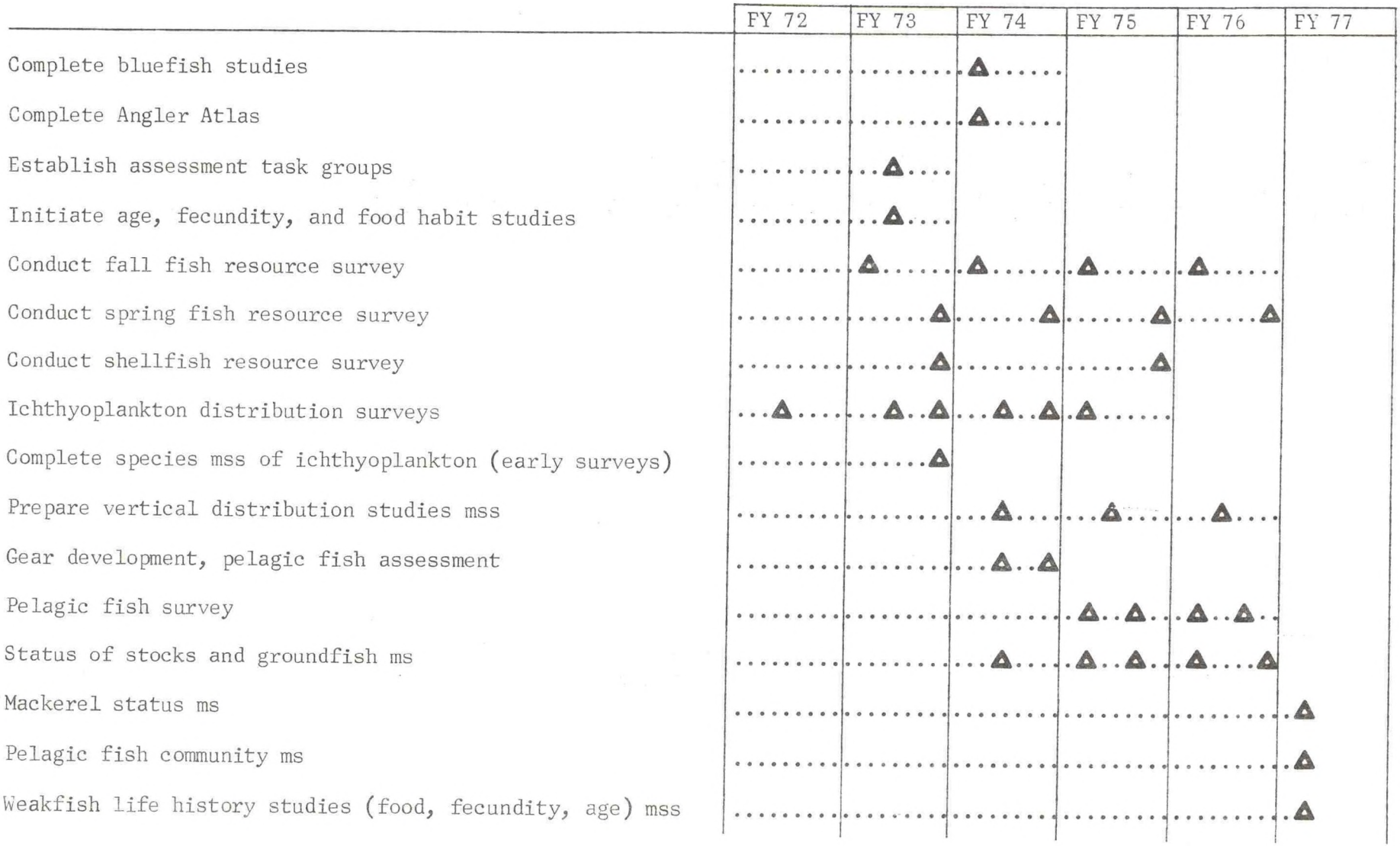


Table 4 - continued

	FY 72	FY 73	FY 74	FY 75	FY 76	FY 77
Status of shellfish stocks ms			△		△	
Initiate interview and sampling program				△		
Complete initial statistical analyses				△		
Conduct estuarine finfish and invertebrate study				△		
Tautog behavior studies	△					
Behavior studies ms		△				
Competition studies		△				
Temperature studies (mackerel)	△			△		
Initiate weakfish photoperiod activity study				△		
Establish Raritan pilot reefs				△		
Reef energy flow study					△	
Waste disposal reports -- New York Bight		△				
Heavy metal distribution study		△				
Mutagenic damage studies			△			
Fin rot and bacterial epizootiology studies			△			

III. ATTAINING SPORT FISHERY PROGRAM OBJECTIVES

Attainment of the overall sport fishery program objectives requires the concerted action of most of the MACFC activities. Major emphasis is on Resource Assessment Investigations, supported by Ecosystems, while input from Experimental Biology Investigations is necessary to assure adequate understanding for resource management purposes (see Table 1).

The MACFC components contributing to the sport fishery program objectives are summarized in Table 5. Each is characterized by a descriptive statement.

A. Resource Assessment Investigations

Objectives

- Define sport fishery stocks;
- Define the results of interactions between the biological characteristics of sport fish stocks and hydrography of the marine environment;
- Derive estimates of stock abundance.

Relevance

As a cooperative effort, MACFC has the responsibility of maintaining a continuing assessment of coastal species. A benefit from such an overview will be the ability to advise the increasing numbers of sport fishermen of the effects of his efforts and other pressures on available fish stocks.

Table 5. Hierarchy of Functional Components.

A. Resource Assessment Investigations
    1. Coastal Resource
        a. Groundfish
        b. Pelagic fish
        c. Species-intensive studies
            (1) Fecundity
            (2) Food habits
            (3) Age and growth
        d. Census of sport fishing activities and atlases
    2. Ichthyoplankton
    3. Estuarine Resource Assessment
B. Ecosystems Investigations
    1. Environmental Rehabilitation
    2. Behavior
C. Pathobiology Investigations
D. Experimental Biology Investigations
E. Aquaculture Investigations

The continued assessment of stocks will also make anglers aware of species which are available but not actively sought as game fish, and will emphasize the availability of traditional species in underfished areas.

Activities

The principal activity of resource assessment is the "Biological Field Survey," a statistical sampling of animals in accordance with a sampling plan generally defined by geographic location, water depth, time of year, and animal characteristics.

Unique biological stages or environmental situations such as egg, larvae, adult; coastal, estuarine; spring, summer, etc. are sometimes useful for allocating tasks among assessment activities.

The Field Survey generally includes the following subactivities:

(1) Development of suitable sampling method;

(2) Collection of samples and relevant associated information;

(3) Sorting, preservation, and identification of unknowns;

(4) Conversion of data to manipulatable form and correlation of biological, physical, and chemical data;

(5) Development of predictive model and verification with follow-up survey;

(6) Monitoring of system for change and prediction of population dynamics.

Figure 3 is a PERT-type diagram which shows the sequence of resource assessment activities necessary to achieve desired objectives.

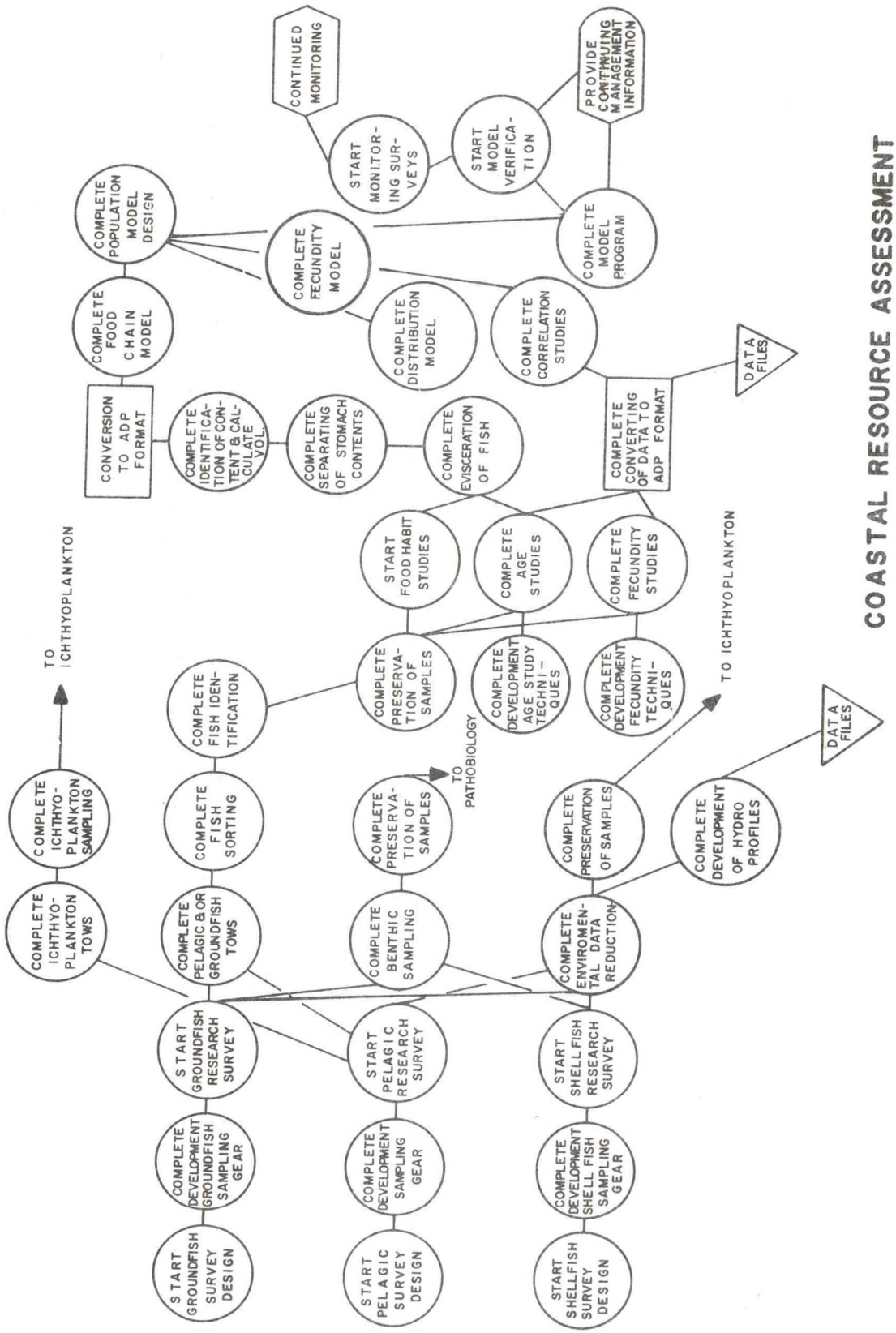

COASTAL RESOURCE ASSESSMENT
START GROUNDFISH SURVEY DESIGN
START PELAGIC SURVEY DESIGN
START SHELLFISH SURVEY DESIGN
COMPLETE DEVELOPMENT GROUNDFISH SAMPLING GEAR
COMPLETE DEVELOPMENT SAMPLING GEAR
COMPLETE DEVELOPMENT SHELL FISH SAMPLING GEAR
START GROUNDFISH RESEARCH SURVEY
START PELAGIC RESEARCH SURVEY
START SHELLFISH RESEARCH SURVEY
COMPLETE ICHTHYO-PLANKTON TOWS
COMPLETE PELAGIC & OR GROUNDFISH TOWS
COMPLETE BENTHIC SAMPLING
COMPLETE ENVIROMENTAL DATA REDUCTION
COMPLETE ICHTHYO-PLANKTON SAMPLING
COMPLETE FISH SORTING
COMPLETE PRESERVATION OF SAMPLES
COMPLETE PRESERVATION OF SAMPLES
COMPLETE DEVELOPMENT OF HYDRO PROFILES
TO ICHTHYOPLANKTON
COMPLETE FISH IDENTIFICATION
TO PATHOBIOLOGY
DATA FILES
TO ICHTHYOPLANKTON
COMPLETE PRESERVATION OF SAMPLES
COMPLETE DEVELOPMENT AGE STUDY TECHNIQUES
COMPLETE DEVELOPMENT FECUNDITY TECHNIQUES
START FOOD HABIT STUDIES
COMPLETE AGE STUDIES
COMPLETE FECUNDITY STUDIES
COMPLETE EVISCERATION OF FISH
COMPLETE SEPARATING OF STOMACH CONTENTS
COMPLETE IDENTIFICATION OF CONTENT & CALCULATE VOL.
CONVERSION TO ADP FORMAT
COMPLETE CONVERTING OF DATA TO ADP FORMAT
DATA FILES
COMPLETE FOOD CHAIN MODEL
COMPLETE POPULATION MODEL DESIGN
COMPLETE FECUNDITY MODEL
COMPLETE DISTRIBUTION MODEL
COMPLETE CORRELATION STUDIES
COMPLETE MODEL PROGRAM
START MONITORING SURVEYS
START MODEL VERIFICATION
CONTINUED MONITORING
PROVIDE CONTINUING MANAGEMENT INFORMATION

Figure 3.

1. Coastal Resource

Objectives

Provide information for assessing abundance and distribution of fishery stocks, including sport fisheries, in inshore (0-15 fathoms) and offshore (15-200 fathoms) waters.

Relevance

To establish and maintain proper management policies, a comprehensive and intensive program of biological research is necessary to assess fishery resources along the entire Atlantic coast.

Activities

Specific activities will be described in the individual subcomponents of this function.

Accomplishment

Specific accomplishments and anticipated objectives will be described in the individual subcomponents of this function.

1a. Groundfish Studies

Objectives

- Gain understanding of factors which affect life history of groundfish species (occurrence, abundance, etc.);
- Continuously monitor resource;
- Predict resource abundance and distribution.

Relevance

Many groundfish species also enter the sport fishery, while other groundfish are significant items in the food of target species.

Activities

- Evaluate existing sampling equipment;
- Continue routine survey cruises
  - (a) Seasonal sampling -- spring and fall;
  - (b) Target sampling for special studies;
- Conduct series of species-oriented studies to obtain detailed information on age/weight/growth, fecundity, and food habits.

Expected Accomplishments

- Coordinate sampling gear and format;
- Describe species distribution as a function of environmental parameters;
- Describe interaction between species;
- Determine availability and recruitment of various components of the total biomass;
- Predict stock changes on basis of juvenile abundance;
- Develop management systems to maintain biomass and yield for needs of food and recreational fisheries;
- Promote public knowledge of the resource, marine environment, and effects of utilization.

Detailed Description

Objectives

Developing a body of biological information from routine and special collections which, through integration of activities, will result in intelligent recommendations for stock management. Species

assessment (including gear evaluation) in concert with survey catch/effort, plankton data, and ecosystem impacts work toward building models for improving utilization. One significant factor is the determination of seasonal stocks of individual coastal species including migration patterns, fecundity, and growth.

Relation to Sport Fish Interest

A significant factor related to sport fishing is the abundance of benthic and near-bottom species available along the middle Atlantic seaboard. Flounders, spot, swellfish, sea bass, croaker, weakfish, and kingfish are target species which offer significant sport fishing effort and success. Many of these are estuarine-dependent, i.e., they either use the estuary as a subadult sanctuary or prey on species spawned in estuaries. Most are harvested commercially and some show long-term reductions in landings. Whether these reductions in commercial availability are due to competition with the growing sport fish harvest, overexploitation by foreign fleets, or mortalities induced by man-made changes in environment is a question that must be determined for each species. By correlating the fish density distribution with hydrographic observations such as salinity, temperature and water quality, a working hypotheses may be derived on the reason for changes in availability. Such data are necessary for documenting long-term changes, evaluating and preparing impact statements, and for preparing working reports on the status of stocks. Information on the availability of fish is necessary in the preparation of yield models for providing management advice.

Activities Necessary to Achieve Objectives

Through use of calibrated trawl and dredge catches, we can derive estimates of groundfish, including shellfish, biomass. The definition of stocks will require a complete analysis of specimens sampled during routine cruises and from those taken during special collections. In addition, we must detect any significant and persistent differences in physiological, morphological, and behavioral factors. PERT details are included in Figure 3 (Resource Assessment Investigations).

Expected Accomplishments

- Develop sampling techniques and catch coefficients for various gear configurations;
- Prepare integrated species codes and standard processing of survey catches, with regular comparisons of availability and distribution;
- Begin efforts to obtain information on effects of fishing and develop a logbook program of sport and commercial fishing success in concert with species-oriented tagging studies as a substantiating and integrating backup for statistical information of catch and effort.

Anticipated milestones are shown in Table 6.

1b. Pelagic fish

Summary Description

Objectives

- Gain understanding of factors which affect life history of pelagic species (occurrence, abundance, etc.);

Table 6. Anticipated Milestones for Coastal Resource Assessment.

	FY 73	FY 74	FY 75	FY 76
Fall survey	▲			
Coordinate data processing system		▲		
Develop coordinated species code	▲			
Develop SYMAP species display	▲			
Report fall survey, calendar year 72	▲			
Prepare field guides		▲		
Prepare briefing books	▲	▲	▲	
Gear comparison studies		▲	▲	
Status of stocks report, fall 73-74		▲		
Spring survey, calendar year 74		▲		
Status of stocks report, spring			▲	
Fall survey, calendar year 74			▲	
Status of stocks report, 73-75			▲	
Spring survey, calendar year 75			▲	
Status of stocks report, spring 73-75				▲
Fall survey, calendar year 75				▲
Status of stocks report, 72-75				▲
Shellfish survey		▲		▲

- Continuously monitor resources;
- Predict resource abundance and distribution.

Relevance

Many pelagic fishes serve as sport fish target species or as prey for sport fish.

Activities

- Evaluate existing sampling equipment;
- Develop new sampling equipment
  - (a) Direct off-bottom sampling;
  - (b) Indirect off-bottom sampling;
- Begin routine survey cruises
  - (a) Seasonal sampling -- 4/year for 36 months;
  - (b) Species selection priorities.

Expected Accomplishments

- Develop sampling technique;
- Describe seasonal distribution of species by location as a function of hydrographic factors;
- Determine interaction between species;
- Estimate abundance;
- Predict stock changes.

Detailed Description

Objectives

The objectives of the MACFC pelagic fish program will be to analyze collections of biological and physical data (obtained by a variety of collection methods) pertinent to marine pelagic fish (i.e., Atlantic

mackerel, little tuna, bluefish, weakfish, wahoo, dolphin, etc.). This program will be initiated to provide a basic biological understanding of these resources and the factors which affect their occurrence, abundance, distribution, and other aspects of their life history. Only after basic biological understanding is achieved can the ultimate goals of predicting resource availability and distribution, developing yield models, and providing scientific evidence to support conservation measures be accomplished.

Results of these pelagic fish surveys will lead to the description of:

(1) Seasonal distribution by location and associations with hydrographic characteristics;

(2) Interaction between species (i.e., food chain associations, species composition, etc.);

(3) Estimates of relative abundance, including yield, from standard methods of capture and seasonal changes in adult fish distribution;

(4) Predictions of stock changes through analysis of young-of-the-year and abundance;

(5) Adult stock dynamics, including analysis of age structure, detection of variation in age distribution along the coast, analyses of morphometric and meristic characteristics as indicators of stocks, and reproductive potential of target species.

Relation to Sport Fish Interest

Since all pelagic species along the east coast are either part of the sport fish catch or a major food item for sport fish, the results of this program will directly relate to the Atlantic coast sport fisheries. The importance of this program is emphasized by the fact that in many cases sport catches far exceed commercial landings. For example, in 1970, over 119 million pounds of bluefish were caught by sportsmen along the east coast, about 20 times more than the commercial catch of 5.8 million pounds (Fig. 2). Other sport fish species are also important along the east coast as targets for surface trolling. In 1970, the most important sport fish by weight were: Atlantic mackerel (70,732,000 lb), dolphin (28,225,000 lb), weakfish (15,684,000 lb), tunas (10,540,000 lb), and wahoo (5,556,000 lb). Data on the quantities of pelagic forage fish needed to sustain the pelagic predators are not available. There are only a few ongoing studies defining the distribution, abundance, and availability of many of these species with relation to the sportsmen, and it is doubtful if there are any studies defining the impact of sportsmen on existing pelagic stocks.

Activities Necessary to Accomplish Research Objectives

The initial efforts of this program will be directed toward evaluation of existing and development of new equipment necessary to obtain comprehensive samples of all species of interest. The problems of sampling off-the-bottom using direct and indirect techniques must be solved in order to reach meaningful conclusions from collected data.

Projected time for this initial phase will depend greatly on the degree of support for this program. A realistic lead schedule of between 18 and 24 months, depending on vessel availability, will be needed for selection, construction, and trial of gear.

Routine survey cruises will begin after direct and indirect sampling techniques are standardized and deemed to be as effective as possible. A cruise schedule for these pelagic surveys should include quarterly sampling on a continuing basis for at least 3 years. The duration and location of surveys will be dictated by the species and fishery problems of higher priority. PERT interactions are indicated in Figure 4 and anticipated milestones are shown in Table 7.

1c. Species-Intensive Studies

(1) Fecundity

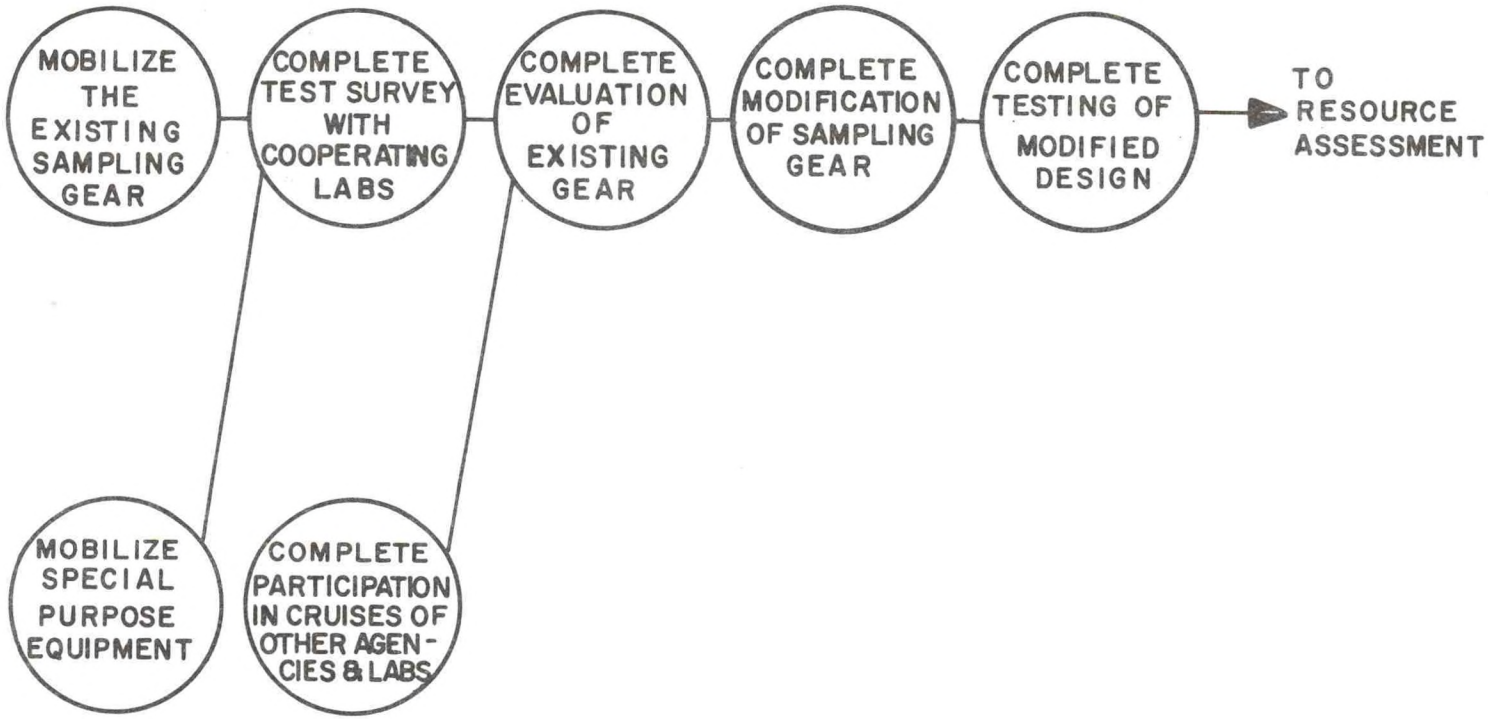
Summary Description

Objectives

- Develop method for measuring fecundity of sport fishing species;
- Determine relationship between fecundity and physical characteristics such as length, age, condition, etc.;
- Determine effect of reproductive capacity on population fluctuations.

Relevance

Sport fish management tools, such as size restrictions and spawning closures, require an understanding of fecundity and spawning for maximum sustained yields.



PELAGIC FISH

Figure 4.

Table 7. Anticipated Pelagic Fish Milestones.

	FY 74	FY 75	FY 76	FY 77
Gear development (co-op with NEFC)	....△			
Gear development (MACFC)	.....△			
Spring mackerel survey	.....△			
Fall/winter mackerel survey	.....△			
Spring mackerel survey	.....△			
Thread herring, round scad, Spanish sardine survey	.....△			
Fall/winter mackerel survey	.....△			
Mackerel status of the stock report	.....△			
Pelagic fish community report	.....△			

Activities

- Sample sport fish species during period of gonadal development;
- Develop a laboratory method for evaluating fecundity;
- Weigh, measure, and dissect fish for gonads;
- Determine age of specimens;
- Weigh and measure ovaries;
- Extract, measure, and count eggs.

Expected Accomplishments

1973:

- Processing method developed and tested on weakfish.

1974:

- Collect weakfish along entire range;
- Begin scup and sea bass collections and monitor for gonadal development;
- Report weakfish data.

1975:

- Establish method for monitoring weakfish fecundity;
- Continue monitoring scup and sea bass;
- Initiate sampling of spot and croaker.

Detailed Description

Objectives

The study and understanding of fish population dynamics are essential for rational decisions on assessment, utilization, and management of the resource. An important cause of population fluctuations requiring study

is change in the reproductive capacity of fish stocks. The objectives of this project are as follows:

(1) To develop an efficient and statistically sound method of sampling and counting eggs from a variety of fishes;

(2) To determine the relation of fecundity to size and age;

(3) To determine exact spawning times by developing a monitoring system of sampling. This system would assess gonad development, geographic variations of spawning times, and yearly changes.

(4) To determine relative fecundity of a population of fish over its entire range and define spawning stocks by comparison of differences in fecundity;

(5) To determine year-to-year changes in fecundity. Fecundity studies outlined above will be carried out on important sport and commercial fishes, and will include as a minimum weakfish, scup, fluke, black sea bass, spot, and croaker.

Relation to Sport Fish Interest

Fluctuations in the abundance of fishes have always been a problem in fisheries. To assess and predict these changes, we must understand biological characteristics of the fish, including fecundity. A biometrician must know stock spawning potential to develop a management model. Through fecundity studies, indicate the optimal population densities for sustaining stocks of important sport fish. Although other factors are involved in determining optimal stock levels, fecundity is one of the most important. Certain sport fish management

methods, such as size restrictions, can be applied most effectively if size/fecundity relationships are understood. Controlling fishing harvest during spawning times may help ensure maximum yield; however, these areas can be defined only when we know when fish spawn, as well as where.

Activities Necessary to Accomplish Research

Sampling fish for fecundity requires that samples be obtained during specific times of the year, governed by the gonad development of the species studied. Therefore, it is necessary to sample at least weekly during the spawning season. Sampling a fish species throughout its range will require that samples be submitted to private, State, or Federal cooperators' laboratories during critical times.

The development of an efficient processing method for laboratory samples will be accomplished using primarily weakfish during 1973. This method will include weighing, measuring, and dissecting each fish for gonads. Scales and/or otoliths will be removed and read for age determination. Each ovary will be weighed and measured; eggs extracted, measured, and counted. PERT details are included in Figure 3 and anticipated milestones are shown in Table 8.

(2) Food habits

Summary Description

Objectives

- To determine the effect of feeding habits upon the distribution of selected species;

Table 8. Anticipated Milestones for Fecundity Studies.

	FY 73	FY 74	FY 75	FY 76
Collect weakfish samples	....	.....	.....	.....
Process weaks in lab	....	.....	.....	.....
Determine weak fecundity	....	..... △		
Process fecundity data	....	..... △		
Publish weakfish results		....	... △	
Monitor weak fecundity		.....	.....	.....
Collect scup	....	.....	.....	.....
Process scup in lab		.....	.....	.....
Determine scup fecundity		.....	..... △	
Process data (scup)		.....	..... △	
Submit for publication			.....	... △
Collect sea bass	....	.....	.....	.....
Process sea bass in lab			.....	.....
Determine sea bass fecundity			.....	... △
Process data (sea bass)			.....	..... △
Submit for publication				.....

- To determine the characteristics of the food web of principal sport fish species;
- To determine type and quantity of food.

Relevance

The ability to predict the occurrence of sport fish depends partly on the availability and utilization of appropriate prey.

Activities

- Develop sampling procedure;
- Obtain samples from groundfish survey;
- Obtain samples from commercial fishery;
- Analyze stomach contents;
- Correlate stomach contents with size and age;
- Correlate stomach contents with geographic incidence.

Expected Accomplishment

Complete analysis of weakfish in northern range of Bight.

Detailed Description

Objectives

Carry on systematic studies of food items of selected species in order to determine the seasonal preferences of various size groups. Relate the variety of forms with seasonal availability along various sections of the coast to determine effects on food supply organisms and available fishery stock. Correlate the energy requirements, preferences, and short-term cycles in feeding activities to delineate the association of fish in various communities and to evaluate the impact of ecological change on availability of resource stocks.

Relation to Sport Fish Interest

A study of food habits is important, not only from the bearing it has on the various aspects of species biology (influence on migration patterns, growth rate, spawning, schooling, etc.) but also with regard to energy requirements of commercially important finfish and shellfish. It is essential to know the food requirements of large schools of commercial and noncommercial fishes and how they affect the food web budget. Until this is known, yield predictions cannot be refined. Effects on diet from results of man-induced deterioration of the environment will be available from Ecosystems Investigations. Continued monitoring of stomach contents on a reduced scale after the base data have been obtained is essential for relating effects of environmental variation in the forage biomass.

The results of the study would benefit all fishermen, the general population, and the scientific community by providing information of seasonal catchability and preferences for individual species. We can understand the variations in diet between stocks of fishes and possible causal factors contributing to change by defining the predator/prey relationship.

Activities

(1) Conduct a study of the food habits of several species of the family Sciaenidae, with emphasis on the weakfish. This study will be carried out along its coastal range, with the major study area concentrated in the northern part of its range. Weakfish and croaker were an important part of the middle

Atlantic fisheries from 1930 to 1949, when they constituted as much as three-quarters of the catch. After 1947, the weakfish catch declined from Virginia northward and after 1949 dropped to a low level. At present, there is some evidence of recovery, judging from increasing numbers in the New York Bight. Once our data process and analysis format is established for weakfish, it will be expanded to include other species of commercially important fishes in order to identify seasonal and long-term variability in the composition of the food web.

(2) Statistical analysis of species in the food web to evaluate preferences and feeding pressure on important prey organisms;

(3) Invertebrate distribution from stomach contents;

(4) Comparison of stomach analysis data with earlier studies to determine changes in the biomass or feeding habits of fishes.

To carry out a similarly systematic study of scup will require coordination of other Federal, State and private laboratories, and utilization of samples from groundfish surveys and commercial landings. PERT details are included in Figure 3 (Resource Assessment) and anticipated milestones are shown in Table 9.

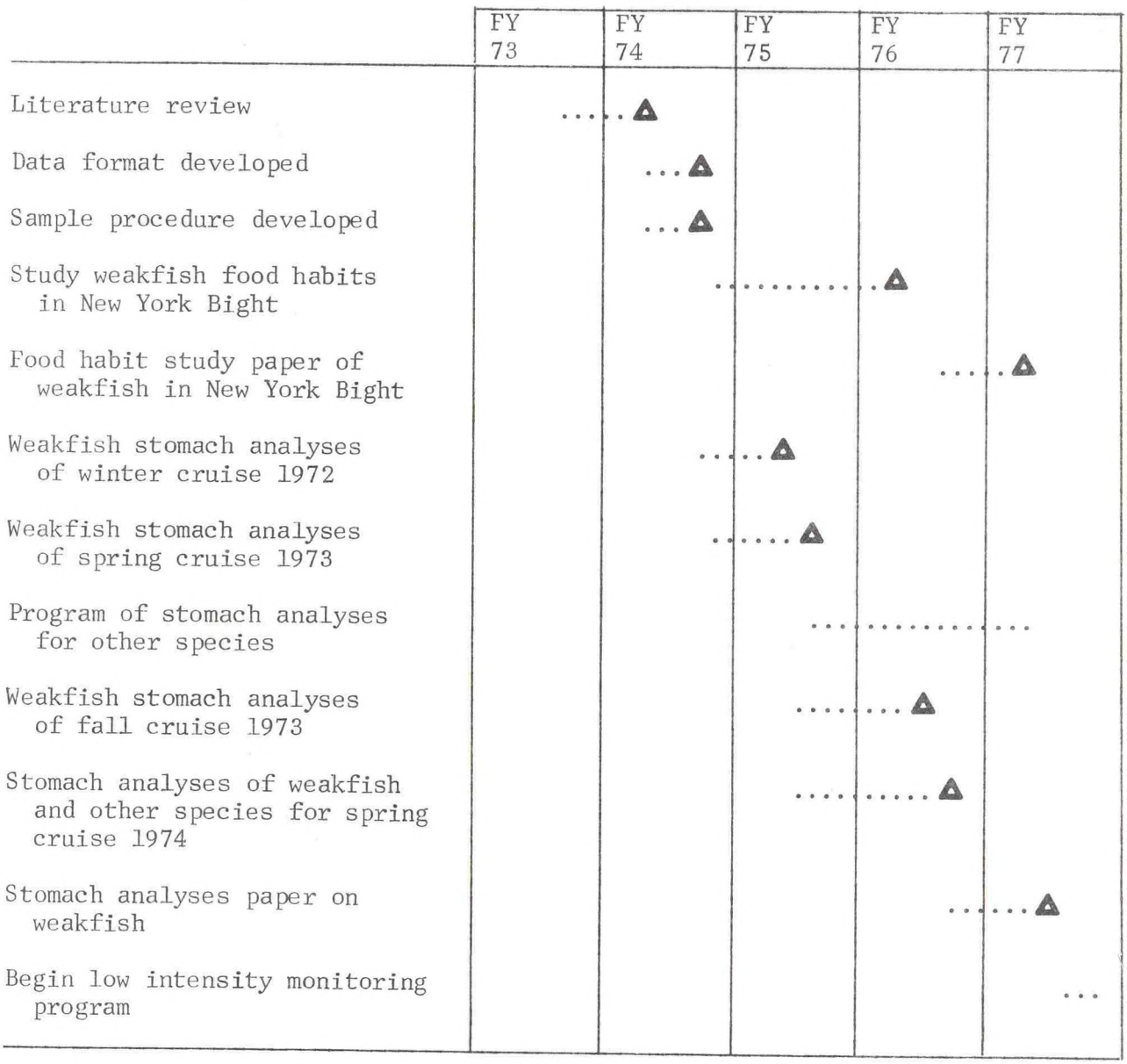
(3) Age and Growth

Summary Description

Objectives

- Establish rates of growth of a variety of demersal and pelagic species of value as sport fish;
- Establish methods for improving estimates of mortality and yield.

Table 9. Anticipated Milestones for Food Habit Studies.



Relevance

- Aging techniques necessary for determining relative contribution of successive year-classes to angler harvest.
- With size data, age provides a measure of growth rate, a necessary element in biostatistics for determining optimal harvest rates.

Activities

- Initiate sampling program (to be continued for 3 years);
- Freeze samples;
- Mount specimens;
- Initiate age determination studies;
- Initiate statistical analysis;
- Initiate ultrastructural studies.

Accomplishments

- Provide monitoring base age composition;
- Determine age-class distribution of different coastal stocks;
- Develop method for measuring seasonal growth.

Detailed Description

Objectives

The primary objectives of this program will be to establish the age and growth rate of a variety of demersal and pelagic species using various methods (i.e., scales, otoliths, etc.) and to apply these basic biological findings to an overall synoptic view of these species throughout their geographical range. Establishment of valid aging criteria is essential for determining age composition. Different stocks may be defined by discretely different growth patterns (i.e., bluefish). Other areas in

which these studies can be applied are estimating total mortality and the establishment of optimum yield. A knowledge of age and growth rate is also essential to food habit and fecundity studies. Studies have been initiated for weakfish, Atlantic croaker, kingfish, and spot.

Relation to Sport Fish Interest

Sport fish interests would benefit from management recommendations developed through these studies and implemented by State or Federal conservation agencies. Biometricians will have access to information necessary to derive recruitment, mortality, and growth estimates for population dynamics modeling. Commercial fisheries interests will be able to plan on the basis of stock monitoring to determine what exploitable fish exist and what changes in harvest are anticipated.

Activities to Accomplish Research Objectives

Develop and implement a regular sampling schedule throughout the range of a given species, utilizing groundfish and/or pelagic sampling cruises, port samples and, whenever possible, coordinated efforts of other organizations. Wet and dry laboratory facilities are essential for processing of frozen samples, age determinations, and statistical analyses. Full-time staffing is necessary for both field and laboratory procedures. Where possible, portions of the heavy workloads and special problems should be contracted to private agencies. After a basic understanding of age and growth of a species is obtained, special ultrastructural studies may be done to correlate with morphometric indices as an indicator of seasonal growth of stocks within a population. This should lead to a better understanding of geographic differences.

PERT details have been included in Figure 3 (Resource Assessment Investigations) and anticipated milestones are shown in Table 10.

1d. Census of Sport Fishing Activities and Atlases

Summary Description

Objectives

- Estimate the sport fishing pressure on fish populations;
- Describe characteristics of catch and localities.

Relevance

For many species, sport fishing utilizes the fishery resource more intensively than does commercial fishing, and there is no direct means of estimating this source of mortality.

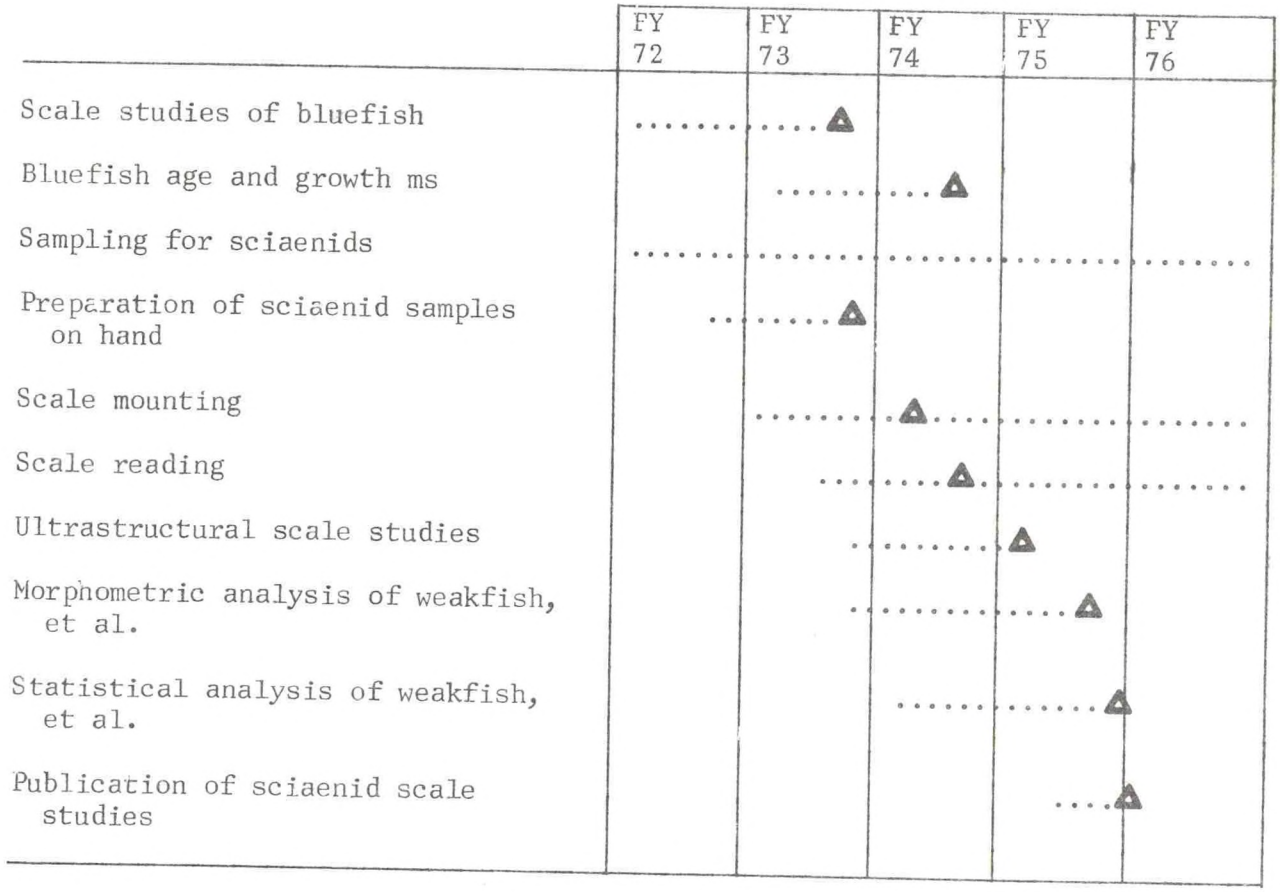
Activities

- At 5-year intervals, prepare "Saltwater Angling Surveys" in collaboration with Census Bureau;
- Conduct interviews and distribute logbooks among elements of the sport fishing community to gain information on angler behavior and details of catch;
- Cooperate with NMFS statisticians and economists in the creation of an efficient and systematic scheme for estimating angler effort, success, and catch characteristics.

Accomplishments

- There has been a general lack of funds and positions to establish a continuous monitoring of sport fishing effort and catch;

Table 10. Anticipated Milestones for Age and Growth Studies.



therefore, 1960, 1965 and 1970 estimates were obtained from household surveys.

- A sport fish atlas of species, fishing grounds, facilities, and regional characteristics of the Atlantic coast is nearing completion, based on literature reviews and interviews.

Detailed Description

Objectives

To determine the catch made by anglers and the effect this catch has on the fishery resource. Ultimately, we seek to learn the availability of our area's various species, their rates of mortality, and replacement by growth and recruitment. An estimate of angler catch is necessary to obtain our ultimate goals. By using commercial statistics and by marking groups of fish, it is possible to determine the proportionate catch by anglers, and gain needed information on migration and availability of various species.

Relevance

Fishes tend to gather in areas where temperature and food supply are favorable, and to remain as long as those conditions persist. The annual diversity of environmental features along the middle Atlantic sections of our coast attracts a parallel diversity of fishes, including boreal, oceanic, tropical and temperature species. All the fishes are represented simultaneously during the warm months, but in winter only the boreal fishes are present. Most of the nearly 200 species found in this area are migratory, with only a few residents.

The most important sport fishes by weight are bluefish, Atlantic mackerel, spot, gray seatrout, puffer, fluke, white perch, striped bass, black sea bass, flounder, croaker, and kingfish. These 12 species comprised nearly 80% of the total catch in 1970. Nearly all of these species are coastal inhabitants; that is, they are mostly concentrated nearshore.

Activities

We envision field units along the coast marking large numbers of fish and working with anglers willing to mark fish on a cooperative basis, so that each year we will obtain estimates of angler catch. Simultaneously, annual estimates of mortality by age groups will be available. The preliminary nature of this concept now precludes the establishment of benchmarks. PERT details of one approach to obtaining biostatistical information are included in Figure 5 as an adjunct to the Resource Assessment Investigations.

2. Ichthyoplankton Investigation

Summary Description

Objectives

- Determine spawning seasons of coastal fishes;
- Determine dependence on estuaries as nurseries;
- Determine geographic distribution of eggs and larvae.

Relevance

Most important, sport fish are coastal inhabitants whose hatchlings drift into shallow coastal waters or estuaries for some part of their life cycle.

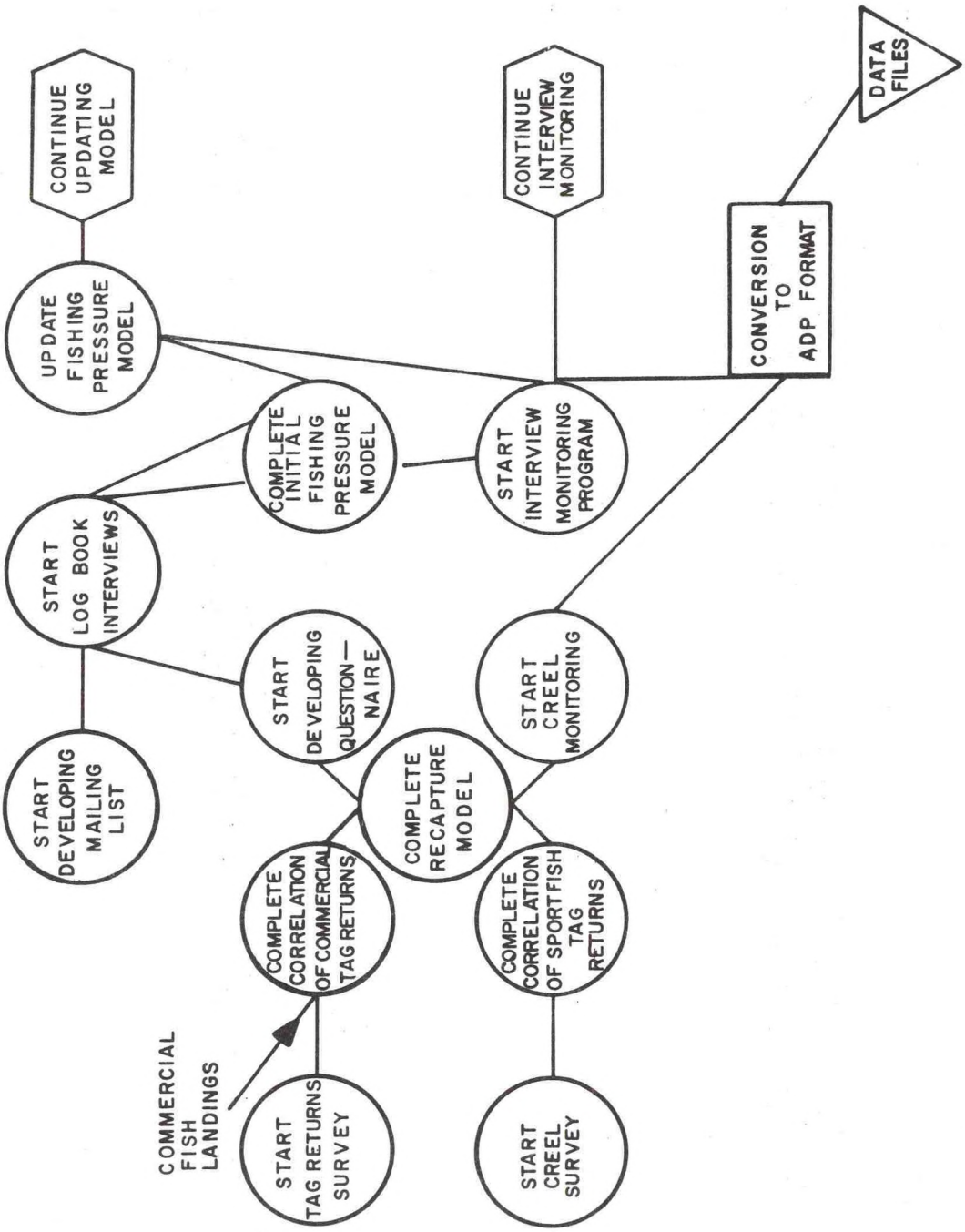

BIOSTATISTICS
START DEVELOPING MAILING LIST
START LOG BOOK INTERVIEWS
UPDATE FISHING PRESSURE MODEL
CONTINUE UPDATING MODEL
START DEVELOPING QUESTION—NAIRE
COMPLETE INITIAL FISHING PRESSURE MODEL
START INTERVIEW MONITORING PROGRAM
CONTINUE INTERVIEW MONITORING
CONVERSION TO ADP FORMAT
DATA FILES
COMMERCIAL FISH LANDINGS
START TAG RETURNS SURVEY
COMPLETE CORRELATION OF COMMERCIAL TAG RETURNS
COMPLETE RECAPTURE MODEL
START CREEL MONITORING
COMPLETE CORRELATION OF SPORT FISH TAG RETURNS
START CREEL SURVEY

Figure 5.

Activities

- Two-year field survey
  - (a) Year 1 -- 8 cruises; 92 stations; 14 transects
    -- Massachusetts to North Carolina;
  - (b) Year 2 -- 4 seasonal cruises on shelf
    -- North Carolina to Palm Beach;
- Separate plankton from samples;
- Divide plankton taxonomically;
- Identify, count, and measure species;
- Convert data to ADP and plot distributions;
- Perform correlation analyses (ADP) -- distribution versus environmental parameters.

Expected Accomplishments

Continue to work on describing geographic distribution of fish eggs and larvae, and illustrate the early stages of previously undescribed species. Study of the vertical distribution of pelagic eggs and the diel movements of larvae will continue, to provide insight into the role of oceanic currents as transport mechanisms. As an integral part of Resource Assessment Investigations, ichthyoplankton studies will provide data for estimating existing abundance and distribution of demersal and pelagic fish stocks.

Detailed Description

Objectives

Primarily, to determine the spawning seasons of coastal fishes and study the dispersion of eggs and larvae away from spawning grounds.

Secondarily, to determine the degree of dependence on estuaries as nursery grounds during postlarval and juvenile development. As subobjectives: (1) sort, identify, measure, and enumerate fish eggs and larvae; (2) conduct studies of the systematics of undescribed larval fishes of the middle and south Atlantic shelf area; (3) prepare and publish tabular, graphic, and descriptive summaries of the distribution, abundance, taxonomy, and early life history stages of fish eggs and larvae; and (4) conduct intensive studies on day/night distribution of selected fish plankton species.

Relevance

These studies will provide a data base required for interpreting results of surveys estimating recruits and adults. A measure of plankton biomass will permit independent assessment of fish stock yield potential.

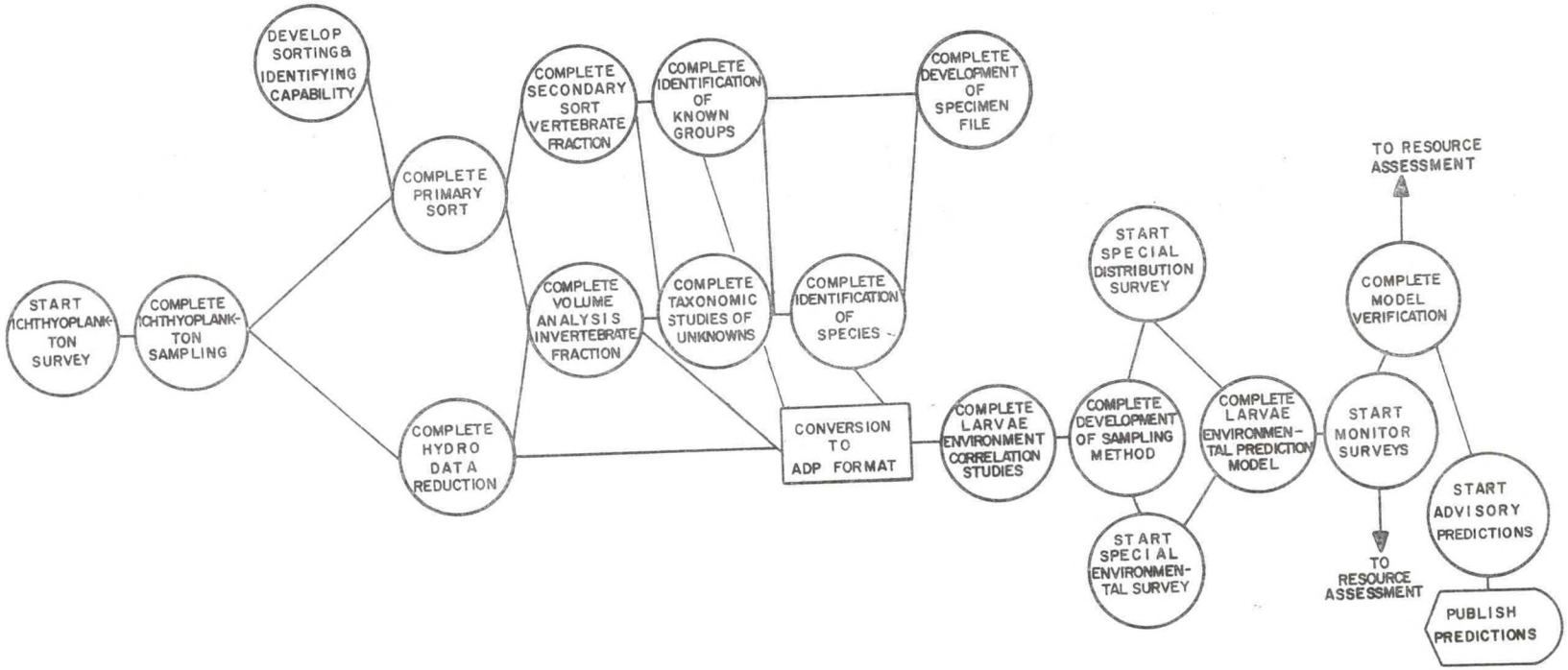
Activities

- Conduct a regular series of plankton surveys in conjunction with MARMAP I;
- Process, identify, and describe distribution of ichthyoplankton fauna;
- PERT details included in Figure 6 relate to the Resource Assessment Investigations. Anticipated milestones are shown in Table 11.

3. Estuarine Resource Assessment (a program anticipated for 1975)

Objectives

- To monitor and assess finfish and invertebrate stocks through contract surveys in major estuarine systems of the middle Atlantic coast -- Long Island Sound, Delaware Bay, Chesapeake Bay, and Pamlico Sound.



ICHTHYOPLANKTON

Figure 6.

Table 11. Anticipated Milestones for Ichthyoplankton Studies.

	FY 72	FY 73	FY 74	FY 75	POST 75
Conduct species-intensive studies (vert. dist.)	A....	.B...C..	.D...E..	..F	
Sort data A		...△			
Identify, count, measure A		...△			
Four mss of early survey data	.....	....△			
Sort data B		...△			
Identify, count, measure B			...△		
Sort data C			.....	△	
Ms of A			.....	....△	
Major ms of early survey data	.....	.....	....△		
Ms of B			...	.....	△
Identify, count, measure C				.....△	
Sort data D				.....△	
Identify, count, measure D				...	△
Sort data E				...	△
Ms of C				..	.....
Ms of D					.....
Sort data F					.....
Identify, count, measure F					.....
Ms of E, F					.....

The surveys must be continuous so that stock changes can be effectively related to fishing pressure, natural disasters, and man-made stress;

- Develop a consistent sampling system to minimize comparison error between locations and years. A common data bank for all contract findings will expedite reporting of comparative aspects. Contractors should conduct special life history studies and interpret field data for particular areas.

Relevance

Many estuarine species are caught by sport fishermen, including striped bass, white perch, weakfish, Atlantic croaker, bluefish, spot, brown bullhead, channel catfish, and white catfish. From the size and numbers of many of these species, it is obvious that the estuarine tributaries play a major role as spawning and nursery grounds, while several species utilize these waters for their entire life cycle. In addition to finfish assessment, the Investigation will monitor water quality of these tributaries to relate riverine condition to the survival of finfish stocks. The prime objective of these studies is to understand fully the role of estuaries as sanctuaries for finfish stocks and the impact of man-induced factors on estuarine fisheries.

PERT details are shown in Figure 7, but milestones are not included because these activities are tentative.

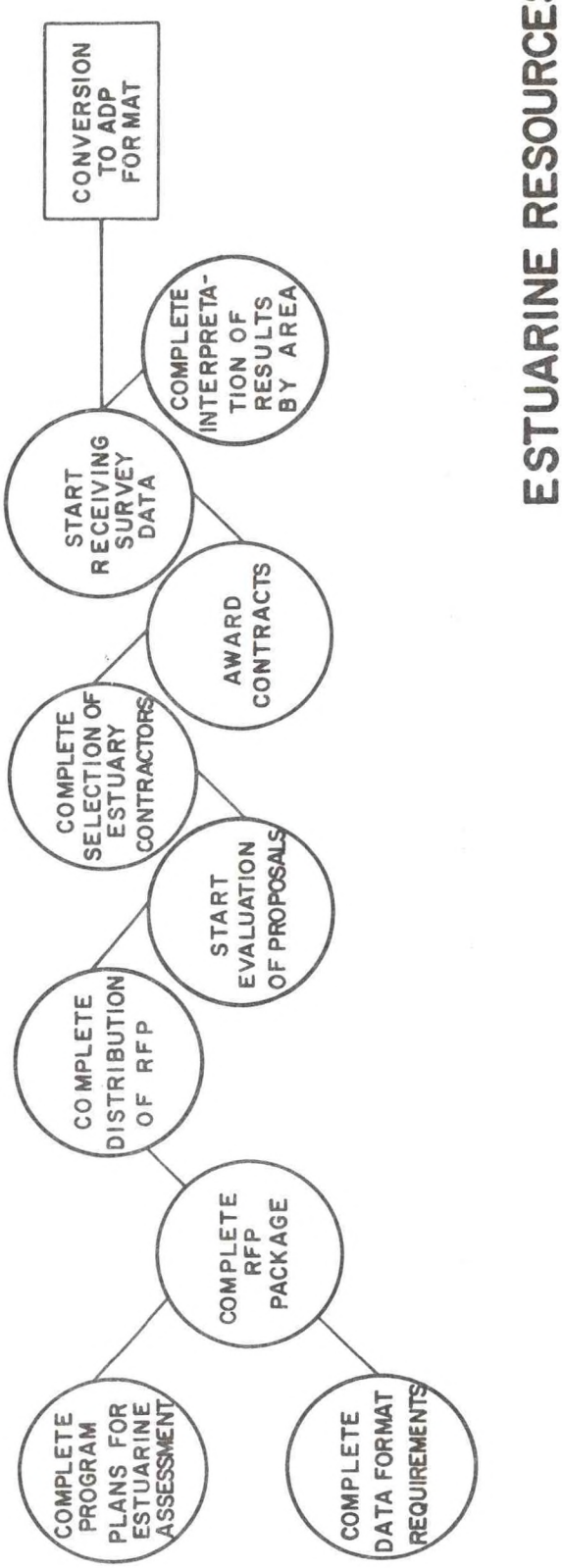

ESTUARINE RESOURCES
COMPLETE PROGRAM PLANS FOR ESTUARINE ASSESSMENT
COMPLETE DATA FORMAT REQUIREMENTS
COMPLETE RFP PACKAGE
COMPLETE DISTRIBUTION OF RFP
START EVALUATION OF PROPOSALS
COMPLETE SELECTION OF ESTUARY CONTRACTORS
AWARD CONTRACTS
START RECEIVING SURVEY DATA
COMPLETE INTERPRETATION OF RESULTS BY AREA
CONVERSION TO ADP FORMAT

Figure 7.

B. Ecosystems Investigations

Summary Description

Objectives

- Determine changes in marine fauna resulting from such activities as dredging, dumping, and thermal addition;
- Determine levels of chemical contaminants in marine biota;
- Determine distribution of microorganisms in marine animals, particularly human pathogens.

Relevance

The proximity of heavily polluted waters to urban centers and related sport fishing pressures requires improved information for protecting the sportsman and the public from health hazards, and for preserving the fishery.

Activities

- Determine capacity of marine waters to assimilate waste materials, seasonally and by area;
- Measure the spread rate of pollutants over the bottom of the New York Bight;
- Determine distribution and biomass of faunal components;
- Determine the forms of heavy metals and develop bioassay system for assessing biotic effects of exposure to metal complexes;
- Determine effects of man-induced stresses, such as dredging, dumping and thermal addition, as well as natural disasters;
- Delineate the distribution of microbial species in marine environments and their association with nutrients and chemical pollutants.

Expected Accomplishments

The impact of MESA projects is significant in relating environmental quality to the well-being of stocks and the aesthetics of fishing experience. The diversity of relevant projects and their anticipated sequencing are presented in the detailed section.

Detailed Description

Objectives

In concert with other interested groups, establish a base line of environmental information, sufficiently broad and reliable, so that future changes can be detected and impact statements completed with confidence on such activities as dredging, dumping, and thermal additions. Areas include Long Island Sound, Raritan and Barnegat Bays, and New Jersey coastal waters (as a part of a broader MESA study of the New York Bight where man-made changes are most profound).

Research is primarily concerned with benthic/zooplankton food chain studies, physiological responses to toxins and organic wastes, zoogeographic distribution of benthic populations, evolution and succession of reef structures, and surveys and analyses of the effects of man-made environmental changes on abundance and distribution of marine organisms.

Environmental chemistry and microbiology ecosystems investigations are primarily concerned with the determination of the level of chemical contaminants in marine resources, food chain organisms, and in the environment of the marine animals. They are also concerned with the distribution of microorganisms (bacteria, viruses, fungi, and algae) in the marine animals

and in the estuarine, inshore and marine environment, with particular attention to the introduction and survival of potential human pathogens in the marine environment and effects of man-made changes on the flora.

Relevance

Ecosystems analyses provide data on shellfish, forage species, and environmental degradation for assessing trends in community and population structure necessary for resource programs and management. Sport fishermen benefit from support of pollution abatement, particularly in the areas of emphasis. The high human population density of the middle Atlantic seaboard results in extraordinary recreational demands placed on the coastal and estuarine living resources.

Results of this task group will particularly affect coastal fisheries. Resource species primarily affected include American lobster, blue and rock crabs, surf, hard and soft clams, oysters and scallops, bluefish, striped bass, weakfish, tautog, herring, and menhaden. Information on food chain organisms such as polychaete worms, mysid and sand shrimp will also be available.

Evidence already points to low diversity and low biomass in portions of the New York Bight. Policymakers need information to allocate dumping practices to avoid accumulations of waste which stress or kill communities. Present knowledge of marine and estuarine ecosystems is generally inadequate for making management decisions. We must continue to determine and monitor the effects of microbial populations and chemical pollutants on the utilization of the food resources. Microbial forms may cause diseases, in fishes and humans, and restrict the use of bathing beaches.

As pollution abatement occurs, demands for saltwater recreation will increase, accompanying the increase of population and leisure time activities. Effective ways must be found to increase the sport fishing potential in coastal waters accessible to city dwellers. Artificial habitats can improve fishing in environments relatively free of pollution or other degrading factors. It is likely that artificial reefs can be used as one method of rehabilitating impoverished aquatic ecosystems, particularly where sediments cannot support normal forage.

To evaluate environmental stress, the normal patterns of responsiveness in selected marine species must be observed and quantified. The Behavior Investigation described later will be incorporated in the Ecosystems Investigations. Observations on feeding habits, activity and social behavior, including schooling and territoriality, have obvious relevance to life history studies of sport fish species.

Activities

Ecosystems Investigations are dependent on field collections of biota, sediments, and water. Laboratory studies must then be made to quantify the nature and extent of pollutants in the environment and the biota to develop ecological models for predicting the effects of stress.

Phases include:

(1) Determining capacity of marine waters to assimilate waste materials seasonally and by area;

(2) Measuring the spread rate of pollutants over the bottom of the New York Bight;

(3) Determining distribution and biomass of faunal components;

(4) Determining the forms of heavy metals and developing bioassay systems for assessing biotic effects of exposure to metal complexes;

(5) Determining effects of natural disasters as well as man-induced stresses, such as dredging, dumping, and thermal addition;

(6) Delineating the presence of microbial species in marine environments and their association with nutrients and chemical pollutants;

(7) Understanding the relationship of reef-dwelling and reef-feeding finfish to habitats and forage organisms -- information necessary for the development of reefs in deteriorated coastal waters.

All of these research phases require a similar evolutionary sequence of subactivities which include:

(1) Development of sampling methods;

(2) Collection of samples;

(3) Sorting;

(4) Preservation;

(5) Identification;

(6) Data conversion to manipulative form;

(7) Correlation analyses;

(8) Interpretation.

Some PERT details have been included in Figure 8 and anticipated milestones are shown in Table 12.

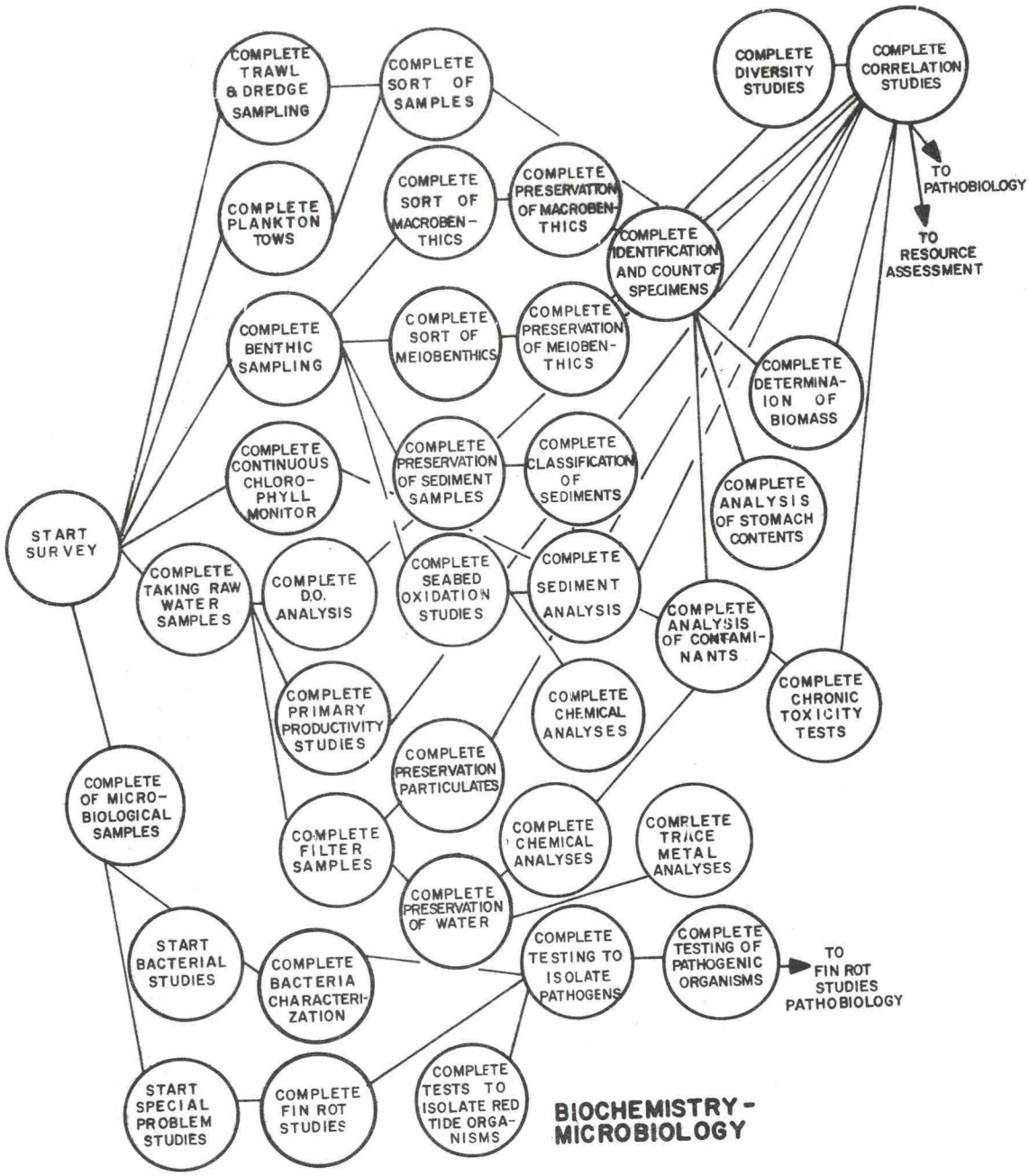

START SURVEY
COMPLETE TRAWL & DREDGE SAMPLING
COMPLETE SORT OF SAMPLES
COMPLETE PLANKTON TOWS
COMPLETE SORT OF MACROBEN-THICS
COMPLETE PRESERVATION OF MACROBEN-THICS
COMPLETE BENTHIC SAMPLING
COMPLETE SORT OF MEIOBENTHICS
COMPLETE PRESERVATION OF MEIOBEN-THICS
COMPLETE CONTINUOUS CHLORO-PHYLL MONITOR
COMPLETE PRESERVATION OF SEDIMENT SAMPLES
COMPLETE CLASSIFICATION OF SEDIMENTS
COMPLETE TAKING RAW WATER SAMPLES
COMPLETE D.O. ANALYSIS
COMPLETE SEABED OXIDATION STUDIES
COMPLETE SEDIMENT ANALYSIS
COMPLETE PRIMARY PRODUCTIVITY STUDIES
COMPLETE CHEMICAL ANALYSES
COMPLETE OF MICRO-BIOLOGICAL SAMPLES
COMPLETE PRESERVATION PARTICULATES
COMPLETE FILTER SAMPLES
COMPLETE CHEMICAL ANALYSES
COMPLETE TRACE METAL ANALYSES
COMPLETE PRESERVATION OF WATER
START BACTERIAL STUDIES
COMPLETE BACTERIA CHARACTERI-ZATION
COMPLETE TESTING TO ISOLATE PATHOGENS
COMPLETE TESTING OF PATHOGENIC ORGANISMS
TO FIN ROT STUDIES PATHOBIOLOGY
START SPECIAL PROBLEM STUDIES
COMPLETE FIN ROT STUDIES
COMPLETE TESTS TO ISOLATE RED TIDE ORGA-NISMS
BIOCHEMISTRY-MICROBIOLOGY
COMPLETE DIVERSITY STUDIES
COMPLETE CORRELATION STUDIES
TO PATHOBIOLOGY
TO RESOURCE ASSESSMENT
COMPLETE IDENTIFICATION AND COUNT OF SPECIMENS
COMPLETE DETERMINA-ION OF BIOMASS
COMPLETE ANALYSIS OF STOMACH CONTENTS
COMPLETE ANALYSIS OF CONTAMI-NANTS
COMPLETE CHRONIC TOXICITY TESTS

Figure 8.

Table 12. Anticipated Milestones for Ecosystems Investigations.

	FY 73	FY 74	FY 75	FY 76	FY 77
Rearing techniques of fish, shellfish, and crustaceans	.....	▲			
*Water quality studies	.....	.....	(cont.)		
*Acute and chronic tests	.....	.....	(cont.)		
*Osmoregulation studies	.....	.....	(cont.)		
*Acute and chronic biochemical studies (enzymology)	.....	.....	(cont.)		
*Studies of organic pollutants	.....	.....	(cont.)		
*Heavy metal bioassay	.....	.....	▲		
Genetic studies -- normal and damaged bivalves	.....	▲			
*Completion of reports on waste disposal effects in N. Y. Bight	.....	▲			
*Completion of dump site study off Delaware Bay and interlaboratory marine contaminants investigation	.....	▲			
*Determine distribution of heavy metals, coliform bacteria, and macrobenthos in the Hudson Shelf Valley	.....	.....	▲		
*Initiate sampling in the N. Y. Bight for benthic respiration, redox potential of sediments, primary productivity and water chemistry, zooplankton and benthic fauna	.....	.....	.....	▲	
*Develop techniques to determine trace metals, their forms in the marine environment, and develop sampling procedures for metals and organics at surface and sediment interfaces	.....	.....	.....	▲	

Table 12 - continued

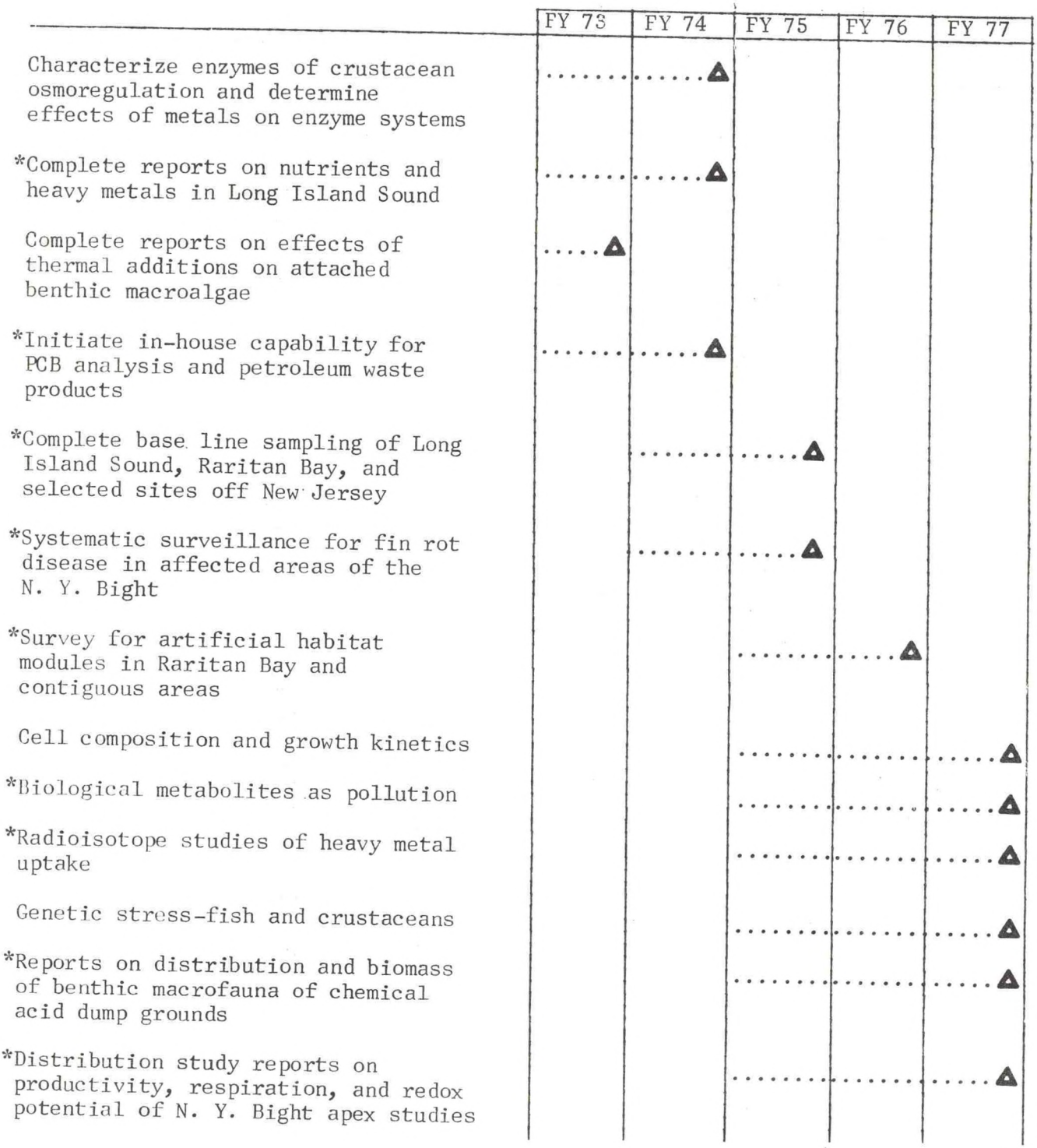


Table 12 - continued

	FY 73	FY 74	FY 75	FY 76	FY 77
*Report on nutrients, microbiology, and sediment (heavy metals)			.....	.....▲	
*Report on Raritan Bay benthic census and analysis of communities			.....	.....▲	
Models of conversion and cycling mechanisms by bacteria and chemicals			.....	.....	.....▲
*Determine bacterial clearance rates for selected invertebrates and finfish			.....	.....▲	
*Design reef modules and test apparatus for determining energy level of reef biota				.....	.....▲
*Initiate base line sampling of the entire Bight					.....

*Denotes particular relevance to sport fishing.

Recent Accomplishments

- Developed grid of sampling stations in the New York Bight and western Long Island Sound;
- Provided tissue samples from several thousand organisms for analysis of heavy metals and other toxic materials;
- Developed 50-station sampling grid in Raritan and Sandy Hook Bays of small reefs to be monitored for invertebrate and algal food species, as well as associated finfish. Analysis of benthic samples from Raritan Bay indicates a highly impoverished benthic infauna.
- Studied epizootics of fin rot disease in several marine fish. They were shown to be associated with several pathogenic bacteria which appear to be related to pollution of the environment. Causative organisms were isolated and cultured to permit laboratory experiments on the disease.
- Isolated causative agents of local red tide phenomena. Epicenters were determined, and toxins associated with red tides isolated and used in virulence experiments.
- Reports were completed on 3 years of research on effects of ocean disposal of sewage sludges and dredging spoils in the New York Bight and on an 18-month base line study of the marine environment and biota around Davids Island in western Long Island Sound;
- Initiated a study of benthic communities and heavy metals in Raritan Bay for a base line index prior to channel dredging and industrial development of the shores.

Two areas of research, those of Environmental Rehabilitation and Behavior, are highlighted in the following section because of their particular relevance to the sport fishing program.

Less detailed summaries of Pathobiology, Experimental Biology, and Aquaculture are also included. Treatment of individual topics varies somewhat in this latter section because research direction in these units does not emphasize the sport fishery. The Center does possess expertise in these disciplines and, depending on future guidelines, some sport fish problems can be resolved by these Investigations.

1. Environmental Rehabilitation

Summary Description

Objectives

- Determine the extent to which artificial habitats can be used to enhance the crop of reef-oriented finfish;
- Determine how pollutants cycle through the marine ecosystem;
- Determine the effect of man-made stresses and natural disasters on ecosystems.

Relevance

The impoverished aquatic ecosystems associated with delineated coastal estuarine environments, in proximity to metropolitan areas, can probably be rehabilitated to restore degraded sport fisheries with appropriate artificial habitats.

Activities

- Survey benthic stations in Raritan Bay for possible habitat locations;
- Determine degree of deterioration of selected sites;
- Design habitat modules;
- Replace modules;
- Conduct biological energy flow studies;
- Survey potential habitat site in Jamaica Bay or Navesink River;
- Locate two sites in dredge spoil and sludge disposal area (cooperate with MUST-COMSED submersible program).

Detailed Description

Objectives

- Through pre- and post-establishment surveys, evaluate effectiveness of various reef configurations in upgrading the population of fishes in areas which can be developed as fishable;
- Work with State and local fishery interest groups to install reefs and monitor change;
- Report on results of experimental reef installations, particularly shifts in fish community and food chain constituents and biomass.

Relevance

Pollution, dredging, and other human actions have deteriorated coastal and estuarine environments, particularly around urban areas where sport fishing should provide a primary recreational outlet. Artificial reefs can be used to rehabilitate impoverished aquatic ecosystems, particularly where existing sediments are unable to support normal forage organisms.

Even as pollution abatement progresses, bringing about an increasing demand for angling recreation, reef development offers a mode of effectively increasing potential harvest for saltwater angling.

Activities

To estimate the extent of improvement in standing crop of reef-oriented finfish and angling success in impoverished estuarine and coastal areas, establish studies such as:

(a) Determining effect of artificial habitats in polluted estuarine areas like Raritan and Jamaica Bays and offshore coastal dump areas;

(b) Determining amount and movement of toxins through habitat food webs;

(c) Calculating caloric flow through artificial and control environments.

Accomplishments

Earlier studies on construction design techniques and survey procedures have been established to a point where construction recommendations and siting processes are available to interested parties. Personnel were transferred to the Atlantic Estuarine Fisheries Center, Beaufort, N. C., to stimulate interest in utilizing this management technique in southern seaboard states. At present, funding has been curtailed.

PERT details are included in Figure 9 and anticipated milestones are shown in Table 13.

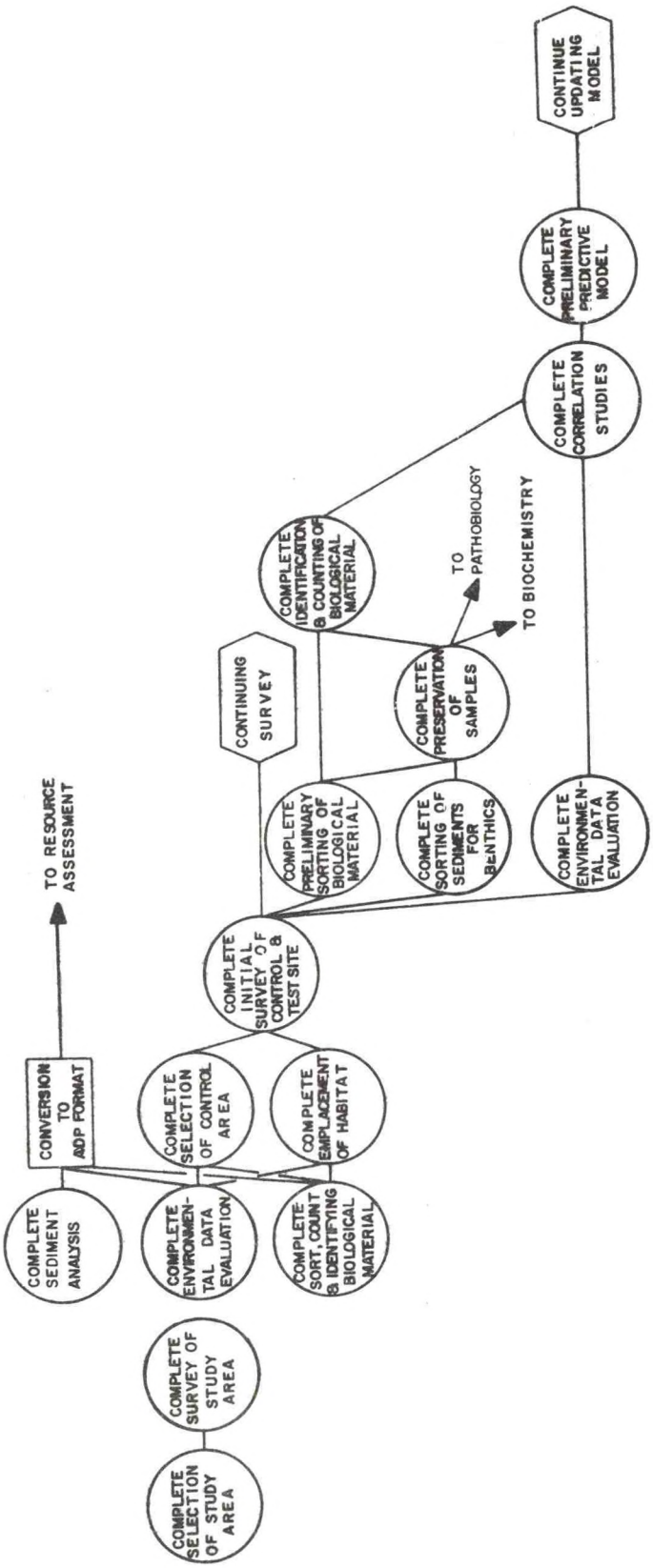

ENVIRONMENTAL REHABILITATION
COMPLETE SELECTION OF STUDY AREA
COMPLETE SURVEY OF STUDY AREA
COMPLETE SEDIMENT ANALYSIS
COMPLETE ENVIRONMEN-TAL DATA EVALUATION
COMPLETE SORT, COUNT & IDENTIFYING BIOLOGICAL MATERIAL
CONVERSION TO ADP FORMAT
TO RESOURCE ASSESSMENT
COMPLETE SELECTION OF CONTROL AREA
COMPLETE EMPLACEMENT OF HABITAT
COMPLETE INITIAL SURVEY OF CONTROL & TEST SITE
CONTINUING SURVEY
COMPLETE PRELIMINARY SORTING OF BIOLOGICAL MATERIAL
COMPLETE SORTING OF SEDIMENTS FOR BENTHICS
COMPLETE ENVIRONMEN-TAL DATA EVALUATION
COMPLETE IDENTIFICATION & COUNTING OF BIOLOGICAL MATERIAL
COMPLETE PRESERVATION OF SAMPLES
TO PATHOBIOLOGY
TO BIOCHEMISTRY
COMPLETE CORRELATION STUDIES
COMPLETE PRELIMINARY PREDICTIVE MODEL
CONTINUE UPDATING MODEL

Figure 9.

Table 13. Anticipated Milestones for Environmental Rehabilitation Studies.

	FY 73	FY 74	FY 75	FY 76	POST
Determine microfaunal species	▲.....	.....	.....	▲.....	.....
Establish Raritan Bay pilot reefs			.....	▲	
Locate Jamaica Bay and dump site reefs			.....	▲	
Establish three deep-water sites				.....	.....
Determine energy flow on reefs				.....	.....
Biotic comparison of unrehabilitated control and quality sites					.....
Quantify community succession					.....

2. Behavior

Summary Description

Objectives

- Determine the role of various environmental factors on the habits of selected marine game fish species and relate these findings to distribution, seasonal movements, patterns of migration, nursery areas, and food requirements;
- Determine the role that specific behaviors play in habitat selection, population density, distribution, and reproduction.

Relevance

Information that increases the capability of predicting the occurrence, distribution and abundance, as well as the effects of potentially detrimental environmental factors, is essential for the effective management of marine game fish resources.

Activities

- Modify controlled environmental laboratory facility;
- Determine effects of light and temperature on cycles of daily and seasonal activity;
- Determine the effect of changing temperature on normal patterns of feeding motivation;
- Examine responses of selected game fish to specific prey characteristics;
- Initiate field studies of a selected species;
- Determine day/night differences in responsiveness;
- Determine the relation between temperature and seasonal movements and abundance;

- Determine feeding habits and requirements;
- Evaluate the physical and biological habitat requirements for a specific population.

Expected Accomplishments

- Complete rapid temperature change experiments: mackerel...FY 73;
- Complete field studies of tautog;
- Complete gradual temperature change experiments: mackerel...FY 74;
- Complete field studies of tautog-cunner competition;
- Begin weakfish experiments: ...FY 75;
- Begin field studies in tautog homing.

Detailed Description

Objectives

The continuing goal is to gain a species by species understanding of important marine fishes and their relations with the environment and with related species. Certain behavioral features, qualitatively and quantitatively described, will be used to characterize the capacity for survival of selected species. These will be used as normal indices to evaluate responses and tolerance limits to temperature and other environmental factors. Although individual studies may be of short duration, the scope of the problem is, of necessity, long range.

Completion of studies depends on the determination and quantification of specific behaviors, especially feeding, feeding motivation, day/night and seasonal activity cycles and, in some instances, social interactions. Base line information will be applied in determining possible effects of a variety of potential stresses within the marine environment.

Relevance

To date, both the field and laboratory behavior studies have concentrated on a number of important game fish, including bluefish, summer flounder, Atlantic mackerel, winter flounder, and tautog.

Knowledge of marine game fish behavior contributes directly to our understanding of their life patterns -- information which can ultimately be used in predicting abundance and distribution and serve as an important management tool. Until recently, behavioral information about most marine fish species was derived indirectly from various field samples and reports of sport and commercial fishermen. These sources were essential in advancing knowledge of the movements, distribution, and abundance of certain fishes as related to biotic and abiotic causes, but did not reveal the underlying causes for specific responses to individual or sets of stimuli. By observing and defining patterns of behavior for selected marine fish species under both laboratory and field conditions, we will be better able to determine the limits of various environmental factors, and how specific behaviors might affect the growth, density, and distribution of a population.

Activities

Laboratory investigations of selected species demonstrate the role of light and temperature as well as their seasonal movements and distribution. Studies on feeding habits examine the interaction between feeding and activity to show how environmental factors, such as temperature, affect appetite and motivation to feed. Other specific characteristics, such

as prey size, are studied to determine their influence on predator feeding motivation. Present studies on Atlantic mackerel are measuring response to rapid changes in temperature in order to evaluate how this might affect their distribution and availability in the sea.

Subsequent field studies concentrated on defining the relationship between a selected population of tautog and both artificial and natural underwater habitats. Various aspects of the species' home range and homing sense are being determined by underwater observations and sonic tracking.

Accomplishments

Recent observations on summer flounder revealed the importance of vision in the specialized behavior patterns characteristic of active food search and prey capture. Although they are primarily an inshore and coastal sport fish, we found these fish especially well-adapted for moving long distances at sea with minimal expenditures of energy, gliding from surface to bottom using body shape and natural negative buoyancy to best advantage.

Field studies begun several years ago on winter flounder showed that this animal was primarily a day-active species, feeding and moving about during the day and inactive at night. Contrary to reports in the literature, we found a large population of winter flounder feeding and thriving in inshore areas during the summer, at temperatures higher than expected. These fish were readily available for capture, especially by hook and line, providing a potential recreational resource at this time of the year.

We found basic differences in the relation of young adult and older adult winter flounder to specific underwater habitats which have a direct bearing on population management in inshore areas. We are also continuing a study of the various trophic levels utilized by and available to this species, and how dependence on certain foods relates to life habits and movements. This species and other northern inshore benthic species represent an important present and future recreational fishery because of their availability and the ease with which they are caught. The basic information we are compiling on their behavior should influence management plans for optimizing abundance and distribution of these species.

PERT details have been included in Figure 10 and anticipated milestones are shown in Table 14.

The following sections include less detailed descriptions of Center studies because these Investigations are only tangentially directed toward sport fish interests, although PERT-type evaluation of interaction with other sport fishing activities has been provided.

C. Pathobiology

Objectives

Recognizing that susceptibility of aquatic poikilotherms to disease is influenced by environmental factors and biotic and abiotic stress conditions, a laboratory function is to identify, classify, and describe infectious and noninfectious diseases affecting feral and cultured marine fish and shellfish.

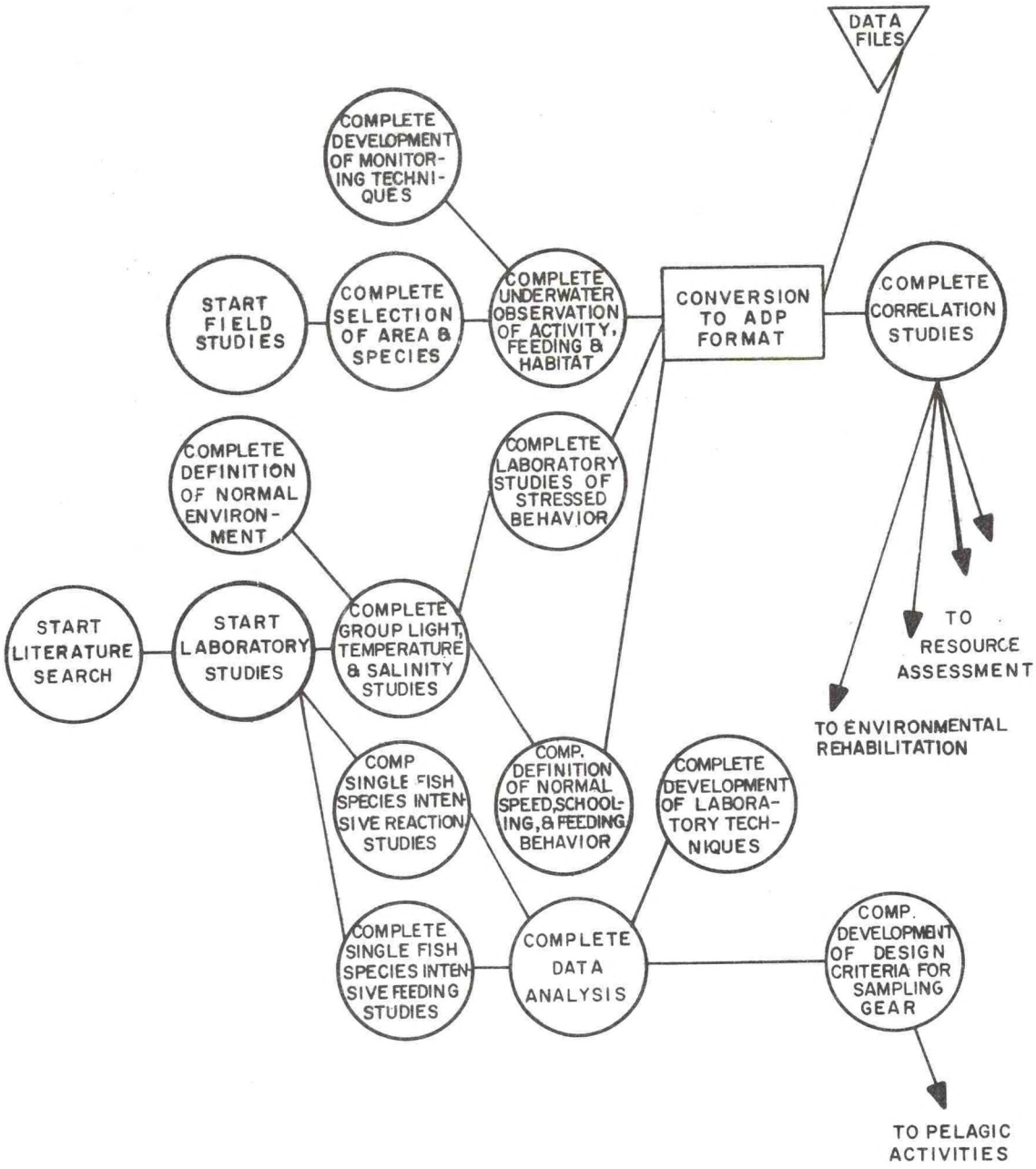
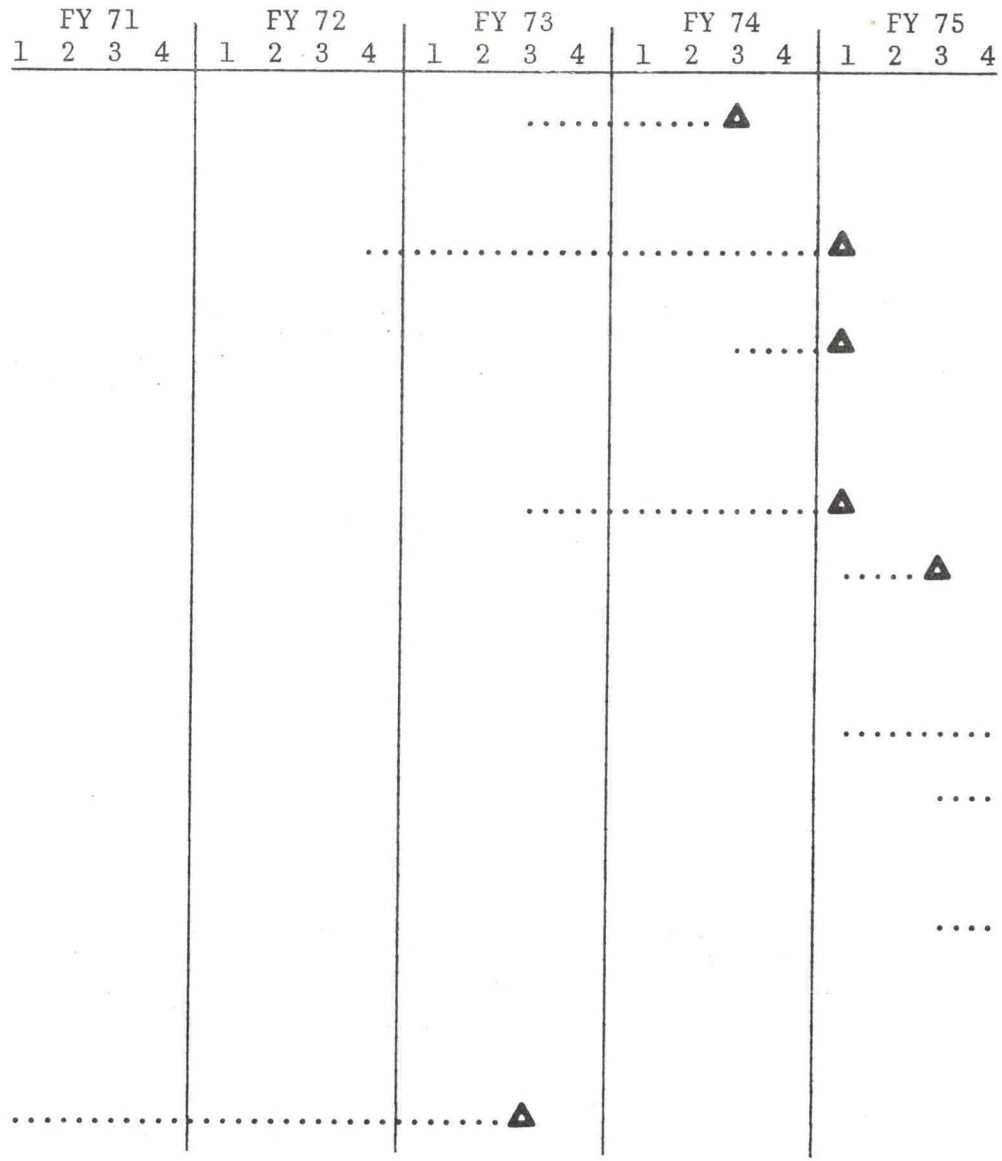

DATA FILES
COMPLETE DEVELOPMENT OF MONITOR-ING TECHNI-QUES
START FIELD STUDIES
COMPLETE SELECTION OF AREA & SPECIES
COMPLETE UNDERWATER OBSERVATION OF ACTIVITY, FEEDING & HABITAT
CONVERSION TO ADP FORMAT
COMPLETE CORRELATION STUDIES
COMPLETE DEFINITION OF NORMAL ENVIRON-MENT
COMPLETE LABORATORY STUDIES OF STRESSED BEHAVIOR
START LITERATURE SEARCH
START LABORATORY STUDIES
COMPLETE GROUP LIGHT, TEMPERATURE & SALINITY STUDIES
TO RESOURCE ASSESSMENT
TO ENVIRONMENTAL REHABILITATION
COMP SINGLE FISH SPECIES INTEN-SIVE REACTION STUDIES
COMP. DEFINITION OF NORMAL SPEED, SCHOOL-ING, & FEEDING BEHAVIOR
COMPLETE DEVELOPMENT OF LABORA-TORY TECH-NIQUES
COMPLETE SINGLE FISH SPECIES INTEN-SIVE FEEDING STUDIES
COMPLETE DATA ANALYSIS
COMP. DEVELOPMENT OF DESIGN CRITERIA FOR SAMPLING GEAR
TO PELAGIC ACTIVITIES
BEHAVIOR

Figure 10.

Table 14. Anticipated Milestones for the Behavior Investigation.

A	Start lab studies on Atlantic mackerel	A	FY 71 1 2 3 4	FY 72 1 2 3 4	FY 73 1 2 3 4	FY 74 1 2 3 4	FY 75 1 2 3 4
1.	Define normal day/night activity and schooling patterns under a controlled temperature and photoperiod	1.	▲				
2.	Establish feeding routine; measure and define normal feeding behavior under a controlled temperature and photoperiod	2.	▲				
3.	Quantitative analysis of normal activity, schooling, and feeding behaviors	3.	.....▲				
4.	Measure and define effects of gradual temperature rise on activity, schooling, and feeding behaviors	4.	.....▲	.....▲			
5.	Quantitative analysis of effect of gradual temperature change on these behaviors	5.	.....▲	.....▲			
6.	Measure and define effects of rapid temperature rise on activity, schooling, and feeding	6.		.....▲	.....▲		
7.	Quantitative analysis of effect of rapid temperature change on these behaviors	7.		.....▲	.....▲		
8.	Measure and define effects of gradual temperature decrease on activity, schooling, and feeding behaviors	8.			.....▲	.....▲	

Table 14 - continued



9. Quantitative analysis of effect of gradual temperature change on these behaviors

10. Correlate results from normal and altered temperature experiments

11. Correlate resultant information with knowledge of other benthic species to define broadly the underlying effects of temperature changes

12. End literature search

13. Publish findings

B Start lab studies on weakfish

1. Begin literature search

2. Define normal day/night activity and schooling patterns under a controlled temperature and photoperiod

3. Define normal feeding behavior under a controlled photoperiod and temperature

C Field studies commence

1. Literature search begins

Table 14 - continued

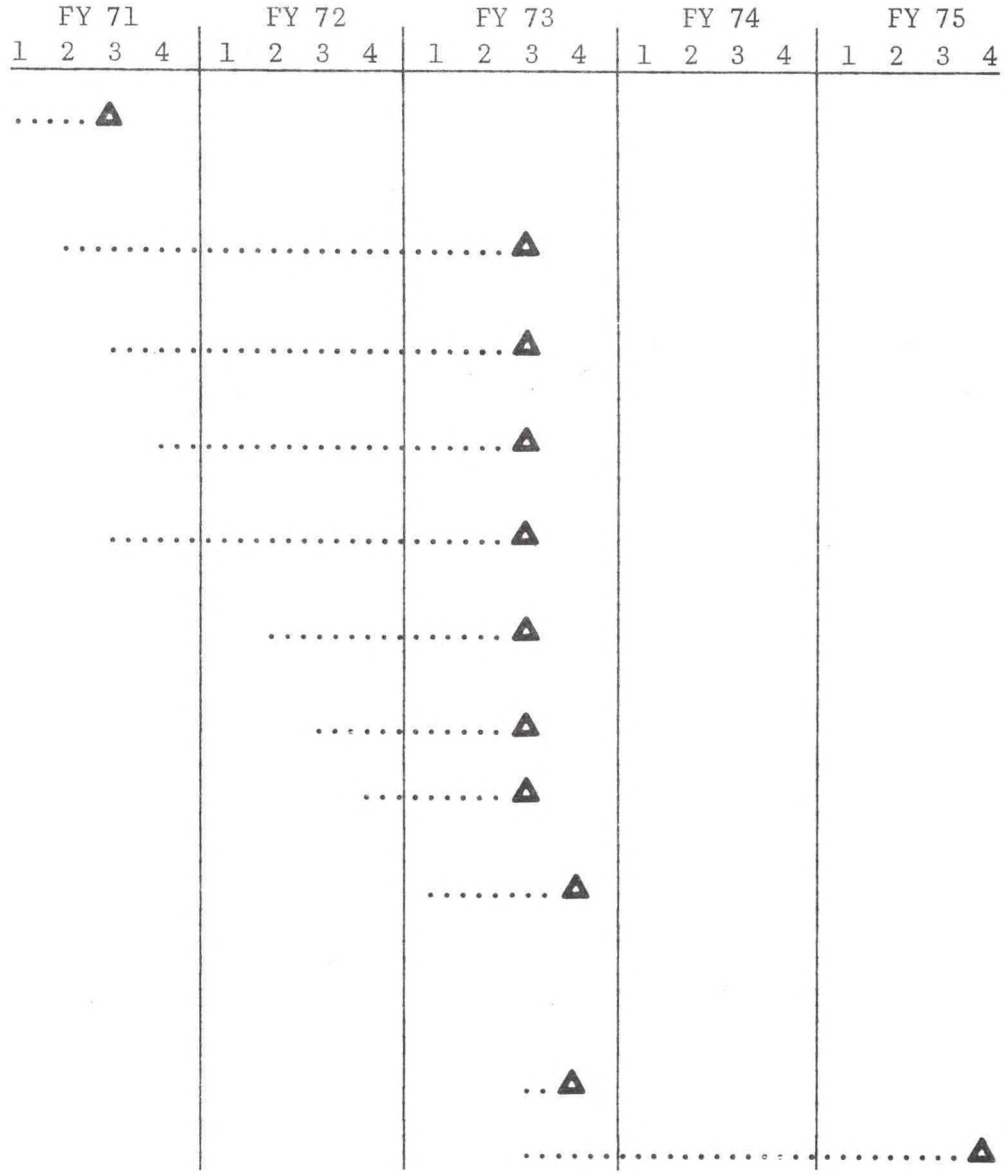


Table 14 - continued

	C	FY 71				FY 72				FY 73				FY 74				FY 75			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
13. Begin observations on interspecific competition for available food sources (tautog/cunner)	13.												..	.....	.....	.....		△			
14. Begin observations on interspecific competition for available physical habitat	14.														.....	.....	...	△			
15. Analysis and correlation of above findings to define impact of competition on the stability of tautog population	15.															.....	...	△			
16. Publish results	16.																		.....	△	
17. Begin literature search	17.															..	.....	.....	.....		
18. Begin observations on tautog homing ability	18.																		.....		

Relevance

Disease limits abundance of mollusks, crustaceans and fishes, limits intensive culture and transfer of marine forms in aquaculture, and is a consequence of man-induced degradation of aquatic environments. Besides its direct effect in mortality of fishery stocks, the occurrence of diseased fish and massive fish kills are aesthetically inimical to recreational as well as commercial interests. Pathological studies establish causes of disease and mortality, and may help define the impact of environmental stress on fish, crustaceans, and mollusks.

Activities

Survey cruises provide a method for studying the prevalence of natural diseases. Laboratory study develops procedures for diagnosing disease and assessing environmental stress in marine fish and shellfish.

Accomplishments

- Characterize immune responses of crabs;

  Determine pathogenicity of Vibrio in larval and adult mollusks;
- Study epizootiological and bacteriological features of fin rot in fish;
- Study bacterially-caused menhaden mortalities;
- Describe free-living and parasitic estuarine and marine amoebae.

PERT details are included in Figure 11.

D. Experimental Biology

Objectives

Marine contamination studies provide information on deleterious changes caused by pollution on genetic material of marine organisms.

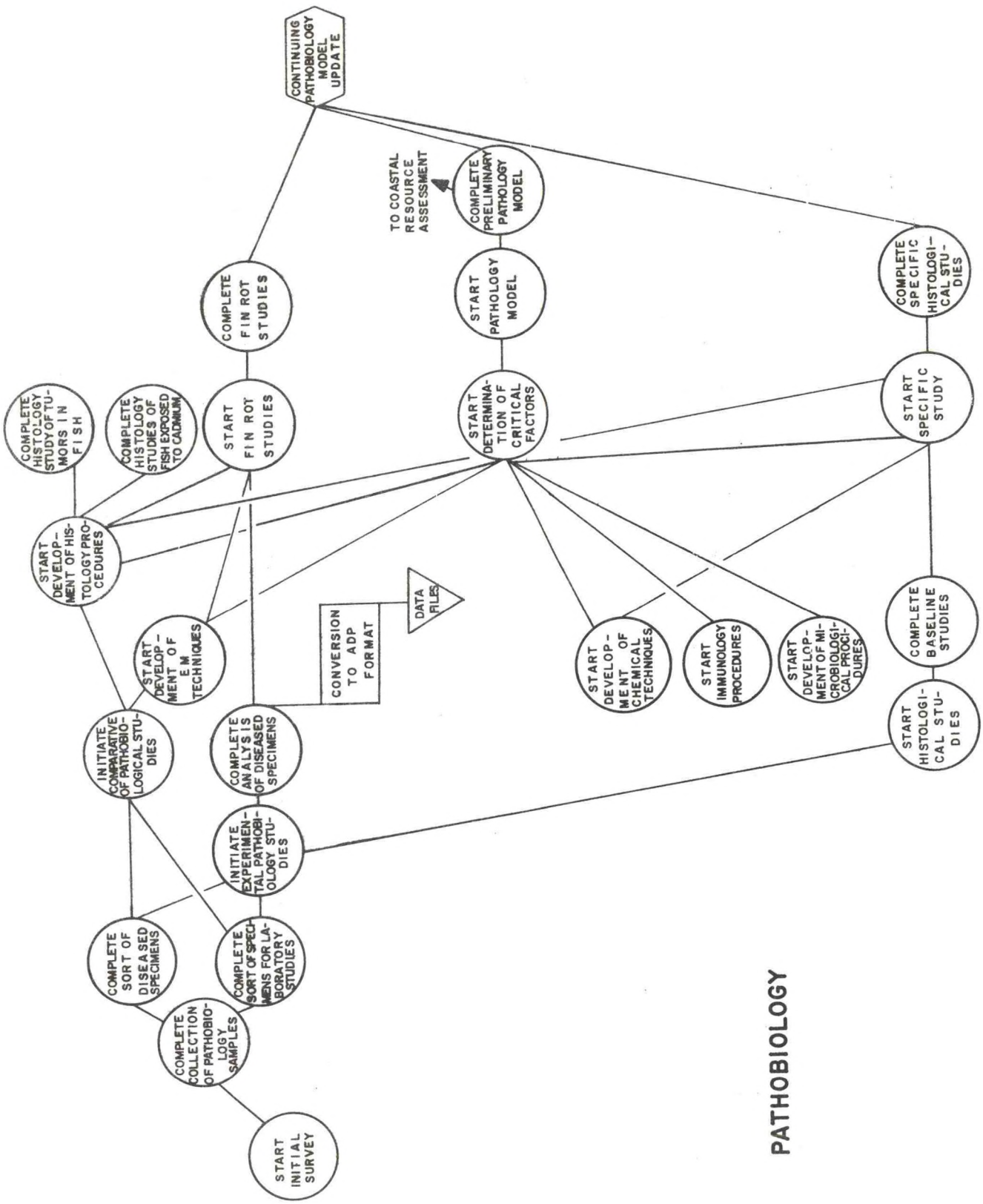

PATHOBIOLOGY
START INITIAL SURVEY
COMPLETE COLLECTION OF PATHOBIOLOGY SAMPLES
COMPLETE SORT OF DISEASED SPECIMENS
COMPLETE SORT OF SPECIMENS FOR LABORATORY STUDIES
INITIATE EXPERIMENTAL PATHOBIOLOGY STUDIES
INITIATE COMPARATIVE OF PATHOBIOLOGICAL STUDIES
COMPLETE ANALYSIS OF DISEASED SPECIMENS
CONVERSION TO ADP FORMAT
DATA FILES
START DEVELOPMENT OF EM TECHNIQUES
START DEVELOPMENT OF HISTOLOGY PROCEDURES
COMPLETE HISTOLOGY STUDY OF TUMORS IN FISH
COMPLETE HISTOLOGY STUDIES OF FISH EXPOSED TO CADMIUM
START FIN ROT STUDIES
COMPLETE FIN ROT STUDIES
CONTINUING PATHOBIOLOGY MODEL UPDATE
TO COASTAL RESOURCE ASSESSMENT
COMPLETE PRELIMINARY PATHOLOGY MODEL
START PATHOLOGY MODEL
START DETERMINATION OF CRITICAL FACTORS
START DEVELOPMENT OF CHEMICAL TECHNIQUES
START IMMUNOLOGY PROCEDURES
START DEVELOPMENT OF MICROBIOLOGICAL PROCIDURES
START HISTOLOGICAL STUDIES
COMPLETE BASELINE STUDIES
START SPECIFIC STUDY
COMPLETE SPECIFIC HISTOLOGICAL STUDIES

Figure 11.

The long-term responsibility is to (1) determine lethal effects of a large variety of known pollutants individually and in combination on the life stages of mollusks, crustaceans and fish; (2) determine sublethal effects on growth, reproduction and behavior; and (3) define biochemical pathways and relate them to metabolic disorders resulting in death or damage to marine organisms.

Relevance

Such life studies affect sport fisheries by providing an estimate of factors reducing recruitment into the fishery. Another effect is the reduced value of fish or shellfish brought about by adverse publicity about normal or pathological findings. Detrimental effects, besides affecting target species directly, can manifest in various links of the food web. The information obtained on ecosystems can be utilized to evaluate environmental impact statements, and such information will enhance intelligent management of coastal affairs, improve environmental quality and the recreational quality of sport fishing.

Activities

- Study water quality and effects of pollutants on all classes of organisms;
- Develop techniques for rearing and maintaining bivalves and other marine forms to determine genetic stress from exposure to contaminants in laboratory stocks.

Accomplishments

- Challenge oysters and hard clams with heavy metal ions to determine deleterious and lethal levels;

- Determine effects of pollution on osmoregulation and respiration of green and rock crabs.

FY 73-74 Milestones

- Rearing techniques: shellfish, crustaceans, fish;
- Acute and chronic tests (Cd on cunner and larval bivalves);
- Acute and chronic biochemical (enzymology) studies;
- Heavy metal bioassay;
- Genetic studies -- normal and damaged bivalves.

FY 75-77 Milestones

- Cell composition and growth kinetics;
- Genetic stress -- fish and crustaceans.

E. Aquaculture and Nutrient Studies

Planning for this Investigation (to be centered at Milford) includes finfish work. However, since such studies require facilities quite different from those for invertebrates, it is unlikely that any work will be initiated prior to FY 75 or FY 76, depending largely on funding. Preliminary work on developing rearing techniques for some species of finfish might be undertaken in the Life History/Water Quality Investigation when aquaculture funds become directly available.

Nutrient studies would mesh with the development of techniques for rearing fish in selective or hybrid breeding studies. Successful diet formulas are necessary for the varying life cycle stages. Aside from the usefulness of having selected species from known genetic stocks for experimental studies, there may be some advantage in being able to derive

disease resistant stocks to rehabilitate areas. It seems unlikely that NMFS could or should develop a cultural capacity for "put-and-take" stocking comparable to freshwater practice.

SUMMARY AND CONCLUSIONS

Fishery management has never been a matter of individual effort. Information from a variety of sources is required. Our concept of the required channeling of data and effort for a total sport fish program is shown in the Appendix Figure. The individual activities are shown in interfaces between activities. A time-line proceeds from left to right, but the start time and stages of processes for individual projects are not scaled. The figure is essentially a flow plan of events and activities which must be completed or accomplished.

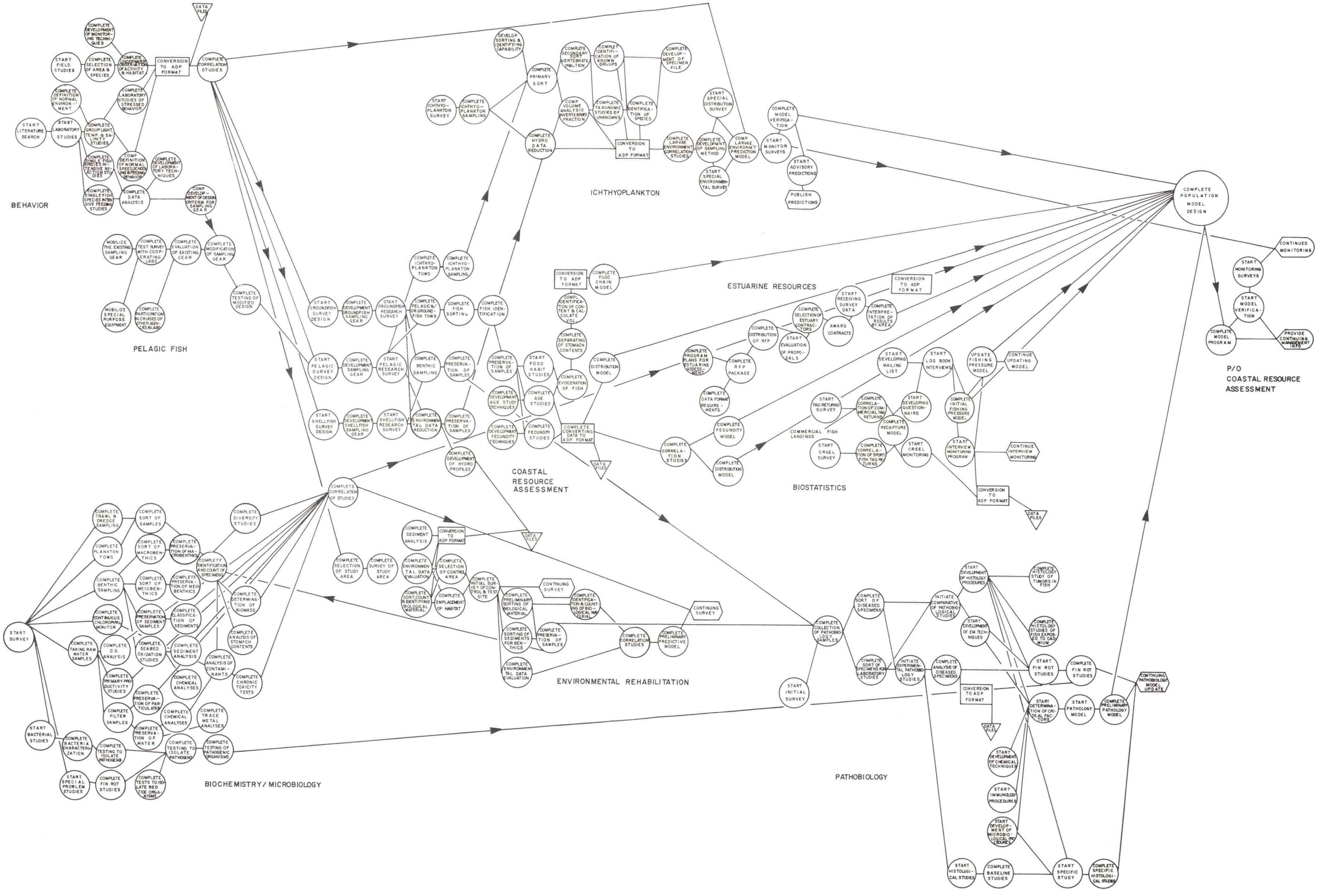
Each activity in the network has an output which feeds into the population modeling design of coastal fish stocks. The model utilizes information to meet the MACFC sport fishing objectives and incorporates information to define positive and negative components. Design of a population model requires inputs on recruitment, growth, and death rates.

An annual stock is measurable from our abilities to identify, determine distribution and density of young stages. The correlations with subadult, yearling, or preharvest fractions are possible with material obtained from regular assessment cruises. Estimates of catch derived from biostatistics activities serve to verify and improve predictive statements. Estimates of mortality can emerge from contaminant studies, diseased fish incidence, changes in tagged fish recovery, and decline in the succession of older fish.

The use of this diagram is in its function of visualizing a program plan, evaluating status of completed work, forecasting problems, and setting priorities in funding.

Because of certain reorganizational and funding constraints, it has become increasingly difficult to predict time requirements of activity phases. From study of the flow network, certain critical paths can be identified. The assignment of pelagic fish studies to NEFC and of environmental rehabilitation efforts to the Beaufort Laboratory, for example, necessitates a coordination of effort and information retrieval between our three Federal laboratories and those several State agencies involved in detailed studies which also feed the modeling requirements.

A balanced program of sport fish research must necessarily derive knowledge from a wide range of disciplines. To satisfy our mission of developing and evaluating management strategies, our knowledge must be shared to maximize quality of judgment and minimize the cost of research. An awareness of rate of progress and potential bottlenecks is an administrative dictate.


BEHAVIOR
START LITERATURE SEARCH
START LABORATORY STUDIES
START FIELD STUDIES
COMPLETE DEVELOPMENT OF MONITORING TECHNIQUES
COMPLETE SELECTION OF AREA & SPECIES
COMPLETE DEFINITION OF NORMAL ENVIRON-MENT
COMPLETE GROUP LIGHT, TEMP. & SALINITY STUDIES
COMPLETE SINGLE FISH SPECIES INTENSIVE REACTION STUDIES
COMPLETE SINGLE FISH SPECIES INTENSIVE FEEDING STUDIES
COMPLETE OBSERVATION OF ACTIVITY & HABITAT
COMPLETE LABORATORY STUDIES OF STRESSED BEHAVIOR
COMP. DEFINITION OF NORMAL SPEED, SCHOOLING & FEEDING BEHAVIOR
COMPLETE DATA ANALYSIS
CONVERSION TO ADP FORMAT
COMPLETE CORRELATION STUDIES
DATA FILES
COMPLETE DEVELOPMENT OF LABORATORY TECHNIQUES
COMP. DEVELOPMENT OF DESIGN CRITERIA FOR SAMPLING GEAR
PELAGIC FISH
MOBILIZE THE EXISTING SAMPLING GEAR
COMPLETE TEST SURVEY WITH COOPERATING LABS
COMPLETE EVALUATION OF EXISTING GEAR
COMPLETE MODIFICATION OF SAMPLING GEAR
MOBILIZE SPECIAL PURPOSE EQUIPMENT
COMPLETE PARTICIPATION IN CRUISES OF OTHER AGENCIES/LABS
COMPLETE TESTING OF MODIFIED DESIGN
ICHTHYOPLANKTON
START ICHTHYO-PLANKTON SURVEY
COMPLETE ICHTHYO-PLANKTON SAMPLING
DEVELOP SORTING & IDENTIFYING CAPABILITY
COMPLETE PRIMARY SORT
COMPLETE HYDRO REDUCTION
COMPLETE SECONDARY SORT INVERTEBRATE FRACTION
COMP. VOLUME ANALYSIS INVERTEBRATE FRACTION
COMPLETE IDENTIFICATION OF KNOWN GROUPS
COMPLETE TAXONOMIC STUDIES OF UNKNOWNS
COMPLETE DEVELOP-MENT OF SPECIMEN FILE
COMPLETE IDENTIFICATION OF SPECIES
CONVERSION TO ADP FORMAT
COMPLETE LARVAE ENVIRONMENT CORRELATION STUDIES
START SPECIAL DISTRIBUTION SURVEY
COMPLETE DEVELOPMNT OF SAMPLING METHOD
COMP. LARVAE ENVIRONM'T PREDICTION MODEL
START SPECIAL ENVIRONMENTAL SURVEY
COMPLETE MODEL VERIFICATION
START MONITOR SURVEYS
START ADVISORY PREDICTIONS
PUBLISH PREDICTIONS
COMPLETE POPULATION MODEL DESIGN
P/O COASTAL RESOURCE ASSESSMENT
CONTINUED MONITORING
START MONITORING SURVEYS
START MODEL VERIFICATION
COMPLETE MODEL PROGRAM
PROVIDE CONTINUING MANAGEMENT INFO
ESTUARINE RESOURCES
CONVERSION TO ADP FORMAT
COMPLETE FOOD CHAIN MODEL
COMPL. IDENTIFICATION OF CONTENT & CALCULATE VOL.
COMPLETE SEPARATING OF STOMACH CONTENTS
COMPLETE EVISCERATION OF FISH
COMPLETE DISTRIBUTION MODEL
START RECEIVING SURVEY DATA
AWARD CONTRACTS
COMPLETE SELECTION OF ESTUARY CONTRACTORS
START EVALUATION OF PROPOSALS
COMPLETE INTERPRETATION OF RESULTS BY AREA
COMPLETE DISTRIBUTION OF RFP
COMPLETE PROGRAM PLANS FOR ESTUARINE ASSESSMENT
COMPLETE RFP PACKAGE
COMPLETE DATA FORMAT REQUIREMENTS
COMPLETE FECUNDITY MODEL
COMPLETE DISTRIBUTION MODEL
COMPLETE CORRELATION STUDIES
COMPLETE CONVERTING DATA TO ADP FORMAT
DATA FILES
COASTAL RESOURCE ASSESSMENT
START GROUNDFISH SURVEY DESIGN
COMPLETE DEVELOPMENT GROUNDFISH SAMPLING GEAR
START GROUNDFISH RESEARCH SURVEY
COMPLETE PELAGIC & GROUNDFISH TOWS
COMPLETE FISH SORTING
COMPLETE FISH IDENTIFICATION
START PELAGIC SURVEY DESIGN
COMPLETE DEVELOPMENT SAMPLING GEAR
START PELAGIC RESEARCH SURVEY
COMPLETE BENTHIC SAMPLING
COMPLETE PRESERVATION OF SAMPLES
COMPLETE PRESERVATION OF SAMPLES
START FOOD HABIT STUDIES
COMPLETE DEVELOPMENT AGE STUDY TECHNIQUES
COMPLETE AGE STUDIES
START SHELLFISH SURVEY DESIGN
COMPLETE DEVELOPMENT SHELLFISH SAMPLING GEAR
START SHELLFISH RESEARCH SURVEY
COMPLETE ENVIRONMENTAL DATA REDUCTION
COMPLETE PRESERVATION OF SAMPLES
COMPLETE DEVELOPMENT FECUNDITY TECHNIQUES
COMPLETE FECUNDITY STUDIES
COMPLETE DEVELOPMENT OF HYDRO PROFILES
COMPLETE CORRELATION OF STUDIES
BIOSTATISTICS
START TAG RETURNS SURVEY
COMPLETE CORRELATION OF COMMERCIAL TAG RETURNS
START DEVELOPING QUESTIONNAIRE
COMPLETE RECAPTURE MODEL
COMMERCIAL FISH LANDINGS
START CREEL SURVEY
COMPLETE CORRELATION OF SPORT FISH TAG RETURNS
START CREEL MONITORING
START DEVELOPMNG MAILING LIST
START LOG BOOK INTERVIEWS
UPDATE FISHING PRESSURE MODEL
CONTINUE UPDATING MODEL
COMPLETE INITIAL FISHING PRESSURE MODEL
START INTERVIEW MONITORING PROGRAM
CONTINUE INTERVIEW MONITORING
CONVERSION TO ADP FORMAT
DATA FILES
BIOCHEMISTRY / MICROBIOLOGY
START SURVEY
COMPLETE TRAWL & DREDGE SAMPLING
COMPLETE PLANKTON TOWS
COMPLETE BENTHIC SAMPLING
COMPLETE CONTINUOUS CHLOROPHYLL MONITOR
COMPLETE TAKING RAW WATER SAMPLES
COMPLETE D.O. ANALYSIS
COMPLETE PRIMARY PRODUCTIVITY STUDIES
COMPLETE FILTER SAMPLES
COMPLETE SORT OF SAMPLES
COMPLETE SORT OF MACROBENTHICS
COMPLETE SORT OF MEIOBENTHICS
COMPLETE SORT OF SEDIMENT SAMPLES
COMPLETE PRESERVATION OF MACROBENTHICS
COMPLETE PRESERVATION OF MEIOBENTHICS
COMPLETE CLASSIFICATION OF SEDIMENTS
COMPLETE SEABED OXIDATION STUDIES
COMPLETE SEDIMENT ANALYSIS
COMPLETE IDENTIFICATION AND COUNT OF SPECIMENS
COMPLETE DIVERSITY STUDIES
COMPLETE DETERMINATION OF BIOMASS
COMPLETE ANALYSIS OF STOMACH CONTENTS
COMPLETE ANALYSIS OF CONTAMINANTS
COMPLETE CHRONIC TOXICITY TESTS
COMPLETE PRESERVATION OF PARTICULATES
COMPLETE CHEMICAL ANALYSES
COMPLETE PRESERVATION OF WATER
COMPLETE CHEMICAL ANALYSES
COMPLETE TRACE METAL ANALYSES
COMPLETE TESTING TO ISOLATE PATHOGENS
COMPLETE TESTING OF PATHOGENIC ORGANISMS
START BACTERIAL STUDIES
COMPLETE BACTERIA CHARACTERIZATION
COMPLETE TESTING TO ISOLATE PATHOGENS
START SPECIAL PROBLEM STUDIES
COMPLETE FIN ROT STUDIES
COMPLETE TESTS TO ISOLATE RED TIDE ORGANISMS
COMPLETE SELECTION OF STUDY AREA
COMPLETE SURVEY OF STUDY AREA
COMPLETE SEDIMENT ANALYSIS
CONVERSION TO ADP FORMAT
DATA FILES
COMPLETE ENVIRONMENTAL DATA EVALUATION
COMPLETE SELECTION OF CONTROL AREA
COMPLETE EMPLACEMENT OF HABITAT
COMPLETE SORT, COUNT & IDENTIFYING BIOLOGICAL MATERIAL
COMPLETE INITIAL SURVEY OF CONTROL & TEST SITE
CONTINUING SURVEY
COMPLETE PRELIMINARY SORTING OF BIOLOGICAL MATERIAL
COMPLETE IDENTIFICATION & COUNTING OF BIOLOGICAL MATERIAL
COMPLETE SORTING OF SEDIMENTS FOR BENTHICS
COMPLETE PRESERVATION OF SAMPLES
COMPLETE ENVIRONMENTAL DATA EVALUATION
COMPLETE CORRELATION STUDIES
COMPLETE PRELIMINARY PREDICTIVE MODEL
CONTINUING SURVEY
ENVIRONMENTAL REHABILITATION
START INITIAL SURVEY
COMPLETE COLLECTION OF PATHOBIOLOGY SAMPLES
COMPLETE SORT OF DISEASED SPECIMENS
COMPLETE SORT OF SPECIMENS FOR LABORATORY STUDIES
INITIATE EXPERIMENTAL PATHOBIOLOGY STUDIES
INITIATE COMPARATIVE OF PATHOBIOLOGICAL STUDIES
COMPLETE ANALYSIS OF DISEASED SPECIMENS
START DEVELOPMENT OF HISTOLOGY PROCEDURES
START DEVELOPMENT OF EM TECHNIQUES
CONVERSION TO ADP FORMAT
DATA FILES
START DEVELOPMENT OF CHEMICAL TECHNIQUES
START IMMUNOLOGY PROCEDURES
START DEVELOPMENT OF MICROBIOLOGICAL PROCEDURES
START HISTOLOGICAL STUDIES
COMPLETE BASELINE STUDIES
START SPECIFIC STUDY
COMPLETE SPECIFIC HISTOLOGICAL STUDIES
COMPLETE HISTOLOGY STUDY OF TUMORS IN FISH
COMPLETE HISTOLOGY STUDIES OF FISH EXPOSED TO CADMIUM
START FIN ROT STUDIES
COMPLETE FIN ROT STUDIES
START DETERMINATION OF CRITICAL FACTORS
START PATHOLOGY MODEL
COMPLETE PRELIMINARY PATHOLOGY MODEL
CONTINUING PATHOBIOLOGY MODEL UPDATE
PATHOBIOLOGY