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Proceedings of the Workshop on the Collection and Use of Trawl Survey Data for Fisheries Management

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Proceedings of the Workshop on the Collection and Use of Trawl Survey Data for Fisheries Management

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edited by
Tina Berger

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Preface

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Table of Contents

Preface i
Acknowledgements ii
Table of Contents iii
List of Tables v
List of Figures vi
Executive Summary viii
Opening Remarks
David Cupka, South Carolina Department of Natural Resources 1

SESSION I: REVIEW AND COMPARISON OF ATLANTIC COAST TRAWL SURVEYS
Northeast Fisheries Science Center Bottom Trawl Surveys
Thomas R. Azarovitz, National Marine Fisheries Service, Northeast Fisheries Science Center 4
A Report on Current State of Maine Groundfish Surveys
Richard Langton, Daniel Schick, Sally Sherman, and Michael Brown, Maine Department of Marine Resources 8
Massachusetts Inshore Bottom Trawl Survey
Steven J. Correia, Massachusetts Division of Marine Fisheries 22
State of Connecticut Marine Finfish Trawl Survey
Mark Johnson, State of Connecticut Division of Marine Fisheries 24
Peconic Bay Small Mesh Trawl Survey 1985 -1994
Christina M. Grahn, New York State Department of Environmental Conservation 27
Stock Assessment of New Jersey's Nearshore Recreational Fisheries Resources
Don Byrne, New Jersey Division of Fish, Game & Wildlife 36
Delaware's Bottom Trawl Surveys
Stewart Michels, Delaware Division of Fish and Wildlife 43
Trawl Survey Summary for Estuarine Fisheries Program in Maryland
Jim Mowrer, Maryland Department of Natural Resources 47
Virginia Institute of Marine Science's Trawl Survey
Patrick J. Geer, Virginia Institute of Marine Science 61
Georgia DNR's Shrimp and Crab Trawl Survey
Jim Music, Georgia Department of Natural Resources 80
Review of the History & Development of the Sampling Design Used by the SEAMAP-South Atlantic Shallow Water Trawl Survey
Dr. Elizabeth Wenner, Randy Beatty, Jeanne Boylan and Pearse Webster, South Carolina Department of Natural Resources, Marine Resources Research Institute 85
NCDMF Current Trawl Surveys
Katy H. West and Chris J. Wilson, North Carolina Division of Marine Fisheries 97

Table of Contents (con't)

The Florida Marine Fisheries-Independent Monitoring Program: Trawl Survey Component
James A. Colvocoresses and Timothy C. MacDonald, Florida Department of Environmental Protection, Division of Marine Resources.....116

SESSION II: COOPERATIVE DATA MANAGEMENT SYSTEMS

Data Collection and Management: Developing Multi-Agency Cooperative Programs
Ronald R. Lukens, Gulf States Marine Fisheries Commission.....133

Development of a Multi-Participant Database Management Program for Marine Resources Research and Management
Dwayne E. Porter, William H. Jefferson, Virginia Ogburn-Matthews and Daniel S. Taylor, Belle W. Baruch Institute for Marine Biology and Coastal Research University of South Carolina..... 136

SESSION III: DATA ANALYSIS AND ASSESSMENT

A Brief Overview of the Use of Trawl Survey Data for Stock Assessment with Emphasis on the ADAPT VPA Tuning Model
Jon Brodziak, National Marine Fisheries Service, Northeast Fisheries Science Center..... 146

Application of Trawl Survey Information in Massachusetts
Steven J. Correia, Massachusetts Division of Marine Fisheries.....149

Uses of Trawl Survey Data Beyond Traditional Stock Assessment Applications
Stuart Wilk, Robert Pikanowski, Donald McMillan, and Eileen MacHaffie, National Marine Fisheries Service, James J. Howard Marine Science Laboratory..... 155

SESSION IV: SURVEY TECHNIQUES AND NEW TECHNOLOGIES

Effective Sample Size and Precision of Marine Surveys
Michael Pennington, National Marine Fisheries Service, Northeast Fisheries Science Center.....157

Northeast Fisheries Science Center Survey Vessel and Gear Research
Thomas R. Azarovitz and Charles J. Byrne, National Marine Fisheries Service, Northeast Fisheries Science Center..... 165

Comparison of Relative Fishing Powers of Two Research Vessels
Gilmore Pellegrin, Jr., National Marine Fisheries Service, Mississippi Laboratory.....169

Hydroacoustic Techniques Can Complement Trawl Surveys
Dr. Charles A. Barans, South Carolina Department of Natural Resources, Marine Resources Research Institute.....170

SESSION V: WORK GROUP DISCUSSIONS & DEVELOPMENT OF RECOMMENDATIONS

Summary of Discussions and Recommendations
Tina Berger, Atlantic States Marine Fisheries Commission.....175

Table of Contents (con't)

APPENDIX A
List of Workshop Participants.....179

APPENDIX B
List of SEAMAP - South Atlantic Contacts.....185

APPENDIX C
Bibliography of SEAMAP - South Atlantic Publications and Others Based Upon SEAMAP Data Collection or Specimens.....187

List of Tables

Table 1. Species ranking by relative abundance....30
Table 2. Key and sample collection summary of the VIMS Trawl Survey, 1955-1993....66
Table 3. VIMS Trawl Survey - Area/Time/Size/Value by Species....69
Table 4. Assessment trawl station locations sampled each month as part of Georgia's Resources Assessment Survey....82
Table 5. Total lengths and mean number per pound (heads-on) count size for white shrimp in Georgia....83
Table 6. Target species for SEAMAP Shallow Water Trawl Survey....88
Table 7. North Carolina juvenile striped bass trawl survey index, Western Albemarle Sound, CPUE - catch per tow....99
Table 8. North Carolina brown shrimp survey best catch per minute, salinity and commercial landing, 1983-1994....100
Table 9. North Carolina estuarine trawl survey juvenile abundance indices for spot, southern flounder, croaker, blue crab, weakfish and brown shrimp, 1979-1994....104
Table 10. North Carolina Pamlico Sound survey juvenile indices for summer and southern flounder, spot, Atlantic croaker, weakfish and blue crab, 1987-1993....109
Table 11. Selected species list....118
Table 12. Multi-participant database management activities....137
Table 13. Selected indicators of estuarine water quality....140
Table 14. Contents of a metadata documentation form....141
Table 15. Summary statistics for estimating the mean length of haddock on Georges Bank....160

List of Figures

Figure 1. Sampling sites: Seasonal location of shrimp and juvenile groundfish.....10
Figure 2. Bottom water temperatures on four of the coastal survey cruises in 1992.....12
Figure 3. Distribution of winter flounder on quarterly coastal cruises in 1992.....13
Figure 4. Distribution of gray sole on quarterly cruises in 1992.....14
Figure 5. Distribution of American plaice on quarterly coastal cruises in 1992.....15
Figure 6. Change in abundance of gray sole over the course of coastal cruises from May 1992 through January 1994.....17
Figure 7. Occurrence of red and white hake on transects 1 through 6, expressed as mean number of fish per tow for the period May 1992 through January 1993.....18
Figure 8. Occurrence of Atlantic cod in the east, mid-coast and western sectors of the Gulf of Maine for May 1992.....19
Figure 9. Distribution of northern shrimp on quarterly coastal cruises in 1992.....20
Figure 10. Peconic Bay trawl survey stations.....28
Figure 11. Survey area of New Jersey Ocean Stock Assessment Program.....38
Figure 12. Summer flounder annual abundance index, 1989-1992.....42
Figure 13. Bluefish young-of-year annual index, 1988-1992.....42
Figure 14. Location of sampling stations for the blue crab survey and juvenile American shad and river herring within Maryland's portion of the Chesapeake Bay.....49
Figure 15. Maryland DNR coastal bay survey trawl stations.....51
Figure 16. Alewife weighted juvenile index 1985-1993, rivers combined.....52
Figure 17. Blueback herring weighted juvenile index 1985-1993, rivers combined.....53
Figure 18. Trends in monthly recruit c/f in the summer trawl survey and monthly commercial landings.....55
Figure 19. Trends in monthly legal-size c/f in the summer trawl survey and that same month's commercial landings (in million of pounds), 1988-1991.....56
Figure 20. Mean catch per trawl for weakfish in Maryland's coastal bays, 1972-1992.....57
Figure 21. Mean catch per trawl for summer flounder in Maryland's coastal bays, 1972-1992.....58
Figure 22. Number of species collected in otter trawls from Maryland's coastal bays, 1972-1992.....59
Figure 23. VIMS Trawl Survey sampling effort, 1955-1993.....62
Figure 24. VIMS Juvenile Fish Trawl Survey sampling changes, 1955-1994.....67
Figure 25. VIMS juvenile finfish stock assessment for spot, Atlantic croaker, weakfish, summer flounder and black seabass.....72
Figure 26. VIMS juvenile finfish stock assessment for northern puffer, silver perch, white perch, striped bass and blue crab.....73
Figure 27. VIMS juvenile finfish stock assessment for white catfish, channel catfish and scup.....74
Figure 28. Gear conversions for VIMS juvenile indices.....76

List of Figures (con't)

Figure 29. Chart of the SEAMAP sampling area..... 86
Figure 30. Seasonal length-frequencies of *Scomberomorus cavalla* collected in inner strata during 1993..... 90
Figure 31. Regional length-frequencies of *Scomberomorus maculatus* collected in inner strata during 1993..... 91
Figure 32. Regional and seasonal densities of mackerel taken in inner strata in 1993..... 92
Figure 33. Regional and seasonal densities of *Penaeus setiferus* taken from inner strata in 1993..... 94
Figure 34. Abundance of *Penaeus setiferus* among depth zones during Spring 1994..... 95
Figure 35. Gonadal development of white shrimp in 1993..... 96
Figure 36. North Carolina juvenile striped bass survey stations..... 98
Figure 37. North Carolina estuarine survey 10.5 ft. headrope trawl stations..... 103
Figure 38. Pamlico Sound trawl survey sample frame..... 106
Figure 39. North Carolina biological masterfile hierarchical structure composed of seven record types..... 111
Figure 40. Map of estuarine systems where Florida's Fisheries Independent Monitoring Program has established, or will establish, field labs..... 119
Figure 41. Map of Florida Bay fixed stations..... 121
Figure 42. Map of Tampa Bay sampling zones and fixed stations..... 122
Figure 43. Map of Charlotte Harbor sampling zones and fixed stations..... 123
Figure 44. Map of Ft. Walton sampling zones and fixed stations..... 124
Figure 45. Map of Indian River sampling zones and fixed stations..... 125
Figure 46. Map depicting the grid system for a small section of the Tampa Bay estuary..... 126
Figure 47. Grid divided into 100 microgrids..... 127
Figure 48. Length-frequency distributions of haddock (group 1, 2 and overall) for 1967.... 161
Figure 49. Length-frequency distributions of haddock (group 1, 2 and overall) for 1978.... 162

Executive Summary

In August 1994, the Atlantic States Marine Fisheries Commission (ASMFC) convened a ***Workshop on the Collection and Use of Trawl Survey Data for Fisheries Management*** in Folly Beach, South Carolina. The workshop was funded through grants from the U.S. Fish and Wildlife Service's Federal Aid in Sport Fish Restoration Program and the National Marine Fisheries Service's (NMFS) Southeast Area Monitoring and Assessment Program (SEAMAP). At the workshop, representatives from Atlantic coastal state fishery agencies, NMFS, the Atlantic and Gulf States Marine Fisheries Comissions, and academia gathered to discuss the problems, issues and opportunities associated with the collection and use of trawl survey data in fisheries management on the Atlantic coast.

Every state along the Atlantic coast, with the possible exception of New Hampshire, conducts trawl surveys for the collection of their fishery-independent data. In most states, it is their only source of fishery-independent data. Yet, even with similarities in terms of needs for and use of the data, there are very few similarities in terms of survey methodologies, protocols and data management systems among states, regions and federal agencies. The goal of the workshop was to bring these similarities and differences to light and work together as a group to develop recommendations that would facilitate data utility.

This report represents the proceedings of the workshop, which includes workshop presentations as well as a summary chapter describing work group discussions and the development of recommendations. The report is divided into five sections. The first section entitled, "Review and Comparison of Atlantic Coast Trawl Surveys," provides descriptions of all state, federal and cooperative trawl surveys -- both nearshore and offshore -- that occur along the U.S. Atlantic coast. The papers within this section are formated similarly, beginning with a description of the survey's purpose, history, timeframe, design and methodology. Each paper concludes with a discussion of the type of database management system employed, how the survey data are analyzed and used in fisheries management, the availability and dissemination of reports, and the integration of the survey with other reported surveys.

The second section focuses on the formation and implementation of cooperative data management systems. Ron Lukens, Assistant Director of the Gulf States Marine Fisheries Commission, discusses his experiences with the formation and development of multi-agency cooperative data management systems, such as SEAMAP, the Recreational Fisheries Information Network (RecFIN Southeast), and the Commercial Fisheries Information Network (ComFIN). Specifically, he describes the formative stages of developing a cooperative data management system, including the lengthy, although necessary, process of bringing all the interested groups together to reach consensus on the need for and utility of such a system. The author also addresses the importance of maintaining long-term program stability through the long-term commitment of program participants -- in terms of state/federal agency support at both the director and technical levels.

Also in this section, Dwayne Porter of the Belle W. Baruch Institute for Marine Biology and Coastal Research presents programmatic and technical issues that are important for consideration in the development and implementation of a multi-participant database management program. The author discusses the particular components that make-up a multi-participant program, including: a user needs assessment, data collection protocol; quality assurance and quality control procedures; program documentation and metadata; and connectivity and communication. Many of the workshop recommendations echo the information presented in this paper.

In the third section on Data Analysis and Assessment, authors Jon Brodziak (NMFS, Northeast Fisheries Science Center) and Steven Correia (Massachusetts Division of Marine Fisheries) present the use of trawl survey data in various stock assessment methodologies. Jon Brodziak focuses on the analysis of trawl survey data using the ADAPT VPA Tuning Model, while Steven Correia discusses how Massachusetts uses it's trawl survey data to determine simple index-based assessments, recruit and pre-recruit indices for DeLury assessment, and tuning indices for virtual population analyses. Stuart Wilk and colleagues (NMFS, James J. Howard Marine Science Laboratory) discuss the use of trawl survey data beyonf traditional stck assessment applications.

The fourth section, Survey Techniques and New Technologies, provides an overview of new and emerging survey techniques and technologies. Researchers from NMFS' Woods Hole and Mississippi Laboratories discuss issues such as determining effective sample size and precision in marine surveys, and current survey vessel and gear research. Charles Barans (South Carolina Department of Natural Resources) explores how new advances in hydroacoustic techniques can be used to complement trawl surveys.

The final chapter, "Work Group Discussions and Development of Recommendations," summarizes the findings of a half day of work group deliberations. Workshop participants were divided into four groups, each group examined identified issues under one of the following categories: data utilization, data management, trawl survey logistics and regional coordination. Issues that were addressed under the categories included: survey coordination, data accessibility, data collection and documentation protocols, common data elements, and communication among data collectors, users and managers. Not surprisingly, many of the recommendations were common among the work groups. Probably the most cross-cutting recommendation of all was for the establishment of a "committee," composed of state, federal and regional interests, to conduct a user needs assessment, surveying all possible data collectors, users and managers to identify : (1) data uses (i.e., stock assessment, management programs, research); (2) data management systems (hardware, software, networks and operating systems); (3) how data requests are handled and in what format?; (4) extent and type of documentation (changes in survey methodologies, data codes); (5) error checking mechanisms (i.e., data validation); (6) sampling strategies; and (7) user expectations/needs of the data management system for both primary and secondary users.

From the findings of the survey, the committee could then develop a data exchange protocol that would allow for the transference and conversion of different data formats to a common format. It was also recommended that the committee serve as an information nexus -- linking data collectors, users and managers and providing regional coordination.

Opening Remarks

by
David Cupka, Director
Office of Fisheries Management
South Carolina Department of Natural Resources

Good Morning. I have been asked to welcome you to Charleston and to say a few words about this workshop on the collection and use of trawl survey data for fisheries management. The workshop is being jointly sponsored by the Atlantic States Marine Fisheries Commission and the Southeast Area Monitoring and Assessment Program or SEAMAP. This workshop is a follow-up to an earlier Commission sponsored workshop on bottom trawl surveys that was held during November 1988 in Woods Hole, Massachusetts. The purpose of the first workshop was to provide a forum for information exchange. Its primary objectives were to identify the Atlantic coastal states and federal agencies which were conducting bottom trawl surveys, to look at what types of survey methodologies were being used, and to discuss survey purposes. The goals of this workshop are much broader in scope than those of the first survey. The workshop organizers not only want to identify the current status of Atlantic coastal trawl surveys and survey objectives, but also to examine how the data from these surveys are being used by the various agencies in the fisheries management process. In addition, the organizers want to develop a set of recommendations that will help to provide for improved collection, analysis, and accessibility of trawl data for use in Atlantic coastal fisheries management.

In these days of increasing regulations as a part of the fisheries management process, the acquisition of fisheries-independent data, such as that being discussed during this workshop, is becoming more and more important. Traditionally, fisheries have often been managed based on fisheries-dependent data but as more and more regulations are applied to fisheries, the use of fisheries-dependent data is becoming less and less appropriate in certain types of data analyses used for formulating management actions. A case in point for our part of the coast involves the red drum or channel bass. The stock assessment techniques which have been utilized to examine the status of red drum stocks have depended to a very large degree on fisheries-dependent data. With the imposition of management actions such as bag limits and especially slot size limits, you are essentially working with the same data set each time a stock assessment is undertaken and the data in the data set represent only a portion of the total red drum population. Utilizing this fishery-dependent data set, which is biased by the imposition of fishery regulations, you will never be able to demonstrate that your management efforts are having any positive effects and that the red drum stocks are being rebuilt.

Only recently have agencies been able to obtain the fiscal resources to monitor red drum stocks using fisheries-independent means. And therein lies one of the major concerns regarding fisheries-independent sampling -- it is generally very expensive to carry out. That is one reason why workshops such as this are so important as ways to maximize the use of the data obtained, while minimizing the costs associated with fisheries-independent sampling are explored and discussed.

As a voting member of the South Atlantic Fishery Management Council and the immediate past Chairman of the SEAMAP-South Atlantic Committee, I see firsthand the growing importance of fisheries-independent data in the fisheries management process. For the first time this year, SEAMAP data on Spanish mackerel were utilized in the stock assessment process and helped to provide the data which the South Atlantic Fishery Management Council considered to set the Spanish mackerel quotas. You will be hearing more about SEAMAP during the workshop, but it has taken about six years in the South Atlantic to build a fisheries-independent database under this program which is just now beginning to provide benefits. Databases built by trawl surveys need to be long-term in nature and the longer the time period covered by the survey, generally the more valuable the database. So it is important that trawl surveys be well designed, carried out on a long-term periodic basis, and that the data obtained be accessible in order to build databases which can be utilized in the fisheries management process.

The next two and a half days will be busy ones and the workshop organizers will be counting on everyone's input- - both monitoring and assessment people -- to achieve the workshop objectives. I hope that this workshop is a productive and enjoyable experience for you and I look forward to seeing the workshop recommendations and proceedings. Thank you.

SESSION I: REVIEW AND COMPARISON OF ATLANTIC COAST TRAWL SURVEYS

Northeast Fisheries Science Center Bottom Trawl Surveys

by
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Introduction

Bottom trawl surveys for finfish and shellfish resources have been conducted in continental shelf waters by the Woods Hole Laboratory of the Northeast Fisheries Science Center (NEFSC), National Marine Fisheries Service (NMFS) since it was established under the auspices of the U.S. Fish Commission over 100 years ago. Current time series include several finfish surveys as well as shellfish surveys for surf clams, ocean quahogs, sea scallops and shrimp. This report will concentrate on bottom trawl surveys targeting finfish. Information about shellfish surveys can be obtained from the Resource Surveys Investigation (RSI) at the NEFSC, Woods Hole Laboratory.

Currently the RSI conducts four bottom trawl surveys a year, one during each of the four seasons. The summer and winter surveys are relatively new. The summer survey targets Gulf of Maine fishery resources, especially juveniles; this series began in 1991. The winter survey which covers the mid-Atlantic and southern New England regions, is primarily directed towards flatfish species, although important data are collected for many other species as well. This series was initiated in 1992. The spring and autumn surveys represent our longest and most important time series; these cover the Atlantic shelf between Nova Scotia and Cape Hatteras, and are truly multi-species in nature. The spring survey was initiated in 1967 and the fall survey in 1963.

All NEFSC bottom trawl surveys are designed to gather fishery-independent abundance and distribution data for management purposes and to provide data for broad-scale ecosystem research. The benefits of this program have been very significant particularly in the case of the spring and fall surveys which, because of their longevity, have provided a very valuable monitoring tool to evaluate the effects of fishing and environmental factors on northeast fishery resources over time.

The following paper describes the NEFSC survey program and some of the initiatives that have been developed over the years to improve and insure comparability of survey indices throughout the survey time series.

Survey Methods

Most survey cruises have been conducted using the *R/V ALBATROSS IV*, a 57-meter (m) long stern trawler; however some cruises have also been made on the 47-m stern trawler R/V *DELAWARE II*. Ideally, one vessel should be used to avoid potential fishing power differences. Evaluation of this factor is described in more detail later in this report (see SESSION IV: Survey Techniques and New Technologies).

Beginning with the first trawl survey in 1963 it was decided that a multispecies ecosystem approach was required, which would yield data for both population and broad-scale biological studies. For population studies, a statistically valid quantitative sampling was required to provide estimates of sampling error or variance. Use of a stratified random design provided such estimates and, at the same time, permitted a fairly uniform spacing of stations for distribution studies. The study area, which now extends from the Scotian shelf to Cape Hatteras including the Gulf of Maine and Georges Bank was stratified by depth. The stratum depth limits are < 9 m, 9 - 18 m, >18 - 27 m, >27 - 55 m, >55 - 110 m, >110 - 185 m, and >185 - 365 m. Most strata are further subdivided into sampling units to achieve a more even sampling distribution.

Before 1972, the 27 m contour marked the shallowest sampling. In the 1970s and early 1980s, the surveys were extended south of Cape Hatteras to Cape Fear, and (primarily in the mid-Atlantic) coverage was extended inshore to depths of less than 9 m wherever possible. Stations are randomly selected within strata, the number of stations in a stratum being proportional to stratum area. The total survey area is 283,137 square kilometers (sq. km), about the same size as all of the New England states plus New York. We currently complete about 320 hauls per survey, equivalent to one station for about every 885 sq. km. In the late 1970s and early 1980s as many as 450 stations were occupied on a survey, with more extensive sampling being conducted in important resource areas such as Georges Bank. In recent years sampling south of Cape Hatteras, on Browns Bank (near Nova Scotia), and in the Bay of Fundy has been eliminated and coverage reduced in the most inshore (<18 m) and offshore (>110 m) strata, as a cost and time saving exercise.

On most spring, summer and autumn survey cruises, a standardized, roller rigged #36 Yankee otter trawl has been used. On the winter survey, a standardized flounder trawl with a cookie rigged chain sweep is employed. From 1972 until 1981, a larger #41 Yankee trawl was used on spring surveys, and from 1972 until 1975, a 3/4 Yankee trawl was used on some of the inshore (<27 m) surveys. The standardized #36 Yankee trawls are rigged for hard-bottom with wire foot rope and 0.5 m roller gear. Since data on juvenile fish abundance is important to our time series, all trawls have been lined with a 1.25 cm stretched mesh liner. BMV Oval doors were used on all surveys until 1985 when a change to Polyvalent doors was made. This was necessitated because the manufacturer could not continue meeting NEFSC specifications. The change in doors is the most significant disruption to have been introduced to our survey time series. Procedures used to evaluate and correct for this change are discussed later in this report (see SESSION IV: Survey Techniques and New Technologies).

During the early years of the surveys, a third wire trawl mensuration package was developed. Initially, trawls were tested and certified prior to a survey. This practice was discontinued because the specially constructed trawls were never found to under-perform. In subsequent years, several attempts were made using different instruments to routinely monitor the trawls during surveys to assure standard performance. This objective has yet to be achieved. A more detailed discussion of this topic can be found in another section of this report (see SESSION IV: Survey Techniques and New Technologies).

Operations on these surveys are conducted on a 24 hour basis. The scientific party is divided into two groups working watches of six hours on and six hours off. Trawl hauls are made for 30 minutes at a vessel speed of 3.5 knots measured relative to the bottom (as opposed to measured through the water). Tow direction is randomized by towing towards the next random station but seas, currents, proximity to shoals, and the need to follow the depth contour in deep water can occasionally force changes in this procedure. Currently spring and autumn surveys take 48 days, the winter survey 24 days and the summer survey 12 to 16 days. In addition to regular survey trawling operations, some vessel time is used for plankton sampling and trawl hauls to collect specimens for special studies.

The entire catch is sorted by species. The species weight is recorded to 0.1 kilos and all fish and selected invertebrates are measured. If the catch is so large (either in total or of a given species) that it is impractical to measure, the catch is quantitatively subsampled so the data can later be expanded to the total amount. Samples are also taken for age, growth, maturity, feeding habits, fecundity, pathology and other studies. Although many of the above parameters are recorded in detail on the vessel, many samples are preserved for subsequent workup and analysis in the laboratory.

Data are recorded on two-sided waterproof paper forms. The data forms or logs are manually pre-processed at sea and data are entered into preliminary computer files by a contractor following the cruise. A series of audits are then initiated to eliminate recording or entry errors. Data are available for assessments or other research needs within two to three months.

Future Changes/Enhancements

One of the primary objectives of the RSI program has been to develop on-board data entry, thus reducing errors and processing time. Attempts to enter the data at sea using conventional computer keyboards have not been successful. Berthing is limited on the vessels and dedicated data entry staff would reduce ability to collect biological information. Also, sea conditions are often such that data entry tasks cannot be conducted with sufficient reliability for any length of time.

Recently, significant strides have been made in developing at-sea data entry systems employing pen-based computers and PCs to log catch data, and a ship's computer system to record environmental data and ships operating parameters while minimizing conventional keying operations. A prototype system has been successfully tested on shellfish surveys, and a bottom trawl survey system is under development. As envisioned, the completed system will include, in addition to the above, electronic measuring boards for collection of length frequency data along with bar code generators and readers. Data may either be transmitted via satellite on a daily or more frequent basis, or downloaded from the ship directly into laboratory computers upon return to port.

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A Report on Current State of Maine Groundfish Surveys

by
Richard Langton, Daniel Schick, Sally Sherman and Michael Brown
Department of Marine Resources, Marine Resources Laboratory

Introduction

In 1979 and 1980, the State of Maine conducted a groundfish survey as part of the Fisheries and Development Project of Maine's Coastal Zone Program, which was administered by the Maine State Planning Office. The two bottom trawl surveys were modelled after the National Marine Fisheries Service (NMFS) groundfish surveys in the Gulf of Maine. It was anticipated that this work would develop into a time series of data on the relative abundance and distribution of the commercial and recreational finfish occurring along the Maine coast. Unfortunately, it was not continued due to loss of funding. Nevertheless, the preliminary results of these studies were described in a completion report to the Maine State Planning Office (Walton, 1979) and the raw data remains in the Department's computer data bank.

In May of 1989 a groundfish survey was again proposed by the Department of Marine Resources and a preliminary cruise was conducted using the *R/V ARGO MAINE* in May of that year. Over a seven day period, only eight randomly selected stations were successfully towed for the designated 30 minute period. An inordinate amount of time was spent searching for trawlable bottom, there were unforeseen manpower requirements, and complications with the gear. For these reasons, the idea of a randomized trawl survey were abandon at that time.

In 1991, the Department responded to a Request for Proposals by the NMFS to conduct biological sampling in the Gulf of Maine. The sampling was to focus on demersal finfish and would involve sequential sampling at selected stations at monthly intervals over a one year period. Biological information such as fish length, weight, sexual maturity and relative abundance were to be determined for a selected suite of species. The Department was awarded this contract and began sampling in May of 1992. At the same time, the Department was the recipient of a Saltonstall-Kennedy (S-K) grant to investigate the seasonal co-occurrence of the northern shrimp, *Pandalus borealis*, and juvenile groundfish through a depth gradient along the entire coast of Maine. Consequently, field work for both projects was closely coordinated. A renewal of the S-K grant extended the sampling through the spring of 1994 and the collection of biological data was also continued. A subsequent S-K gear development grant, to work on square mesh, will be conducted by the Department during 1994-1995 and will visit some of the same stations previously visited along the coast. No other bottom trawl survey work is being contemplated by the Department. This report summarizes the State's results of the sampling programs begun in 1992.

Survey Design and Methodology

The sampling program for the NMFS contract and the S-K grant were combined for financial and logistical reasons. In both cases the sampling stations were not randomly selected. Interviews with local fishermen were used to identify trawlable bottom and stations were selected along a series of transects that extended from inshore to offshore. The transect series covered a depth range of approximately 10 to 70 fathoms.

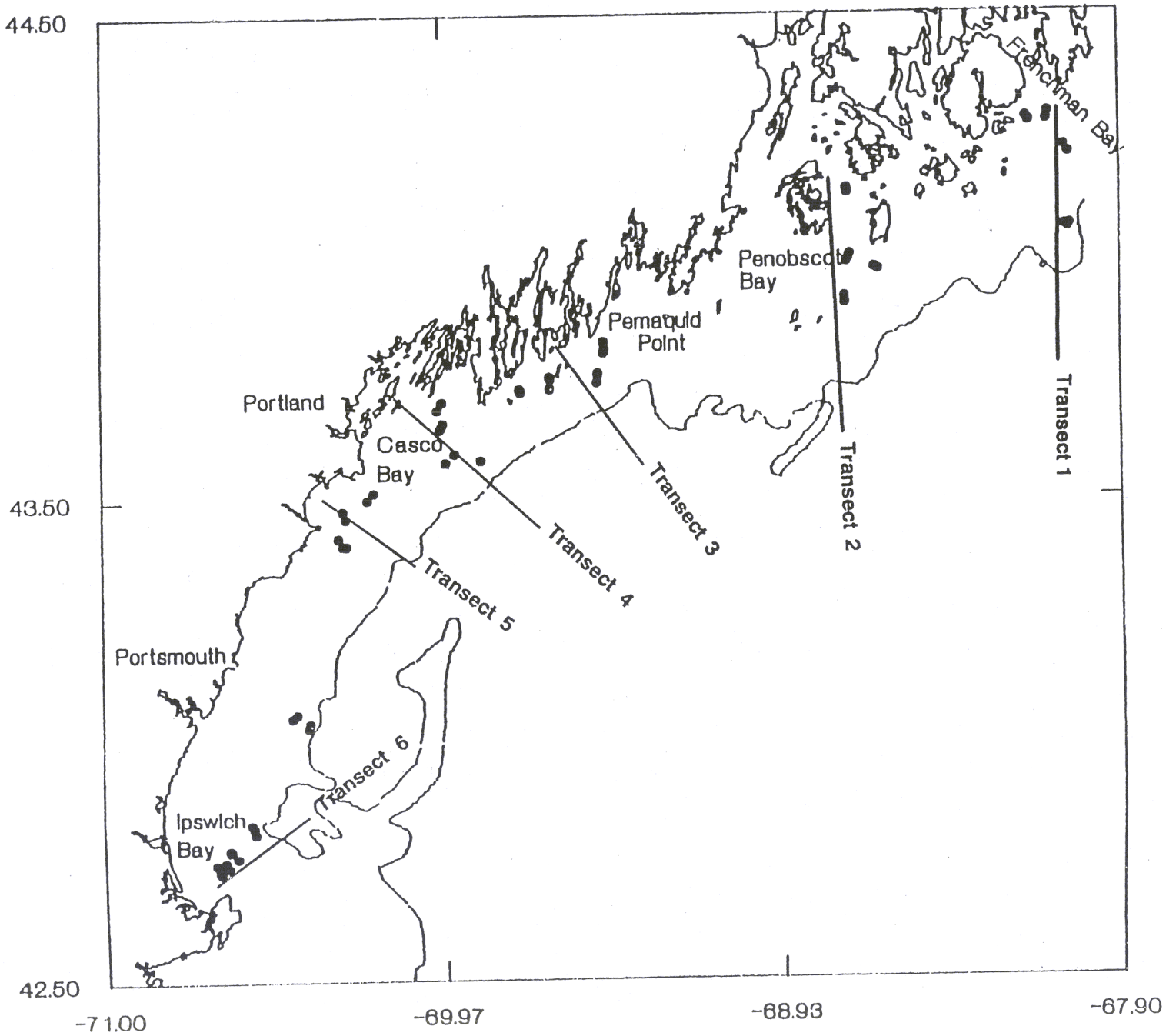
The S-K sampling protocol was more rigid than the NMFS sampling requirements so it was utilized as the basis for both programs. In 1991, the S-K sampling was based on a series of six transects and four stations per transect (see Figure 1). Each station was to be trawled for 30 minutes, in triplicate, in May and September of 1992, and January and March of 1993 during daylight hours. Because of the day length the January sampling was restricted to two samples per station. In 1992, for the renewal of the S-K grant, single tows at each station were completed along three of the six transects in July, August, September and October of 1993, and January through April of 1994.

The NMFS sampling protocol was not necessarily structured to be a survey *per se* as much as a monthly collection of biological samples. For this reason, when the S-K requirements were not overriding, trawls were again restricted to 30 minutes in duration and only during daylight hours but there were usually no replicate tows. In addition, several other stations were added, primarily in the mid-coast area of Maine, and the geographic range of the survey was more restrictive (generally within the bounds of transect 3 and 5 as shown on Figure 1).

The research vessel utilized for all the sampling was the *R/V ARGO MAINE*. It is an 80 ft. boat that has a crew of five and accommodation for up to eight scientific staff. The vessel is set up for otter trawling and is not only used by Maine but has also been chartered by the State of New Jersey for their survey program.

The trawl gear itself was slightly modified over the course of the sampling program. The net is essentially a 3/4 in. whiting net that was originally constructed according to specifications supplied to the Department by the state of Massachusetts. Originally the differences between the Maine and Massachusetts gear were limited to the use of 3/8 in. wire rather than 3/8 in. chain for the bridle and the use of 38 x 51 in. v-shaped otter doors rather than a 39 x 60 in., 325 lbs. Tomkiewicz flat otter trawl door. Ultimately a small set of rollers was added to the footrope, to deal with rough bottom, and the net was modified by shortening the belly and widening the opening, making the net shorter and fatter. Due to a lack of 3.5 in. mesh netting, the wings and the body of the net were all replaced with two inch shrimp mesh, while the cod end remained the same with a 0.25 in. mesh liner.

Figure 1. Sampling sites: Seasonal location of shrimp and juvenile groundfish. Transect lines and actual sampling stations (solid circles) for the groundfish and shrimp survey along the coast of the Gulf of Maine.



Database Management System

In the field, data was recorded manually and entered onto PCs upon return to the laboratory, except in the case of shrimp carapace length measurements. Shrimp lengths were recorded with digital calipers and downloaded directly to a portable Zenith 386 on-board the vessel. Standard software packages have been utilized for data storage and analysis. These include dBase, Systat and Sygraph, and Word-Perfect as well as Stat Pac Gold. Separate databases have been maintained for the NMFS and the S-K projects. For the NMFS database, there are four dBase files for each monthly cruise: a station information file containing Loran-C tow locations, times, depths, temperatures, salinities, and comments; a catch data file containing numbers and weights of fish caught at each location; a length frequency file; and a biological data file for selected species (all flatfish, most gadiform fish and a few others). For the S-K project, data is stored in four ASCII formatted files and Stat Pac Gold is used for maintaining and editing these files. Station location information, environmental data and comments are stored on a header file. Biological data is separated into the remaining three files: a numbers file which contains weights and numbers by species per tow; a length frequency file containing information on fish and shellfish; and a shrimp data file containing shrimp carapace lengths.

The size of the databases is relatively small and they are currently being analyzed so that no long-term archive has been established.

Results

The actual sampling stations are shown in Figure 1. They occur along a loosely defined series of six inshore-offshore transects in the Gulf of Maine. Four stations were usually fished along each transect representing a depth gradient in approximately 10 fathom increments. Station A = 20 fathoms, B = 30 fathoms, C = 40 fathoms and D = 50 fathoms.

Bottom temperatures were recorded at each station on four cruises in 1992 (Figure 2). The temperatures reveal a strong seasonal pattern with minimum temperatures occurring in the spring (March 1992) at the shallowest stations along the coast and maximum temperatures occurring in the autumn (September 1992) also along the coast. Overall the temperature extremes were less severe at the deeper stations in the western part of the Gulf, while the warmest temperatures at these stations occurred in January.

Patterns in the distribution of three commercially important flatfish species were evident in the 1992 data set. Winter flounder, (*Pleuronectes americanus*), although ubiquitous, occurred primarily nearshore (Station A) with some incursion into deeper water during the colder months (Figure 3). In contrast, both gray sole (*Glyptocephalus cynoglossus*), and American plaice (*Hippoglossoides platessoides*) were more abundant in deeper waters (Stations C and D) (Figures 4 and 5). American plaice, however, were more common in the southwestern Gulf of Maine, while gray sole were more commonly caught along the eastern transect line.

Figure 2. Bottom water temperatures on four of the coastal survey cruises in 1992. Transect lines correspond to transects shown in Figure 1. The stations go from inshore (A) to offshore (D) and represent an approximate depth increase from 20 to 50 fathoms.

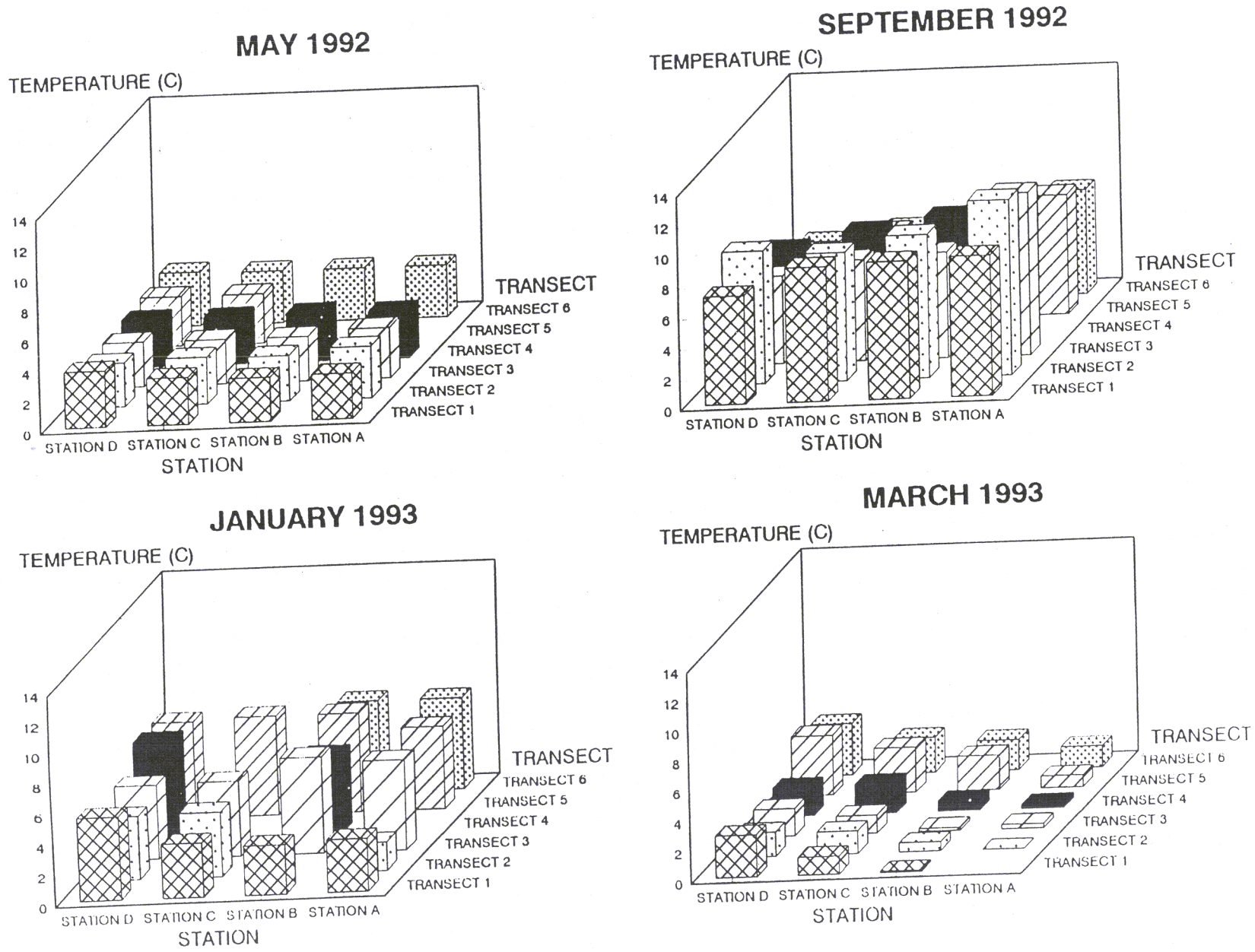


Figure 3. Distribution of winter flounder on quarterly coastal cruises in 1992, expressed as mean numbers of fish per hour towed. Transect locations are shown in Figure 1 and stations represent a depth gradient form inshore (A) to offshore (D).

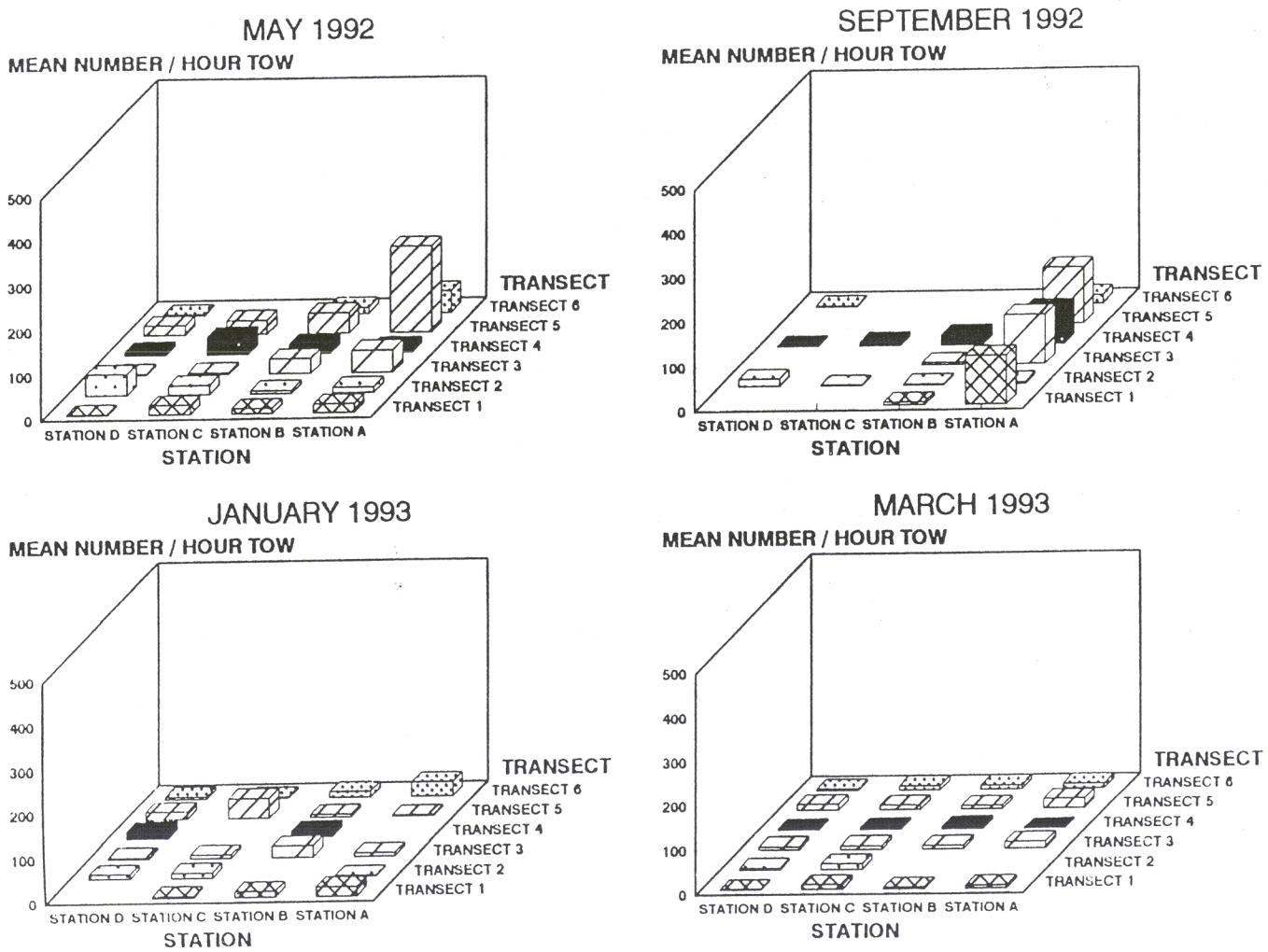


Figure 4. Distribution of gray sole on quarterly coastal cruises in 1992. See Figure 3 for explanation of the axes.

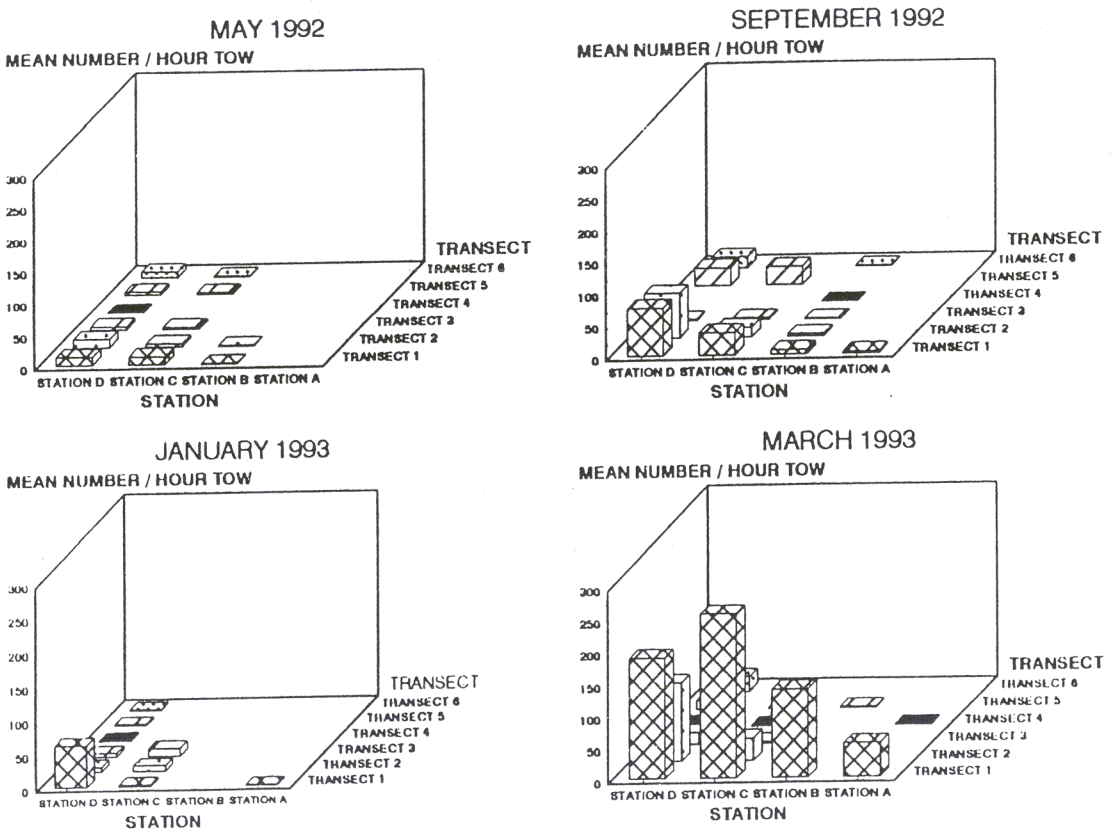
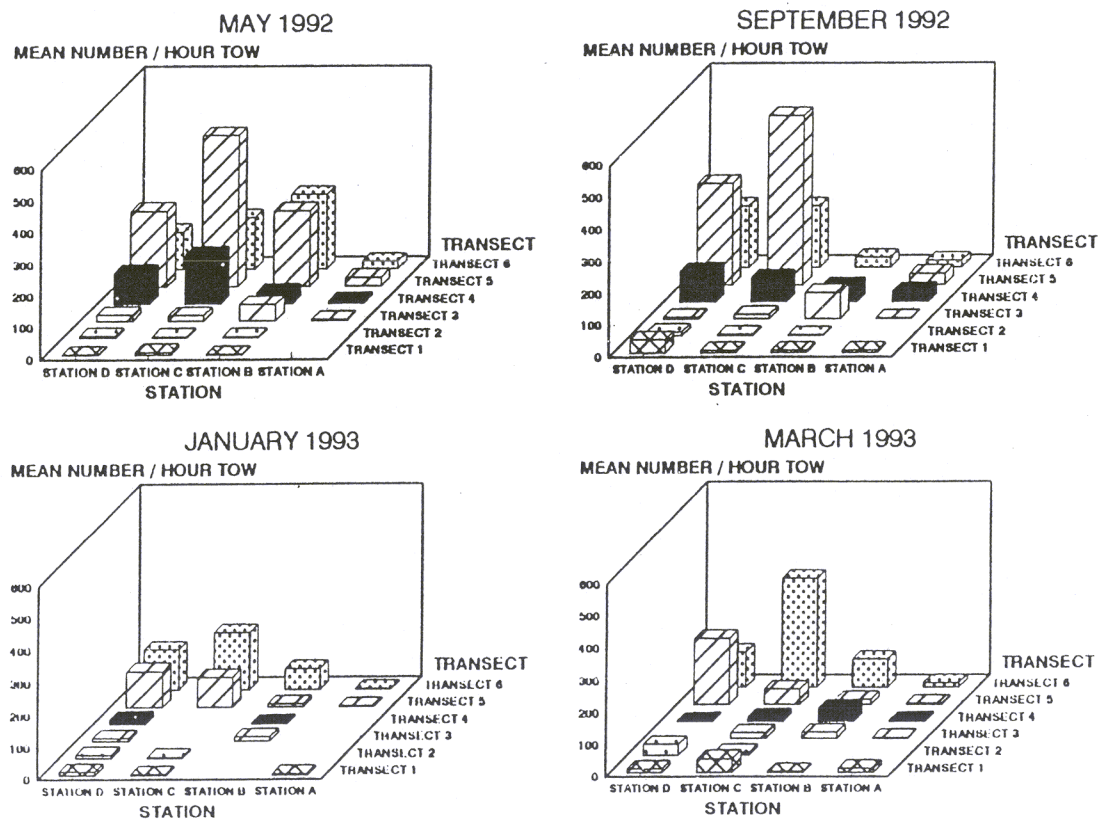


Figure 5. Distribution of American plaice on quarterly coastal cruises in 1992. See Figure 3 for explanation of axes.



Over the course of the study, May 1992 through 1994 there have been some changes in the abundance of different species of fish. One example (Figure 6) demonstrates the change in abundance of gray sole over the course of the study. In this instance, the mean number of fish per tow has shown a significant increase. The eighth and the fifteenth point on the graph, for example, correspond to January 1993 and January 1994, respectively. Patterns in the distribution of the gadiform fishes are also apparent from an examination of the database. The occurrence of two species of hake, red and white or *Urophycis chuss* and *U. tenuis* respectively, demonstrate a strong negative correlation (Figure 7). Red hake are much more abundant in the southwestern Gulf of Maine, while white hake were more common in the trawl catches in the eastern Gulf. Atlantic cod, *Gadus morhua*, also demonstrated an interesting pattern (Figure 8) with the maximum numbers of fish caught in the mid-coast region of the Gulf occurring in the autumn, while the peaks in occurrence in the eastern and western Gulf were observed during the spring.

Part of the study was to document the co-occurrence of northern shrimp and groundfish. Figure 9 shows the distribution of northern shrimp along the transects covered during 1992. They were most abundant during the winter and spring at the deeper sites in the southwestern Gulf of Maine.

Availability and Dissemination of Reports

No reports or publications have resulted from these two studies to date. One poster was presented at the British Fisheries Society meeting in Conwy, North Wales, U.K. in 1993.

Integration of Surveys with Other Reported Surveys

The biological sampling was done on contract for the NMFS. All data collected for the contract was submitted to the Northeast Fisheries Science Center in Woods Hole, Massachusetts and has been incorporated into their larger groundfish database.

Analysis of the data collected for both the NMFS and S-K contracts is continuing. It is anticipated that these data will be incorporated into one or more scientific publications. In the interim, details on the NMFS study can be obtained from Sally Sherman and details on the results from the S-K study can be obtained from Dan Schick.

Figure 6. Change in abundance of gray sole over the course of coastal cruises from May 1992 through January 1994.

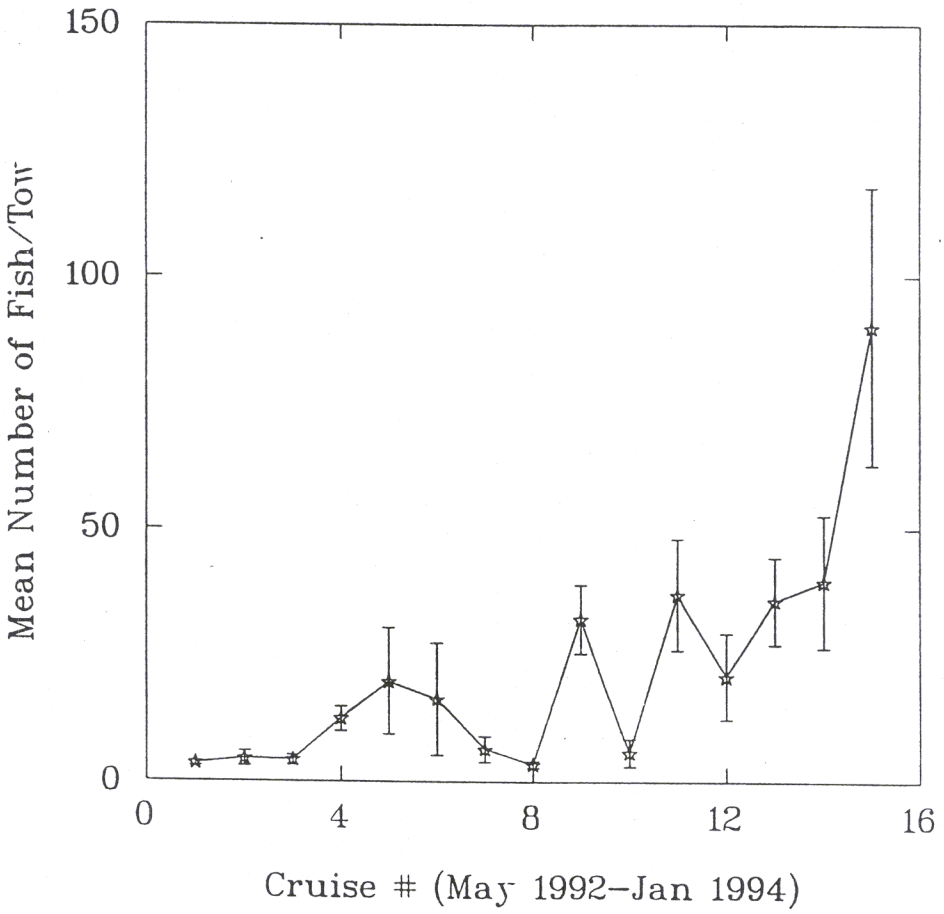


Figure 7. Occurrence of red and white hake on transect 1 through 6, (see Figure 1) expressed as mean number of fish per tow for the period May 1992 through January 1993.

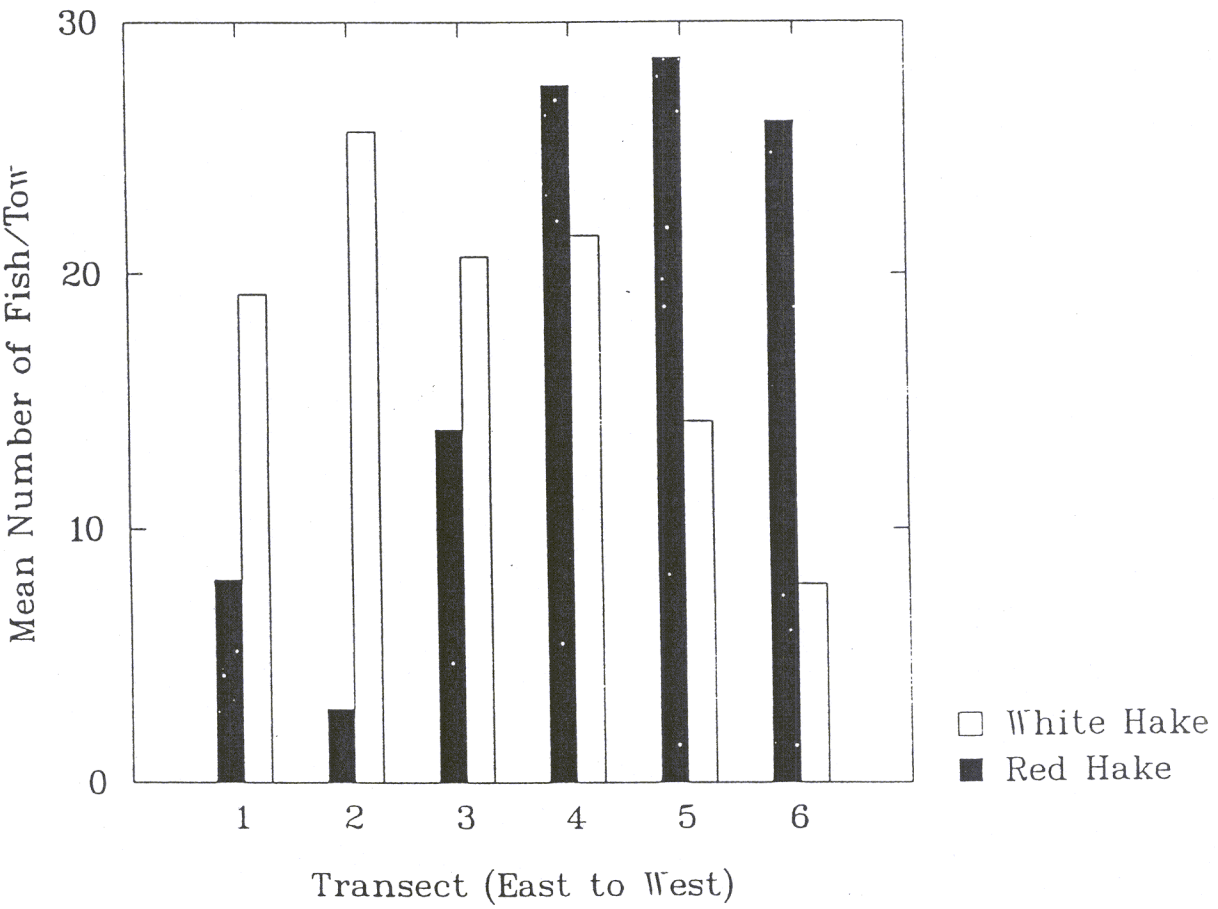


Figure 8. Occurrence of Atlantic cod in the east, mid-coast and western sectors (top to bottom of figure) of the Gulf of Maine for the period May 1992.

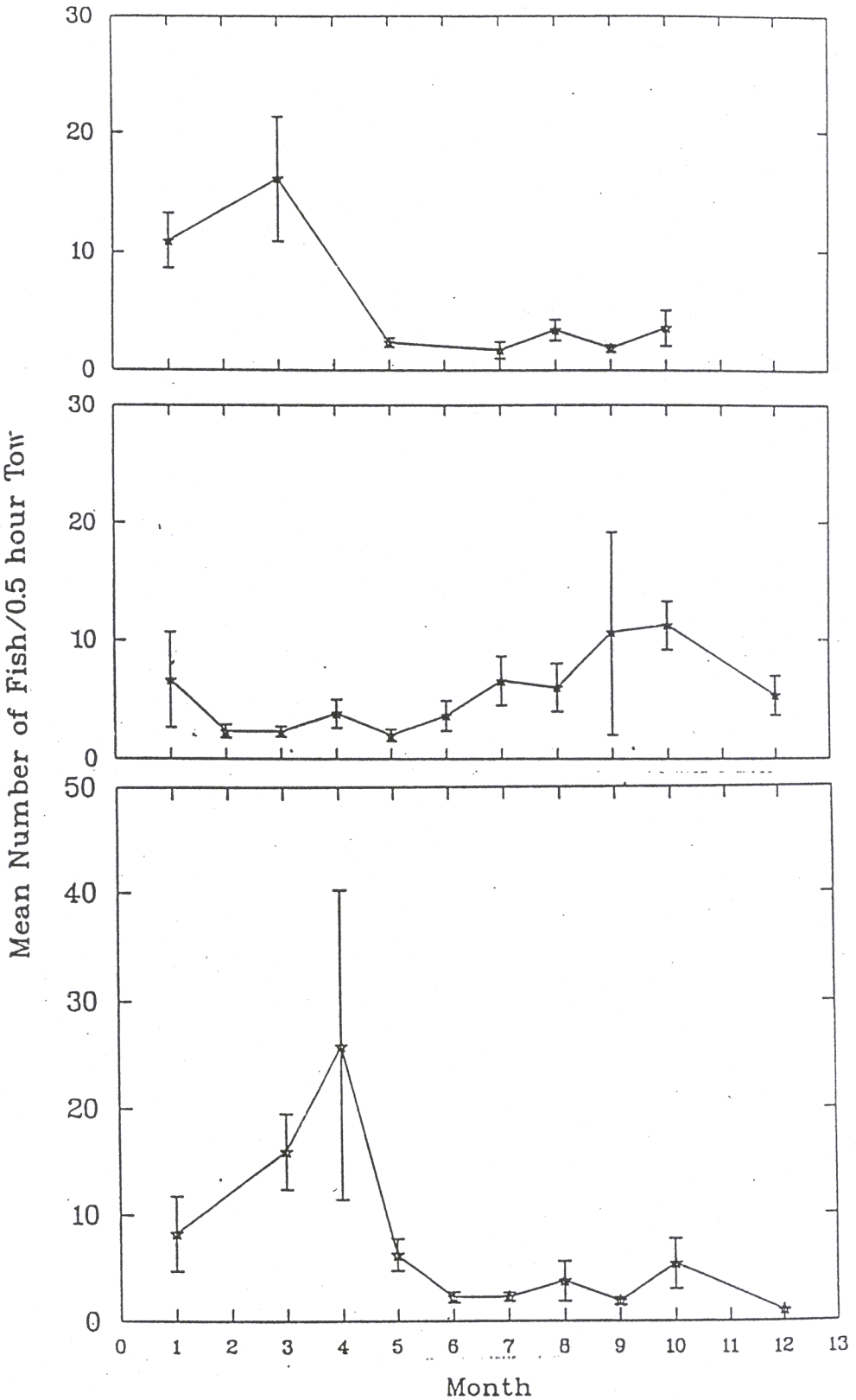
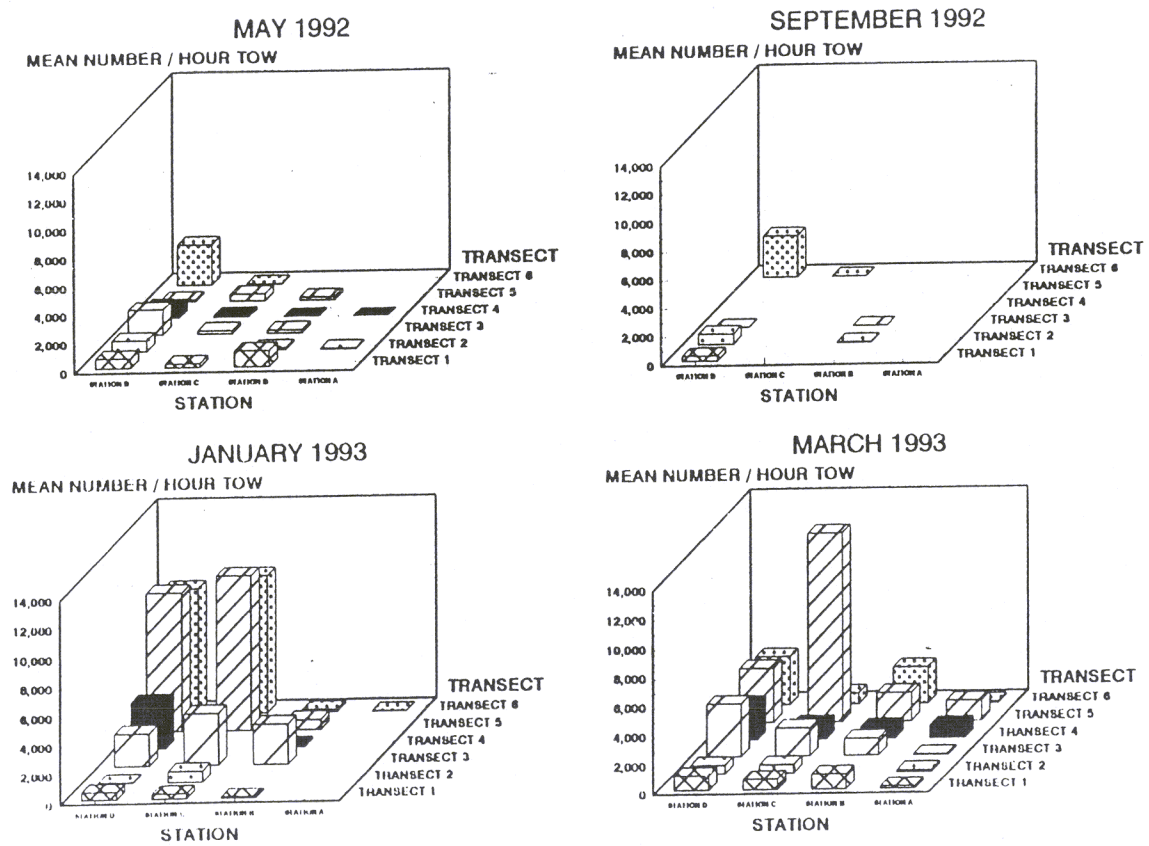


Figure 9. Distribution of northern shrimp on quarterly coastal cruises in 1992. See Figure 3 for explanation of axes.



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Massachusetts' Inshore Bottom Trawl Survey

by
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Since 1978, standard spring and autumn bottom trawl surveys of Massachusetts inshore or territorial waters have been conducted by the Resource Assessment Project, Massachusetts Division of Marine Fisheries (MDMF) in cooperation with the Northeast Fisheries Science Center (NEFSC). The objective of this ongoing daytime survey was to obtain fishery-independent data on the distribution, relative abundance, and size composition of finfish and certain crustaceans and mollusks. Data collected on the surveys have been used for management purposes, biological studies, and to evaluate alterations to nearshore habitat.

The survey utilizes a stratified random sampling design using 23 strata based on six depth zones (<30, 31-60, 61-90, 91-120, 120-180 and >180 ft.) and five bio-geographic regions (Massachusetts Bay north to the Merrimac River, Cape Cod Bay, waters south and east of Cape Cod and Nantucket, Nantucket Sound, and Buzzards Bay/Vineyard Sound). Each region is divided into 1.0 square nautical mile sampling units based upon a LORAN C based grid. A total of 100 stations are allocated to strata, in approximate proportion to each stratum's area; a minimum of two stations are assigned to each stratum in order to provide estimates of variance. Tow location within each sampling unit is based upon presence of "good" bottom and absence of fixed gear. An alternate tow site in the same stratum is selected if concentrations of fixed gear or untowable bottom preclude trawling. Sampling intensity is approximately one station every 19 square nautical miles.

Sampling gear consists of a 3/4 North Atlantic type two seam "whiting" trawl (39 ft. headrope and 51 ft. footrope) equipped with a fine mesh (0.5 in.stretch) codend liner, chain sweep (3.5 in. diameter rubber disc), wooden doors (6 ft. x 40 in., 325 lbs.) and 10 fathom legs. Four complete nets and one set of doors are kept on board during the survey; two nets and an extra set of doors are stored ashore for emergencies. A standard tow is twenty minutes at 2.5 knots with a 3:1 scope. Tows are deemed acceptable with tow durations between 13 and 20 minutes and little or no damage to the trawl. Total weight, total number and length frequencies from short tows are expanded using the ratio of the standard 20 minute tow to the short tow's duration as an expansion factor. When only one individual of a species is caught, number and weight are not expanded.

One exception to the 13 minute minimum tow occurs in the autumn survey when high concentrations of spiny dogfish are noted on the fishfinder. Tows longer than two minutes can result in very large catches of spiny dogfish and occasionally fill the net to the sweep. These large catches are very time consuming to haul back and process, are often impossible to bring aboard, may cause extensive damage to the net, result in no information if the catch cannot be brought on board, and put personnel in potentially dangerous situations (e.g., diving in the water to open the

cod-end). The catches of these tows, which are overwhelmingly dominated in weight and number by spiny dogfish, are also expanded to twenty minutes using the ratio of 20 minutes to the tow's duration as an expansion factor.

Surveys are conducted over the same time period in the months of May and September. The sampling periods coincide with seasons when either adults or their pre-exploitable counterparts are available inshore. The survey takes 17 days (mean) to complete with the average sea day being 12 hours dock to dock. Approximately 194 hours of sea time are required per survey. About 94 stations per survey are completed with an average of six tow attempts per day. Normally two members of the project plus one volunteer from within the agency participate on a daily basis. The MDMF devotes an average of 587 staff hours to each survey. The research vessel's crew, consisting of two to four members, operate the ship and fishing gear, repair damaged gear, and frequently help sort the catch.

Surface salinity, surface and bottom water temperature, wave height, swell height and direction, wind direction and strength, percent cloud cover, time of day, and weather condition are recorded at each station. Total weight, total number, and length are recorded for all finfish, and certain other species on a standard NMFS 'trawl log'. Large catches are subsampled according to standard survey protocol. Subsampling is usually done "by weight", i.e., measuring and counting a pre-weighed subsample of the total weighed catch and expanding the number in the subsample to the total number using the ratio of total catch weight to the subsample weight. Occasions arise when catches are subsampled by volume or number. Hard parts are removed for aging and maturity and gross external pathological examinations are performed on commercially and recreationally important species. Other routine special sampling includes water samples for bacteriological testing and specimens for the MDMF contaminant monitoring program. Biological requests by state, federal, and academic institutions are also fulfilled.

Trawl logs are finalized and coded for computer processing within weeks of the survey's end. Trawl logs are submitted to NEFSC for data entry unto the Woods Hole VAX computer. After entry, data are audited using NEFSC audit software and DATATRIEVE software. The database's format is the same as the NEFSC survey. Stratum mean and variance, stratified mean, variance, and confidence intervals (two standard errors), and stratified mean number per tow at length for 26 species of interest are calculated using the NEFSC's SURVAN program immediately after the survey's audit is completed. In addition to these routine analyses, the database is frequently queried to respond to science and management needs.

State of Connecticut Marine Finfish Trawl Survey

by
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State of Connecticut Department of Environmental Protection
Division of Fisheries

Introduction

The objective of the Connecticut Trawl Survey is to monitor the relative abundance and distribution of marine finfish species in Long Island Sound and determine population parameters for selected finfish species important to marine recreational fishermen.

The survey has been conducted since 1984 with modifications made at various times. What follows is the current survey design.

The survey is divided into spring and fall sampling periods. One hundred and twenty sites are sampled each period for a total of 240 sites sampled annually. In the spring, 40 sites are sampled monthly during April, May and June, and in the fall three cruises of 40 sites each are conducted from September through October. At each site, a 14 x 9.1 m high-rise otter trawl (mesh size: 102 mm in wings, 76 mm in extension, 5 mm codend) is towed for 30 minutes at 3.5 knots. Sampling is conducted during daylight hours to reduce the bias associated with day-night changes in catchability of some species.

The survey is based on a stratified-random sampling design and includes all waters between the Connecticut/New York border in western Long Island Sound and New London, Connecticut/the Race in the east. Sampling sites are 1.85 x 3.7 km (1 x 2 nautical miles) and are defined by depth interval (0-9.1, 9.1-18.3, 18.3-27.1, >27.1 m) and bottom type (mud, sand, or transition). The number of replicate samples within each stratum is determined by dividing the total area in each stratum by 20 square nautical miles, with a minimum of two samples per stratum. Known obstructed bottom and stratum areas smaller than a sample site are not sampled.

Sampling

Prior to each tow, temperature and salinity are measured 1 m below the surface and 0.5 m above the bottom. For each trawl sample finfish, lobsters and squid are separated by species, counted, and weighed (0.1 kg). Invertebrates other than lobsters and squid are weighed but not counted. Sixteen species are measured (cm). Three species -- blackfish, scup and winter flounder -- are subsampled for ageing.

Routine Annual Analysis

A geometric mean catch per tow is calculated as an index of abundance for the 33 most common species. A spring index is calculated for 18 species, and a fall index for 16 species.

Age frequencies are generated for blackfish, scup and winter flounder using age keys developed by staff. Bluefish age frequencies are developed from length frequencies by using a cohort splicing method. Summer flounder age frequencies are developed from age keys of other states. A catch-at-age matrix is developed for each species using the abundance index and age frequency.

Catch-at-age data are used to calculate fishing mortality estimates for blackfish, scup, and winter flounder using within year catch curve, cohort, and pooled cohort methods.

Modifications to the Survey Since 1984

1989

From 1984-1988, only five species that were most important to the recreational fishery were targeted for measuring: bluefish, blackfish, scup, summer flounder, and winter flounder. In 1989 and 1990, subsamples of 18 more species were measured to characterize their occurrence in Long Island Sound.

1990

The 42 ft. fiberglass research vessel used since the beginning of the survey in 1984 was replaced with an aluminum 50 ft. research vessel. Joint cruises were conducted to coordinate tow speed, net retrieval and sampling technique. Comparison tows were then conducted to assess relative fishing power. Six paired tows were conducted each day for two days, with the gear (net and doors) switched the second day. No difference was found in catchability. Not enough paired trawls could be conducted to compare species-specific differences in fishing power (Approximately 480 paired tows would have to be conducted to detect significant differences in catch for the 15 most common species.). However, no noticeable changes in trends of abundance that might be attributable to the change in vessels has been noticed.

1991

The original survey design called for 40 sites per month to be sampled from April through November. By 1991, other data needs were mounting, and the acquisition of the *John Dempsey* made other types of sampling possible. The April through November design was reevaluated to see if calculations of indices on a seasonal basis improved the precision. In 1985, analysis of 1984-1985 data had shown that the month of sampling accounted for most of the variation in the catch data for most species, an average of 22 percent (two to 57 percent). Therefore, abundance indices calculated on a seasonal basis (spring and fall months) were compared to April-November indices to see if precision was maintained or improved. The coefficients of variation (CVs) calculated using the standard deviation showed the variability in catch was reduced for all species. CVs using the standard error generally showed some loss of precision or no improvement. In most cases, the gain made in the reduction of variability were offset by the loss of sample size.

However, for the most important species, there was no significant loss in precision. As a result, the survey was changed to a spring/fall schedule.

With July and August available for other work, a new trawl survey was initiated to assess the relationship of fish abundance to dissolved oxygen and possible changes in ambient dissolved oxygen due to a bi-state effort to reduce nitrogen loading to Long Island Sound.

1992

Temperature and salinity measurements were not collected on a routine basis prior to 1991. In 1991, temperature and salinity measurements were incorporated into the sampling procedures design.

Biomass was not measured from 1994-1991. In 1991 a Doran scale capable of weighing to +/- 25 gm was acquired, and weighing of the catch was incorporated into sampling procedures. Each species was separated and weighed to the nearest 0.1 kg in 1992.

1994

From 1984 to 1988, bluefish and summer flounder scales were collected and aged. However, from 1989 on, the scales were collected and archived since other states were adequately aging both species. In 1994, collection of scales from bluefish and summer flounder was discontinued.

Data Management

As the database grew, management and accessibility of the data was re-evaluated. To improve data entry and error checking, Progress software was employed. SAS was chosen as the data analysis software, and all historical data was converted to SAS datasets. For the foreseeable future, data will be entered into a Progress database and error checked, then converted to SAS datasets.

Peconic Bay Small Mesh Trawl Survey 1985 - 1994

by
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New York State Department of Environmental Conservation

Introduction

In 1985 the New York State Department of Environmental Conservation began a small-mesh trawl survey within the Peconic Bay Estuary to develop a recruitment index for weakfish (*Cynoscion regalis*). This survey was undertaken based on the research recommendations of the Atlantic States Marine Fisheries Commission's Fishery Management Plan for Weakfish (Mercer, 1985; Weber, 1989). Though the initial intent was the development of a recruitment index for weakfish, in 1987 the survey data collections were expanded to include all finfish species encountered. While weakfish remain the primary species of interest, this survey has been able to develop recruitment indices for several other economically important species such as winter flounder (*Pleuronectes americanus)*, scup *(Stenotomus chrysops)*, blackfish *(Tautoga onitis*), bluefish (*Pomatomus saltatrix*) and northern puffer (*Sphaeroides maculatus*). In addition, this survey provides important baseline data on the relative abundance, distribution and presence of juvenile fishes within the Peconic Bay Estuary.

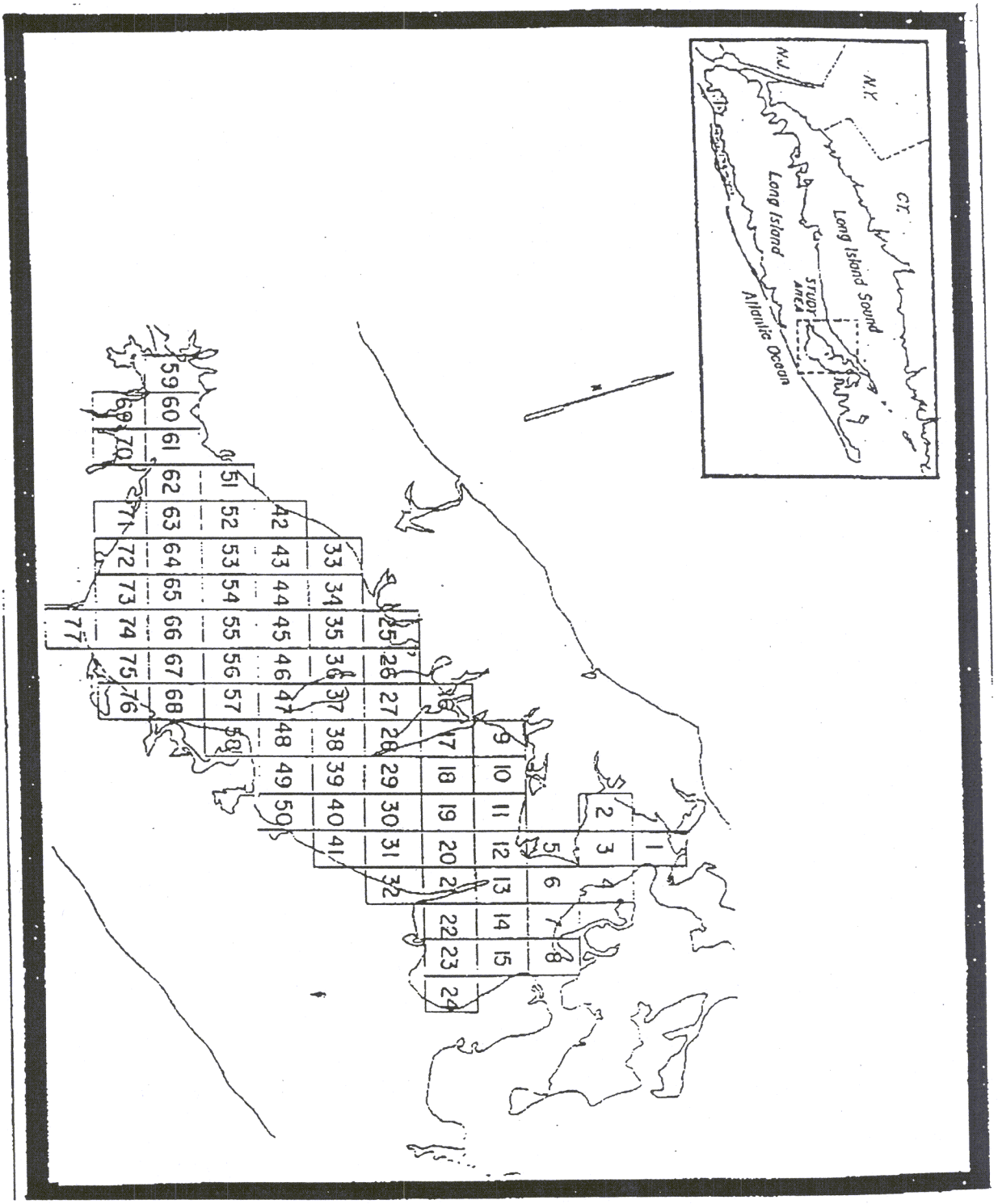
Methods

The Peconic Bay System was chosen as the area of study due to its relative importance as a spawning area for weakfish in New York (Perlmutter, 1939; Weber, 1989). Although currently the dominant landings of weakfish are from the Exclusive Economic Zone, historically 60 percent of commercially landed weakfish within New York State had come from the Peconic and Gardiners Bay estuaries.

Station locations for the survey were selected based on a block grid design superimposed over the sampling area. The survey area was divided into 77 sampling blocks, each of which is measured 1 minute latitude by 1 minute longitude. Blocks were consecutively numbered beginning at the northernmost point (see Figure 10). From May through October of each year, sixteen stations were randomly chosen each week and sampled by otter trawl during daylight hours. In 1990, station number 59, located at the most western terminus of the estuary, at the mouth of the Peconic River was excluded from further sampling because heavy sea grass and algae conditions interfered with trawling.

The research vessel used was the *David H. Wallace*, a 35-ft. Bruno Stillman stationed at the Suffolk County marina at Shinnecock canal. The net used throughout the survey was a semi-balloon shrimp trawl with a 16-ft. headrope and a 19-ft. footrope. The net was made of nylon netting with 1 1/2 in. stretch mesh in the body, 1 1/4 in. stretch mesh in the cod end fitted with a 1/2 in. stretch mesh cod end liner, and was rigged with 12 by 24 in. wooden doors with chain

Figure 10. Peconic Bay trawl survey stations.



bridles. From 1987 through 1990, nets were rigged using 200 ft. warp with 50 ft. scissors of 3/8 in. diameter nylon rope on each end and retrieved using a lobster pot hauler. In 1990, the research vessel was re-outfitted to include an A-frame and hydraulic trawl winches. For the remainder of the study, nets were rigged with 250 ft. warp of 3/8 in. wire cable and 50 ft. scissors of 1/4 in. wire cables and were set and retrieved under hydraulic power.

From 1987 to 1991, stations were located using Loran C navigation. In 1992, SatNav was added and is now the primary position indicator. At the beginning and end of each ten minute tow, location (T/D coordinates) and depth were recorded. At each station the time clock was started when the gear is fully deployed. If a selected tow site was abandoned due to hangs and/or debris, a nearby site within the same sampling grid was chosen and the tow redone. The towing speed of the net was two knots and towing direction within each grid differed and speed varied based on tidal and wind conditions.

Temperature (^{o}C), salinity (ppt), dissolved oxygen (ppm), and secchi disc (ft.) readings were recorded at each station. From 1987 through 1990, bottom and surface temperature and salinity readings were taken using a YSI model #33 S-C-T meter, and bottom dissolved oxygen readings were made using a modified azide Winkler titration. Beginning in 1990, bottom and surface temperature, salinity, and dissolved oxygen readings were taken using a Hydrolab Surveyor II water quality sampling unit, generally calibrated on a bi-monthly basis.

All fish collected in each tow were sorted, counted, identified, and measured to the nearest mm (fork or total length). Large catches were usually subsampled, with length measurements taken on a minimum of 30 randomly selected individual fish of each species. Similar information was collected for several macro-invertebrate species as well; these were sorted, identified and enumerated. For invertebrate species of particular interest, additional length information was recorded. As with finfish specimens, large catches were generally subsampled. All data collected during the course of this survey were entered on a spreadsheet format using Lotus software.

Results

To date (August 1994), a total of 3,330 trawl stations have been sampled in the study area. Since this survey began, 72 species of finfish representing over 40 families have been collected, sorted, and identified, as well as the five major crustaceans species encountered (Table 1). The catches were mostly dominated by the forage or "bait species". Among the economically important species winter flounder has been constantly one of the most dominant. The majority of the winter flounder caught were young of the year.

Since the inception of the study, weakfish year class strength generally remained at a low level until 1991, when a large year class was encountered. The 1991 year class was a magnitude of approximately 10 times that of any previous highest (1985). The 1992 year class was second

TABLE 1. SPECIES RANKING BY RELATIVE ABUNDANCE

SPECIES / YEAR	1985*	1987	1988	1989	1990	1991	1992	1993	1994+
AMERICAN EEL	23					31	33		
AMERICAN SANDLAUNCE		25	8	15	6		21	21	23
ATLANTIC MACKERAL		25	21	31					
ATLANTIC SILVERSIDE		4	2	5	7	9	7	7	5
ATLANTIC TOMCOD	19	20	18	20	21	29	30	19	12
BANDED KILLIFSH		25							
BARNDOOR SKAKE									29
BAY ANCHOVY		1	1	1	1	4	6	3	3
BAY WHIFF	22								
BLACK SEA BASS	12		32	29	27	24	30		28
BLACKFISH	9	11	14	8	12	11	14	12	17
BLUE CORONET							33		
BLUE RUNNER						31			
BLUEFISH	6	9	12	11	16	20	26	22	23
BUTTERFISH	8	18	5	9	9	14	10	13	15
CLEARNOSE SKATE				31	31	28	33	33	
COW NOSE RAY			32						
CREVALLE JACK	23	23	19	24	24	26	31	31	20
CUNNER	21	25	24	23	22	22	24	18	19
DWARF GOATFISH								33	
FOUR SPOT FLOUNDER	23			31		30	33	33	29
FOURBEARD ROCKLING	23	25	28	31	27	28	22	24	26
FOUR-SPINE STICKLEBACK	23	16	31					33	20
GRAY TRIGGERFISH				31					
GRUBBY	20	25		28	32	27	31	23	25
GUAGUANCHE				30					
HERRING SPECIES		2	3	3	3	20	2	4	6
HOGCHOKER	11	17	20	21	20	10	17	25	24
INSHORE LIZARDFISH			32	30	32		28	29	
KINGFISH				30	32		23	27	29
LITTLE SKATE			32		29		25	26	21
LOOKDOWN				31	26				
MACKERAL SCAD				31					

TABLE 1. (cont.). SPECIES RANKING BY RELATIVE ABUNDANCE

SPECIES YEAR	1985*	1987	1988	1989	1990	1991	1992	1993	1994+
MENHADEN	18	22	30	27	17	25	30		29
MOONFISH	23								
MUTTON SNAPPER					32				
NAKED GOBY	15	13	22	19	13	16	20	17	18
NORTHERN PUFFER	10	19	11	12	8	6	8	6	7
NORTHERN PIPEFISH		12	15	10	11	17	12	8	8
NORTHERN SEA ROBIN	17	21	26	16	23	15	18	28	22
NORTHERN SEAHORSE	23		32	28	29	21	29		
ORANGE FILEFISH							33		
OYSTER TOADFISH	5	10	13	13	15	8	13	11	14
PLANEHEAD FILEFISH	23								
POLLACK			32		32				
RED HAKE			30	25	29		32	31	
ROCK GUNNEL		25	32	31		31	32	32	29
ROUGH SCAD	18	14	9	30	28			32	
ROUGHTAIL STING RAY						31			
SCULPIN		25			29	31	33		
SCUP	3	5	6	4	4	3	4	10	13
SEABOARD GOBY			25	18	19	13	11	9	9
SHORT BIGEYE				31					
SILVER PERCH								31	
SILVER HAKE			32	30	31	31	33		
SMALLMOUTH FLOUNDER	21	24	26	27	31	19	15	16	23
SMOOTH DOGFISH	7	8	10	17	21	18	16	20	16
SPOT	22	21	29		30	30		26	
SPOTTED HAKE		24	30	30	25	23	27	27	20
SQUIRREL HAKE									27
STRIPED ANCHOVY			32						
STRIPED BASS	23		32						29
STRIPED SEA ROBIN	18	25	23	14	14	7	9	14	10
SUMMER FLOUNDER	14	15	17	22	18	12	19	15	11
THREADFIN				31					
THREE-SPINE STICKLEBACK			27	29	31			30	

TABLE 1. (cont.). SPECIES RANKING BY RELATIVE ABUNDANCE

SPECIES / YEAR	1985*	1987	1988	1989	1990	1991	1992	1993	1994+
WEAKFISH	2	7	16	6	10	1	5	5	2
WHITE HAKE								32	
WHITE PERCH			32						
WINDOWPANE FLOUNDER	4	6	7	7	5	5	3	2	4
WINTER FLOUNDER	1	3	4	2	2	2	1	1	1
WINTER SKATE				26	32	31	31		20
BLUE CLAW CRAB		4	4	4	4	4	4	5	5
HORSESHOE CRAB		2	2	3	3	3	3	4	4
LADY CRAB		1	1	1	1	1	1	1	1
MANTIS SHRIMP		3	3	2	2	2	2	2	3
SPIDER CRABS#								3	2

*INFORMATION WITH REGARD TO THE FORAGE OR "BAIT SPECIES" AND MARCO-INVERTEBRATES WAS NOT COLLECTED IN 1985
#INFORMATION ON SPIDER CRABS WAS NOT COLLECTED UNTIL 1992
+ As of 8/2/94

highest documented in this survey. The 1993 year class declined precipitously from the prior two years. The 1994 recruitment has surpassed 1992, and when sampling is complete may exceed the 1991 year class.

Discussion

One problem associated with this survey has been the occurrence of the "brown tide" organism (*Aureoccus anorexefferens*) which has periodically plagued Peconic Bay since 1985. While it is impossible to quantify what effect this organism had on the fisheries resources, it is believed to have a major role on abundance and survival of some fish species. One of the dramatic effects of the "brown tide" was extremely high turbidly in the bay. For example in 1987 (a significant brown tide year) the average secchi reading for the year was 3.9 ft. with a weekly average ranging from 2.4 to 8.7 ft. In 1993 (a non-brown tide year) the yearly average secchi reading was 7.5 ft. with the weekly average ranging between 5.6 and 11.7 ft. It is possible that during years in which the brown tide organism was present, there was an avoidance factor by migratory species like weakfish and bluefish which in turn may have affected juvenile abundance of these species. As for the resident species, sight feeders like winter flounder may also have been adversely affected by the high turbidity.

The juvenile weakfish recruitment index generated from this survey is currently being compared to adult indices developed from commercial pound net and ocean haul seine catch/effort and age composition monitoring programs. Preliminary results indicate that there is a positive relationship between the trawl juvenile index and subsequent catch at age distributions of adult weakfish from the ocean haul seine survey. However, the strength and significance of that relationship has yet to be established.

Other Programs

The Peconic Bay small mesh trawl survey was also being augmented each year by a beach seine survey. The seine survey was initiated to answer questions regarding the inshore/offshore movement of young-of-the-year winter flounder, as well as to provide a more complete picture of fish abundance in the Peconic Bay Estuary.

In 1993 a large mesh trawl survey was initiated to develop an index of abundance of adult scup in New York, and to gather data for determining age at maturity. The same research vessel and basic methodology used in the small mesh trawl survey is employed in this survey. The trawl net used in this survey has a 26-ft. headrope and a 32-ft. footrope. The net is made of polypropylene netting with 4 in. stretch mesh in the body, 3 in. stretch mesh in the cod end and was rigged with 18 by 36 in. wooden doors with chain bridles. Nets were rigged with 300 ft. tow warp of 3/8 in. wire cable and 100 ft. scissors of 1/4 in. wire cables and were set and retrieved under hydraulic power. Tows were 20 minutes in duration and the time clock was started when the gear was fully deployed. As with the juvenile trawl survey, if a selected tow site was abandoned due to hangs and/or debris, a nearby site within the same sampling grid was chosen and the tow was redone. In general the towing speed of the net was three knots. However, towing direction within each grid differed and speed varied based on tidal and wind conditions.

During the first year of the survey (1993), towing stations were selected randomly from 15 stations of approximately three square nautical miles each. In the second year of the survey, the sampling area was divided into three stratifications (central, western, and eastern) based on the proportion of scup caught in those areas in 1993. The original three square mile stations were maintained in these areas to insure random sampling of each stratification. Stratifications were then sampled in a proportion corresponding to the 1993 distribution of scup catches.

Dissemination of Information

I. Atlantic States Marine Fisheries Commission
   a. Weakfish S&S
   b. Bluefish S&S
   c. Scup/seabass S&S
   d. Blackfish S&S
   e. Winter Flounder S&S

II. The Peconic Bay National Estuary Program

III. NOAA's Estuarine Living Marine Resources Program.

IV. NYSDEC wetland permit review process

V. Living Marine Resources Science Center at the University of Stony Brook, Stony Brook, N.Y.

Contacts for Small & Large Mesh Trawl Surveys

Christina Grahn - (516) 444 - 0443 or
Sherri Achier - (516) 444 - 0442
Alice Weber (516) 444 - 0437
New York State Dept. Of Environmental Conservation
Finfish And Crustaceans
Building # 40 Suny
Stony Brook, N.Y. 11790 - 2356

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Mercer, L.P. 1985. Fishery Management Plan for Weakfish. Fishery Management Report. No. 7, ASMFC, 129 p.

Perlmutter, A. 1939. An ecological survey of young fish and eggs identified from tow-net collections. In: A biological survey of the salt waters of Long Island, 1938 - Part II. N.Y. Conserv. Dept. pp. 11-71

Weber, A.M. 1989 a. Proceedings of a Workshop on Bottom Trawl Surveys. Special Report No.17, ASMFC, 43p.

NOTE: This program has been funded by the Sportfish Restoration Act FA-5-R.

Stock Assessment of New Jersey's Nearshore Recreational Fisheries Resources

by
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New Jersey Division of Fish, Game and Wildlife

Purpose

New Jersey's trawl survey program is officially entitled "Stock Assessment of New Jersey's Nearshore Recreational Fisheries Resources". The main purpose of the program is to monitor the abundance of recreational fishes in New Jersey coastal waters for fisheries management. More specifically, this purpose comprises the following four objectives:

(1) to develop a comprehensive baseline of data for coastal recreational fishes and their forage item;

(2) to develop recruitment indices for recreational fish and document annual relative abundance of young-of-year fish;

(3) to provide a scientific basis to formulate or modify existing management plans for recreational fishes; and

(4) to provide information to complement other state and federal data for the purpose of species population estimates and predictive models used to manage fish stocks.

History and Timeframe

The New Jersey trawl survey program has been collecting data continuously since August 1988. From 1988 through 1990 sampling cruises were performed once every two months, in February, April, June, August, October, and December. In 1990, the December 1990 and February 1991 surveys were dropped and replaced by a single winter survey in January 1991. This sampling pattern has continued unchanged to the present: a winter survey in January, followed by surveys in April, June, August, and October, or five surveys per year.

The program is currently funded through June 1995 and is planned to continue into the future.

Survey Design and Methodology

Survey Design

New Jersey uses a stratified random sampling design to collect trawl data from its survey area. This area encompasses about 1800 square miles and consists of the coastal waters from Ambrose Channel (or the entrance to New York Harbor) south to Cape Henlopen Channel (or the entrance to

Delaware Bay), and from about the 18 ft. isobath inshore to the 90 ft. isobath offshore.This area is divided into 15 strata (Figure 11). Latitudinal boundaries are identical to those used for this region by the National Marine Fisheries Service (NMFS) Groundfish Survey. Exceptions are those strata at the extreme northern and southern ends of the New Jersey coastline. Where NMFS strata extended into New York or Delaware waters, truncated boundaries were drawn for the New Jersey survey to exclude them, confining the survey area to include only waters adjacent to the New Jersey coastline, except for the ocean waters off the mouth of Delaware Bay, which were also included.

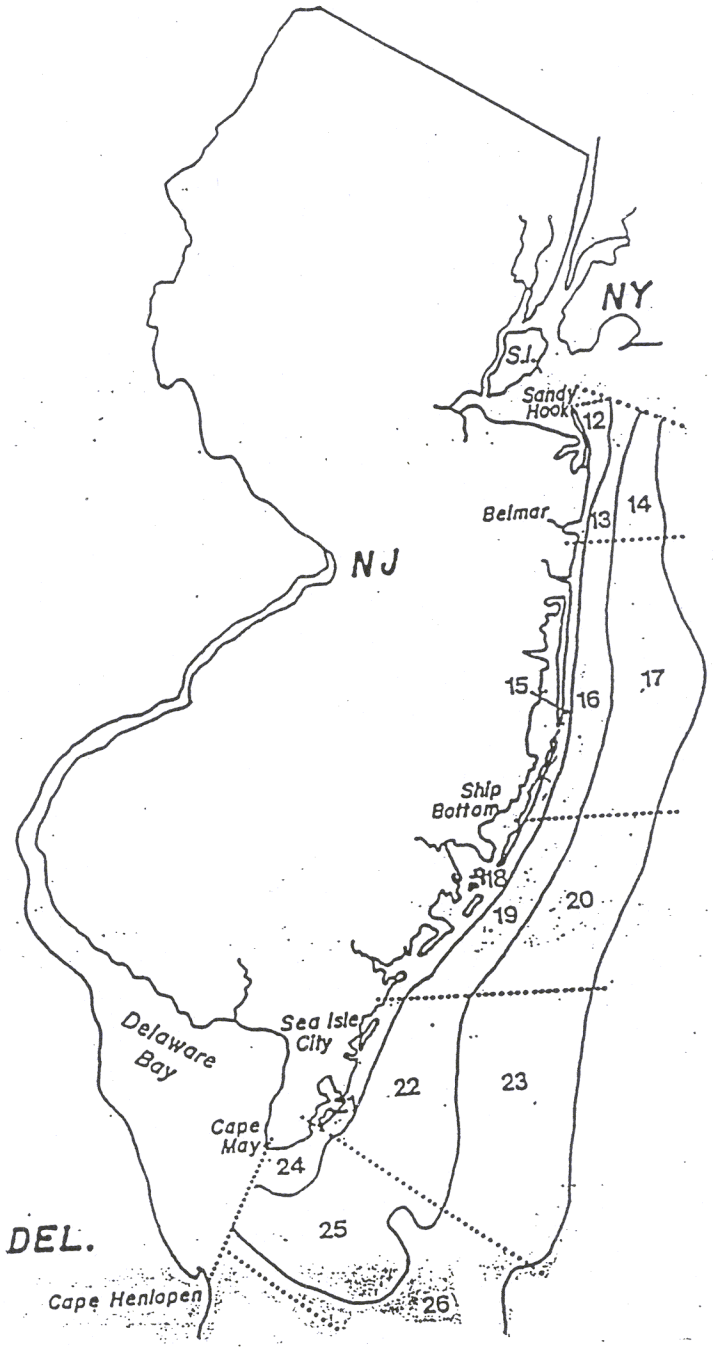
Longitudinal boundaries consist of the 30, 60, and 90 ft. isobaths. Where these bottom contours were irregular, stratum boundaries were smoothed by eye. As a result, the longitudinal strata boundaries for the New Jersey survey area are similar, but not identical, to the corresponding NMFS boundaries.

Each stratum is divided by grid lines into blocks which represent potential sampling sites; each block is identified by a number assigned sequentially within each stratum. The dimensions of mid-shore (30-60 ft.) and offshore (60-90 ft.) blocks are 2.0 minutes longitude by 2.5 minutes latitude; inshore (18-30 ft.) blocks are 1.0 minute longitude by 1.0 minute latitude. Inshore block dimensions are smaller because inshore strata were narrower and of much less area compared to mid- and offshore strata; small block size permits a greater number of potential sampling sites than would be possible with the larger dimensions. Blocks truncated by stratum boundaries have less area than the whole blocks described above; those reduced in area by more than one-half were generally not assigned a number.

Since August 1991, the sampling effort for each trawl survey has consisted of 39 samples, two samples from each strata plus one additional sample in each of the nine larger strata. An exception is the winter survey, when only two samples are collected in all strata. Before August 1991, sampling effort varied due to variability in charter vessel costs, but generally followed the pattern described, with a minimum effort of two samples per stratum per survey.

Sampling sites for 1988 to 1991 were determined by blindly picking disks numbered to correspond to stratum blocks and mixed to assure randomness. In 1992 this method was replaced by using a computer to generate random numbers. Because stratum shapes are elongate and sample size small, a site selection procedure was used to assure some spatial distribution of trawling locations. This consisted of limiting the first sampling site to only the top half of the block numbers and the second site to only the bottom half; where a third site was picked, no limitations were imposed. Thus, for example, for a stratum with 50 blocks, sample one would be picked from 1-25, sample two from 26-50, and sample three from 1-50. For each primary site, three alternate sites are also selected using the same criteria. When fixed fishing gear, bottom obstructions, or other impediments prevent sampling at the primary location an alternate is used instead.

Figure 11. Survey area of New Jersey ocean stock assessment program. Strata correspond to those of the National Marine Fisheries Service's spring and fall groundfish surveys except at Sandy Hook and Cape Henlopen, where they are truncated. Longitudinal boundaries approximate 30, 60, and 90 ft. isobaths.



Survey Methodology

Samples are collected with a three-in-one trawl, so named because all the tapers are three to one. The net was designed by Cliff Goudey of the Sea Grant program of the Massachusetts Institute of Technology. The design is based, to some extent, on the results of test-tank studies. It is a two-seam trawl constructed of polyethylene twine with forward netting (wings, belly) of 12 cm (4.7 in.) stretch mesh and rear netting of 8 cm (3.1 in.) stretch mesh. The codend is 7.6 cm stretch mesh (3.0 in.) and is lined with a 6.4 mm (0.25 in.) bar mesh liner. The headrope is 25 m (82 ft.) long and the footrope is 30.5 m (100 ft.) long.

The trawl bridle is 120 ft. long, the top leg consisting of 0.5 in. wire rope and the bottom leg comprised of 0.75 in. wire rope covered with 2 3/8 in. rubber cookies. A 60 ft. groundwire, also made of 0.75 in. wire rope covered with 2 3/8 in. rubber cookies, extends between the bridle and trawl doors. The trawl doors are wooden with steel shoes, 8 ft. x 4 ft. 2 in, and weigh approximately 1000 lbs. each.

Two vessels have been used by the trawl survey program, the *F/V Amy Diane* from 1988 to 1991 and the *R/V ARGO Maine*, from 1991 to the present. Both are similar in size and capabilities: approximately 80 ft. length, 24 ft. beam, and 10 ft. draft; outboard gallows frames; set and haul off the stern with dual winches and a hydraulic net reel. The *Amy Diane*, a commercial trawler based in Belford, New Jersey has a more powerful engine (600 hp) than the *ARGO Maine* (380 hp), the workhorse of the Maine Maritime Academy. SCANMAR equipment was used to measure the dimensions of the net while fishing from each vessel, with similar results except vertical opening, which was much greater for the *ARGO Maine*. The averaged SCANMAR measurements for the *Amy Diane* were: door spread, 130 ft.; wing spread, 38 ft.; vertical opening, 7 ft. The corresponding values for the *ARGO Maine* were 130 ft., 39 ft. and 11 ft., respectively.

Trawl samples are collected by towing the net for 20 minutes, timed from the moment the winch brakes are set to stop the deployment of tow wire to the beginning of haulback. Target towing speed is 2.5 - 3.0 knots, or about 2.8 knots. A 20 minute tow generally covers about one nautical mile. Tows shortened due to hangs, bottom obstructions, fixed fishing gear and other problems are counted as "good" provided the tow time is longer than 15 minutes and there is no major damage to the net. Tows shorter than 15 minutes are repeated unless there are extenuating circumstances, such as the tow is the second or third try, the bottom is known to be a difficult area to sample, etc. For purposes of standardizing results, catches from short tows are extrapolated to 20 minutes assuming a direct relationship between catch and tow time.

Sampling is performed only during daylight, between the hours of sunrise and sunset. Three hundred feet of wire are released for each tow, regardless of depth. This is to provide a tow wire:depth ratio of about 3:1 at the deepest sampling depth (90 ft.) as well as assure ample distance between the vessel and the net when towing in shallow water (< 30 ft.).

Following haulback, the catch is dumped into a 4 x 8 ft. sorting table where fishes and macroinvertebrates are sorted by species into plastic buckets and wire fish baskets.

The total weight of each species is measured with hanging metric scales and the length of all individuals comprising each species caught, or a representative sample by weight for large catches, is measured to the nearest centimeter (cm). Fork or total length, depending on tail shape, is measured for all fishes except stingrays, which have disk width measured instead. For invertebrates, carapace width is measured on crabs, carapace length (in mm) on lobster, and mantle length on squid. Catches containing large numbers of relatively small specimens are sometimes mixed and the mix subsampled by weight. The mix is then sorted and measured and species components later extrapolated, based upon their representation in the subsample, to determine contribution to the total catch.

Data Management

All data in the field are recorded by hand in pencil on log sheets. There are three logs, a water quality, a supplemental, and a master log. Temperature, salinity, and dissolved oxygen of surface and bottom waters are recorded on the water quality log. However, only temperature is recorded in the field; water samples are collected for the other two parameters and measured in the laboratory, the Winkler method for dissolved oxygen and the conductivity method for salinity. The supplemental log is a scaled down version of the master log. It is used for recording species weight and length data and permits processing of the catch by multiple measuring/recording teams. The master log is the final repository for all the data from a trawl sample. The contents of the water quality and supplemental logs are copied by hand to the master which is the source of all data entered into computer files.

Once master log entries are complete, the log is processed, which consists of tallying length frequencies, coding species, calculating total species weights and numbers, determining expansion factors, and extrapolating subsamples. This work is performed by hand and by calculator; a computer program can be used to assist with the extrapolation of "mix" subsamples.

Data are then entered into one of three computer files: TOWS for station and vessel information (location, depth, weather, water quality, etc.); CATCH for species number and weight; and LENGTH for species length frequencies. Survey code and station number fields are common to all three files and permit file integration. All files are maintained and managed on desktop PCs using dBase IV.

Data verification by eye is performed for master log copy-overs, catch processing, and data entry. Computer verification is performed on the TOWS file, flagging values which exceed prescribed limits, and on the CATCH and LENGTH files, identifying records where the total number in the catch is unequal to the totaled frequency value for the same species and station. A program to compare calculated weight, from species length-weight coefficients, and measured weight is planned for application but has not yet been employed.

Data from recently completed surveys is added to the master database files once all the verification steps have been completed and errors corrected. Missing weights are estimated by using length-weight regression coefficients to calculate the missing weight from the lengths given. Missing lengths are estimated by calculating individual weights for lengths represented in a subset

of other survey catches of the species. The weights are then expanded in proportion to the length frequency distribution in the subset to determine the distribution that would yield the observed weight.

The New Jersey trawl survey databases are not accessible through any computer network, however there are no restrictions on their distribution. Requests for specific information should be made by phone, fax, or letter to the program manager, as follows: Donald M. Byrne, Bureau of Marine Fisheries, P.O. Box 418, Port Republic, NJ 08241; Phone: 609-748-2020; Fax: 609-748-2032

Results

Each year the trawl survey program produces an annual report that summarizes catch data by survey for the predominant species (by weight) and a subset of recreationally important fishes. This data consists of total weight and number, length range, and percent distribution by depth zone and survey area region (north versus south). These reports at one time included survey length frequency distributions and GIS-mapped catch distributions for the recreational fishes, but this information was discontinued when staff transferred. The annual reports do not have a distribution list and are produced principally for the federal agency funding the program, the U.S. Fish and Wildlife Service.

Otherwise data reports are produced irregularly to satisfy requests by staff representing New Jersey on the various technical committees of species management plans, as well as outside investigators. Examples include April length frequency distributions of winter flounder for estimating New Jersey mortality rates, striped bass catch data to represent non-directed fisheries information, and winter length frequency distributions of Atlantic herring for making mortality estimates. In addition, data reports have been prepared for public dissemination to highlight important fisheries issues, such as the rebound of summer flounder and the decline of young-of-year bluefish production (Figures 12 & 13).

Integration with Other Surveys

The New Jersey trawl survey program is modeled after the NMFS groundfish survey. The New Jersey program uses essentially the same log sheets, species codes, stratum boundaries, and strata labels as those used by NMFS. Compatibility was sought to help attain one of the program's objectives, namely to complement data collected by other agencies. Some of this compatibility extends to the Massachusetts trawl survey, which is closely integrated with the NMFS program.

However, for various reasons, integration of the New Jersey program with either NMFS or Massachusetts has not occurred. The potential nevertheless exists and may one day, at some level, be achieved.

Figure 12. Summer flounder annual abundance index, 1989-1992.

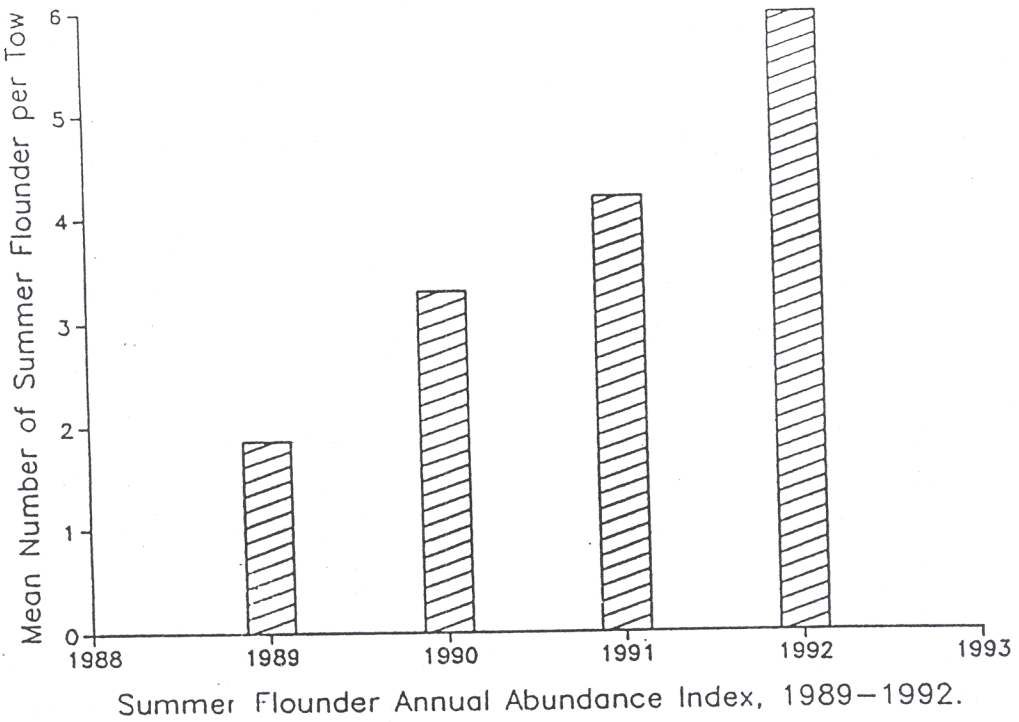
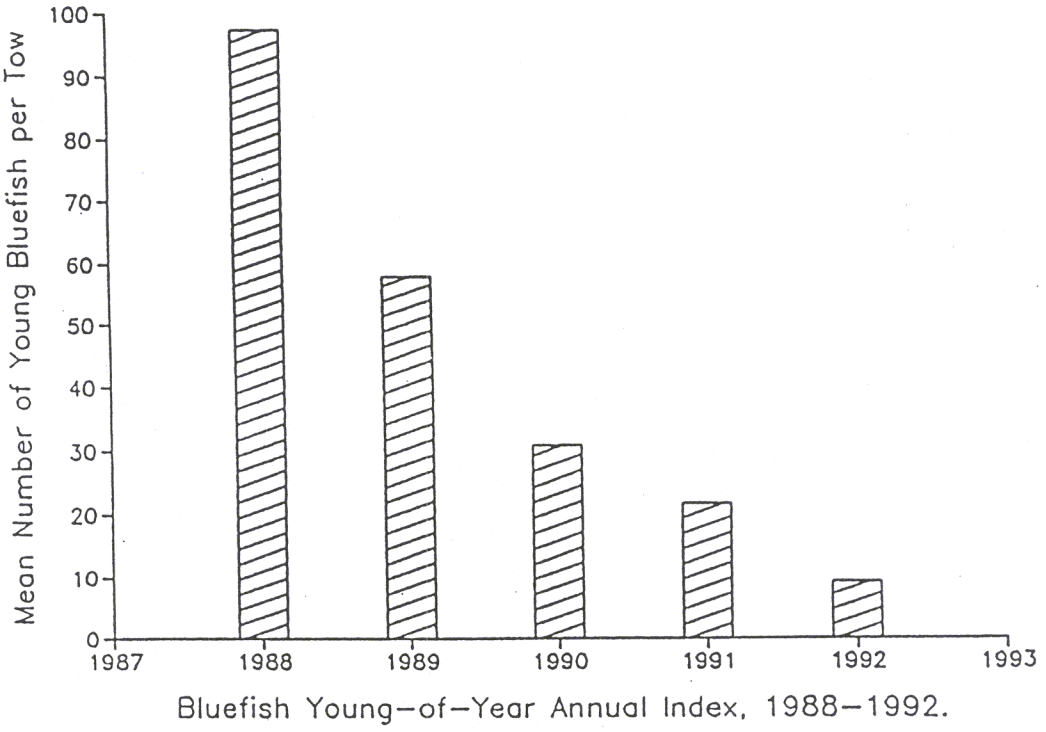


Figure 13. Bluefish young-of-year annual index, 1988-1992.



Delaware's Bottom Trawl Surveys

by
Stewart Michels
Delaware Division of Fish and Wildlife

Introduction

The Delaware Division of Fish and Wildlife currently conducts two trawl surveys to assess the status, trends and distributions of various coastal stocks. Two gear types are used in these surveys: a 16-ft. semi-balloon otter trawl (juvenile survey) and a 30-ft. otter trawl (adult survey).

Juvenile Survey

The juvenile trawl survey was initiated in 1977 to assess the abundance of blue crabs using the lower Delaware Estuary. The survey was expanded in 1980 to incorporate juvenile finfish catch frequency data in an effort to determine their distribution, relative abundance, and where possible, as an indicator of year-class strength. Six stations were added in 1980 (to the original 28 stations) for improved coverage of the weakfish nursery area. In 1989, an additional six stations north of the Chesapeake and Delaware Canal were added to give improved coverage to the striped bass nursery and spawning grounds. Sampling of Delaware's Inland Bays (Indian River and Rehoboth Bays) was initiated in 1986 with objectives similar to those of the Delaware Estuary sampling. Fourteen Inland Bay stations were initially sampled; however, this number was reduced to 12 due to lack of adequate water depth.

Sampling is conducted monthly April through October at fixed stations in the estuary and inland bays. The net has a 17-ft. headrope and a 21-ft. footrope, both consisting of 0.375-in. Poly-dacron rope. The body mesh size is constructed of 1.5-inch stretch mesh number nine thread and the codend is made of 1.25-in. stretch mesh number 15 thread. The inner liner consists of 0.5-in. stretch mesh number 63 knotless nylon webbing. Six 1.5-in. x 2.5-in. floats are spaced evenly on bosom of headrope and 1/8-in. galvanized chain hung loop style on the footrope. The doors measure 12 x 24 in. and are constructed of 0.75-in. marine plyboard with 1.25 x 0.25 in. iron shoes. The bridle arrangement consists of a single line of stainless cable attached to 65-ft. bridle warps of no-lay line.

A 23-ft. aluminum V-hull SeaArk powered by a 260-hp Mercruiser I/O is used to conduct a ten minute tow at each station. The vessel is equipped with an A-frame stern trawling system. A 10:1 ratio of line-out is continually adjusted according to water depth. Tidal stage, weather conditions, water depth and engine speed are recorded for each station. Temperature (^{o}C) and salinity (ppt) are measured at the start of each tow.

Upon completion of each tow the net is hauled over the stern. Finfish, blue crabs and horseshoe crabs are sorted by species and enumerated. Due to practical constraints in the field,

only selected species are measured. Elasmobranchs, eels, hogchokers, bay anchovy and cusk-eels are not measured. A random subsample of 30 specimens per species is measured for fork length to the nearest half centimeter; the remainder are enumerated. Juvenile horseshoe crabs (<160mm) are measured for prosomal width and blue crabs are measured for carapace width. All blue crabs larger than 60mm are measured, however, only the first thirty crabs smaller than 60mm are measured.

The data are coded, then sent to the University of Delaware for computer entry. The data is double keypunched to eliminate entry errors. Data is stored in ASCII files. Monthly and annual summary tables of mean catch per tow and total numbers collected for each species are produced using SPSSx. Currently a mainframe computer is used for the data analysis; however, SAS programs are being written for use on the Division's microcomputers.

Young-of-the-year indices are calculated for summer flounder, Atlantic croaker, spot, bluefish, striped bass, weakfish and blue crabs. Age 0 specimens are separated from the catch based on visual inspection of length-frequency distributions. Weakfish are the single exception, as most (>99 percent) individuals taken are age 0. The months used in the calculation of the indices varies between species:

Species	**Months of Index**
Atlantic croaker	September - October
Bluefish	June - October
Blue crab	June - October
Spot	July - October
Summer flounder	June - October
Striped bass	June - October
Weakfish	June - October

Note: These indices have been used in a number of the coastal stock assessments and FMPs.

Adult Survey

Delaware's 30 ft. trawl survey was initiated in 1966. The purpose of this survey was to characterize the spatial, temporal and length frequency distributions of fish using the Delaware Bay (Daiber and Smith 1972). The survey was discontinued in 1971 due to a shortage of funds. Smith (1987) conducted a similar survey from 1979 through 1984. The purpose of this survey was to assess changes in fish populations and to have pertinent up-to-date information on selected fish stocks. This survey was discontinued in 1985 for lack of an adequate research vessel.

The 65-ft., state-owned vessel *Ringgold Brothers* was equipped with an eastern rigged trawling system in 1989, and in 1990 a survey was initiated following the methods of Daiber and Smith (1972) and Smith (1987). This is an ongoing survey to monitor trends in abundance and distribution, to determine population age/size composition and to develop a pre-recruitment index for a selected group of finfish.

The trawl has a 30.5-ft. x 0.5-in. headrope and a 39.5-ft. x 0.5-in. footrope. The wings and body are made of 3-in. stretch mesh number 36 thread. The cod end consists of 2-in. stretch mesh number 42 thread. Two 40-ft. leglines connect to the otter doors. The doors measure 54 x 30.5 in. and have 1 x 1.5 in. iron shoes. Two steel weights (1 x 12 x 6 in.) are located on the bottom center of each door (as prescribed from previous surveys).

Sampling frequency has varied somewhat since 1966. Nine of the original 11 fixed stations are currently sampled monthly (March-December). Twenty-minute tows are made at each station. Weather conditions, sea state and engine speed are noted for each haul. The distance towed is measured using a Loran C. Average water depth is measured using a recording fathometer. Surface and bottom water samples are collected at the end of each tow and immediately analyzed for temperature, salinity and dissolved oxygen.

After each tow, the sample is emptied on the deck and sorted by species. Aggregate weights are taken for each species, except elasmobranchs and certain invertebrates which are merely sexed and counted. Species represented by less than 50 individuals are measured for fork length to the nearest half centimeter. Species with more than 50 individuals are randomly subsampled for length (50 measurements) and enumerated. Horseshoe crabs are sexed and measured for prosomal width. Blue crabs are sexed and measured for carapace width.

Scales from selected species (primarily weakfish and summer flounder) are collected from a sample of the catch. Impressions are made using a roller press on heated acetate slides and displayed on a microfiche projector. Scale are independently aged by two individuals. Differences in age determination are reviewed; if a consensus is not reached, the sample is discarded. January first birth dates are assumed for weakfish and summer flounder.

The data is coded and sent to the University of Delaware for computer entry. All records are independently keypunched twice and the files compared to verify correct entry. The data (ASCII format) are analyzed using SPSSx on the University of Delaware's IBM3081D mainframe. Data reduction includes monthly and annual summaries of the number, weight and percentage of each species taken. Densities for selected species are calculated as number per distance towed (nautical miles) and presented for each station, month and year. Annual catch-at-age indices are calculated for weakfish and summer flounder. SAS programs are currently being written to allow for microcomputer analysis.

The data from this survey was used in recent stock assessments to illustrate the changes in the size/age structure of weakfish and summer flounder using the estuary. Weakfish age-length data is provided to NMFS for integration into a coastwide age-length key. Catch-at-age indices from the survey should become more valuable as the time series lengthens.

Copies of the annual and final trawl survey reports are available through the Delaware Division of Fish and Wildlife, Federal Aid Coordinator, 89 Kings Highway, P.O. Box 1401, Dover, Delaware 19901. Requests for other data needs may be submitted in writing to: Mr. Richard Cole, Program Manager - Marine Fisheries at the same address.

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Smith, R.W. 1987. Marine fish populations in Delaware Bay. 1982-87 Federal Aid in Fisheries Restoration Project F-33-R, Final Report. Delaware Division of Fish and Wildlife, Dover.

Trawl Survey Summary for Estuarine Fisheries Program in Maryland

by
Jim Mowrer
Maryland Department of Natural Resources

Introduction

Maryland's Chesapeake Bay and Atlantic coastal bays have historically supported large populations of finfish and shellfish; adults of many species of fish are also seasonally common. To monitor the activities of these species, the Estuarine Fisheries Program has developed four separate projects, which use trawls as a basis for stock assessment. Current data on fishery stocks in Maryland's bays are necessary for several reasons. Many species found here such as American shad, alewife and blueback herring, Atlantic croaker, bluefish, spot, summer flounder, weakfish, shark, blue crab, and hard clam are the subject of state, interstate and/or federal management plans. Over the next 20 years, Maryland's human population levels will increase and most of the development will occur along the shoreline in habitat critical to these species. Delineation of essential habitat will aid the management of growth in these important shallow waters.

Mid-water trawls have been used since 1985 to estimate relative abundance and distribution of juvenile species (American shad, alewife and blueback herring) in four river systems in the Chesapeake Bay. These surveys are being used to assess year-class strength and may have the potential to explain the relationship between juvenile production and future adult stock sizes. Maryland's coastal bays have been sampled with a modified otter trawl since 1972, supplying data for environmental reviews and resource management. Recruitment of weakfish, summer flounder, Atlantic croaker, spot, black sea bass, and bluefish are the focus of this survey, but data on diversity of finfish and invertebrates are collected as well. Chesapeake Bay and its tributaries have been surveyed for blue crab abundance by otter trawling since 1973.

Associated juvenile fish data has also been collected from this survey since 1983, and indices for spot, Atlantic croaker, and weakfish have been formulated (Uphoff 1994; ASMFC 1993). This survey provides fishery-independent crab population data which can be used to monitor recruitment and harvest and provide estimates of mortality (fishing and instantaneous). A fourth project initiated in 1993, Compfish, is a multi-species survey designed to describe basic stock characteristics and length frequencies of important recreational species. This trawl survey collects young-of-the-year yellow perch, white perch, spot, croaker, and striped bass in Chester River and 1+ channel and white catfish in the Choptank River. Continuance of Compfish for a sufficient time span may allow for development of abundance indices for these species.

Methods

Alosa Project

During 1993, the Chester River (six stations), Choptank River (nine stations), and Patuxent River (six stations) were sampled for juvenile shad and river herring (alewife and blueback) biweekly by midwater trawl from May through August (Figure 14). The Nanticoke River . (ten stations) was sampled weekly from May through September with the same gear (Figure 14). The 1.53 X 1.53-m midwater trawl has a mouth approximately 1-m deep constructed of 3.18-cm stretch mesh nylon. The remainder of the net is made of 1.27-cm stretch mesh nylon. A single tow at 3.7 km/h for 5 minutes in the same direction as the current was made at each station. Sampling commenced in all four river systems in early May and continued until mid-September. The juvenile index of alewife and blueback herring from the Alosa Project was subsequently calculated for each river system as the geometric mean (GM) catch + 1 per 5 minute trawl during the period when fish were consistently present. Time periods where a high proportion of zeros occurred were not used to calculate indices to minimize bias and maximize precision. Confidence intervals (95 percent) were calculated.

All finfish collected in the midwater trawl survey were identified, counted, and up to 15 of each Alosa species were measured. Surface water temperature (^{o}C), conductivity (umho/cm), salinity (ppt), tide state, and weather condition data were also taken at each sampling station.

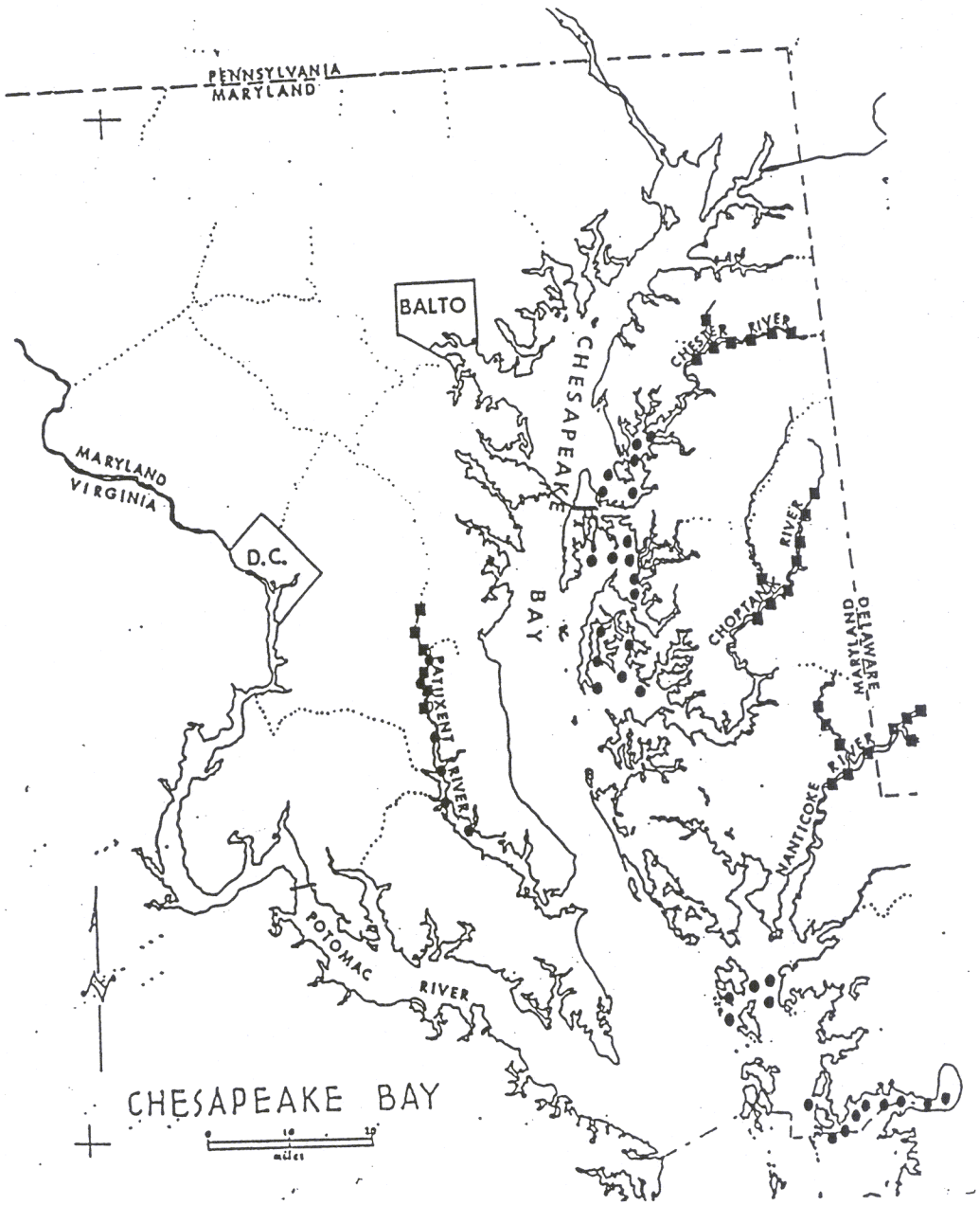
Blue Crab Project

The blue crab survey sampled six areas of the Chesapeake Bay monthly from May through October (Figure 14). Areas on the eastern side of Chesapeake Bay were Chester River (six stations), Eastern Bay (six stations), Tangier Sound (six stations), Choptank River (five stations), Pocomoke Sound (nine stations). The single area on the western side of Chesapeake Bay was Patuxent River with six stations. Each area was sampled during one day each month.

Blue crabs were sampled with a 4.9-m semi-balloon trawl made of 25 mm stretch mesh nylon with a 13 mm mesh cod end liner. A 4.0-m chain was attached between the doors as well as tickler chains (12 - 14 ft. long and 3/16 in. in diameter) were tied to both doors to attract the crabs. A single six-minute tow was made at each station. Tow speed was 4.0-4.8 km/h.

Blue crabs 60 mm or less were designated as recruit crabs. These crabs would appear in the fishery after one or two growing seasons. Arithmetic mean monthly catches per tow (c/f) of blue crab recruits (crabs less than 60 mm), growth crabs (61 - 127 mm), and hard blue crabs 127 mm and larger (legal-size) are used as relative abundance indices. Growth crabs are those sublegal crabs which would recruit into the fishery during the current season.

Figure 14. Location of sampling stations for the blue crab survey and juvenile American shad and river herring within Maryland's portion of the Chesapeake Bay.



In the blue crab survey, carapace width (CW), sex, and condition (mature or immature and soft, peeler or hard) were recorded for each crab and selected finfish. Finfish collected were also identified and counted. Surface water temperature (^{o}C), conductivity (umho/cm), salinity (ppt), tide state, bottom depth, and weather condition data were also taken at each sampling station.

Coastal Bay Project

Juvenile and adult marine and estuarine species were sampled using a 4.9-m (16 ft.) semi-balloon otter trawl in areas over 1 m or more deep. A 4.0-m chain was also attached between the doors along with tickler chains connected to the doors. Trawl samples were collected by single six-minute tows at 20 fixed sites throughout the coastal bays on a monthly basis between April and October, 1992 (Figure 15).

The coastal bay trawl index is an arithmetic mean equivalent derived from the geometric mean. The GM is based on $\log_{10}$- transformed catches and is converted to an arithmetic mean equivalent by multiplying by the sum of 1972-1991 arithmetic means divided by the sum of the 1972-1991 GMs (Ricker 1975).

The coastal bay survey records species, number, and total length (TL) in mm. Surface water temperature (^{o}C), conductivity (umho/cm), salinity (ppt), tide state, bottom depth, and weather condition data were also taken at each station.

Compfish Project

The compfish survey sampled a 12.9 km section of the Chester River drainage as well as a 14.5 km section of the upper Choptank River. Eight random sites from each system were sampled weekly from May 1993 to June 1993. With a 4.6 m wide semi-ballon bottom trawl. The body was 25.4 mm stretch mesh with a 6.3 mm mesh (2-m long) liner in the tail. Trawls were towed four minutes at 6.5 km/hr. Trawl samples were collected from April to June 1993.

The Compfish survey subsampled up to 30 fish from each target species, which were measured (TL), sexed if possible, and the remainder counted. Target species for this survey included white perch, yellow perch, channel catfish, white catfish, carp, crappie, largemouth bass, and chain pickerel.

Summary of Important Results

In the midwater trawl survey, juvenile indices for alewife herring have significantly increased in all four river systems combined (1985-1993; $r^2 = 0.50$, $P = 0.032$) (Figure 16); while those for blueback herring showed no significant trend over the same time period (Figure 17). Overall abundance levels for both herring species have remained quite similar in each of the four river systems. Blueback herring juvenile catches were significantly different among these river systems (Kruskal-Wallis test H = 66.57, 3df, $P \leq 0.001$), whereas alewife herring catch were only marginally significant (Kruskal-Wallis test H = 7.080, 3df, $P \leq 0.032$). During the

Figure 15. Maryland DNR coastal bay survey trawl stations.

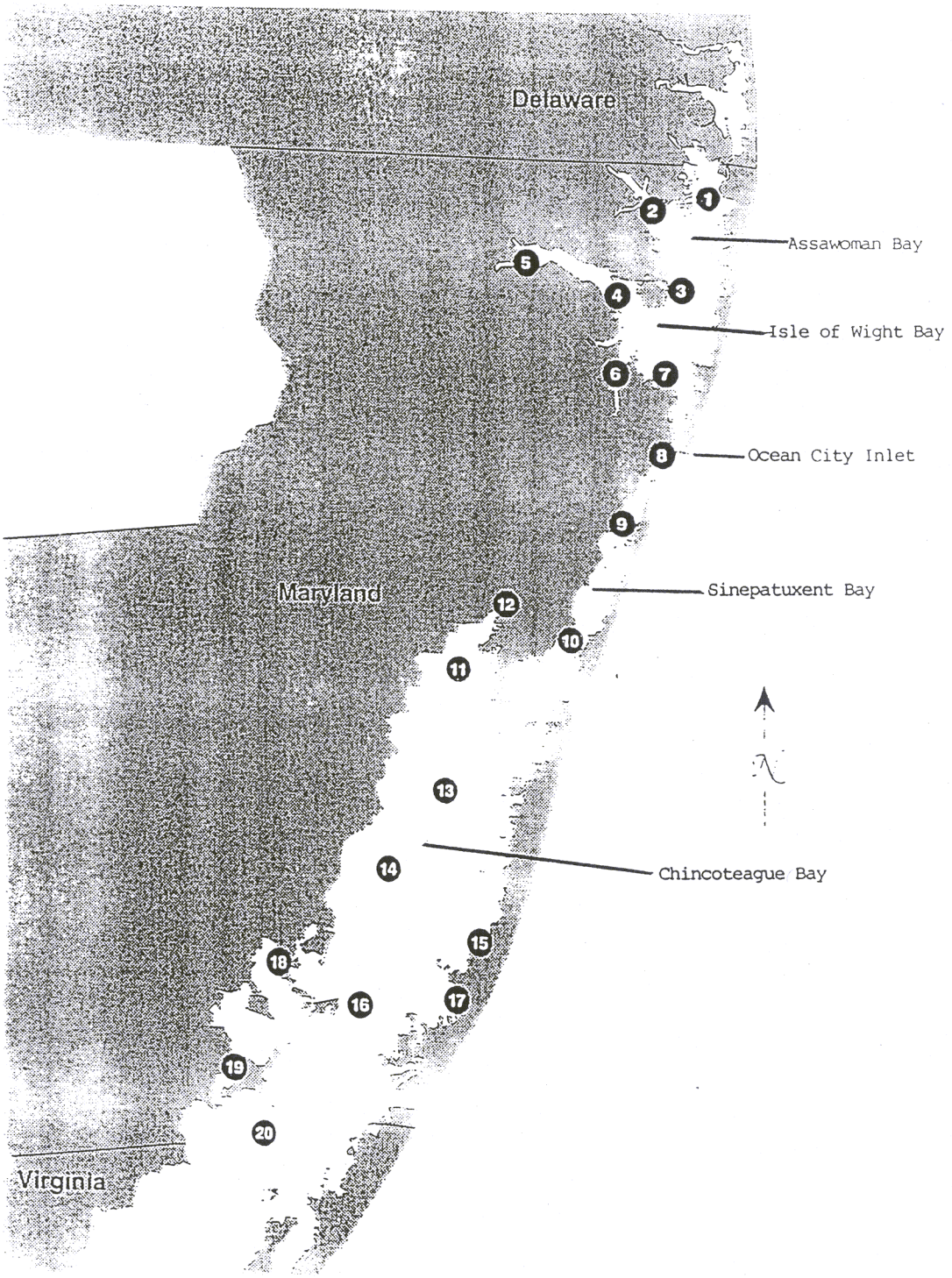
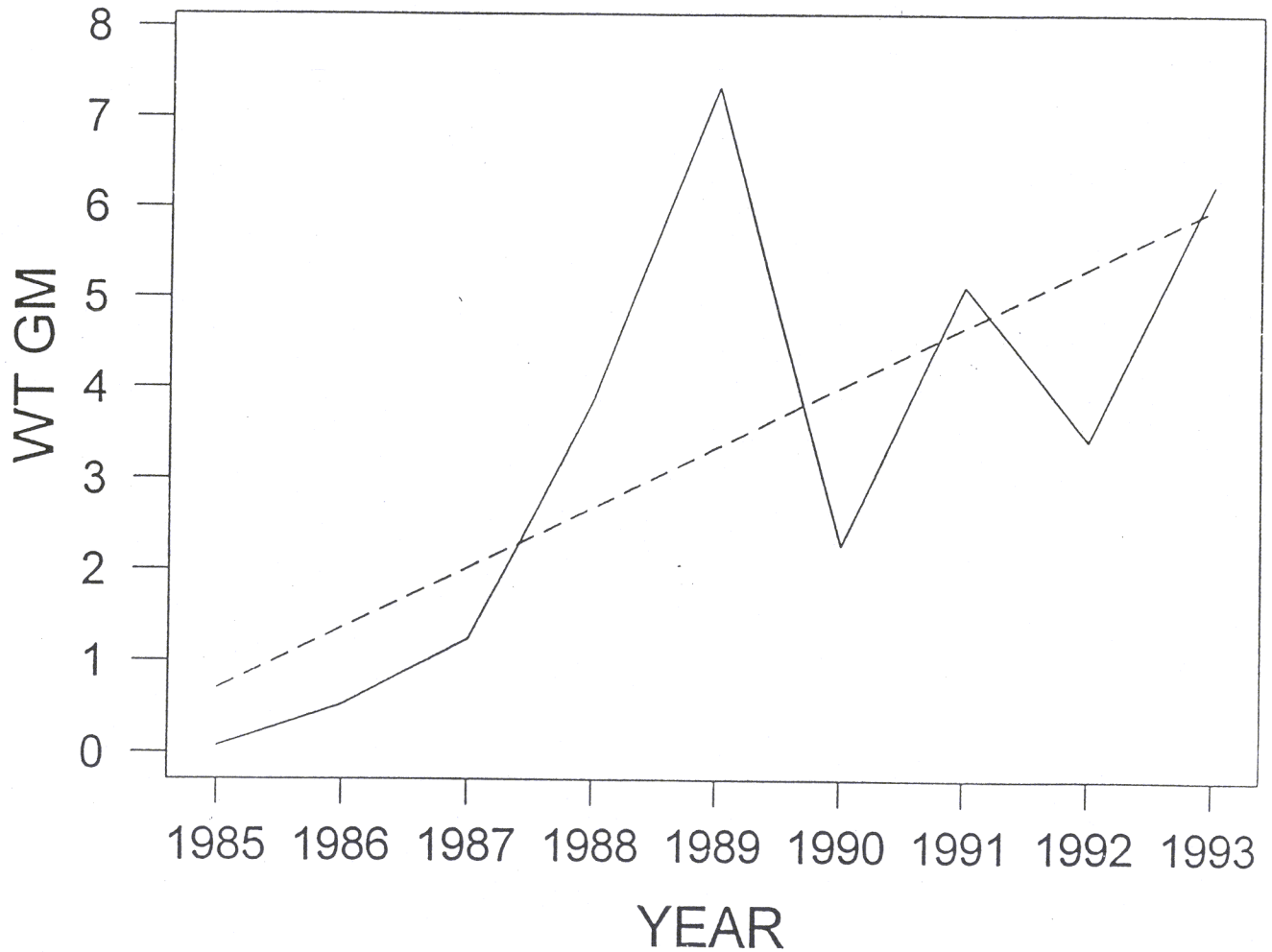
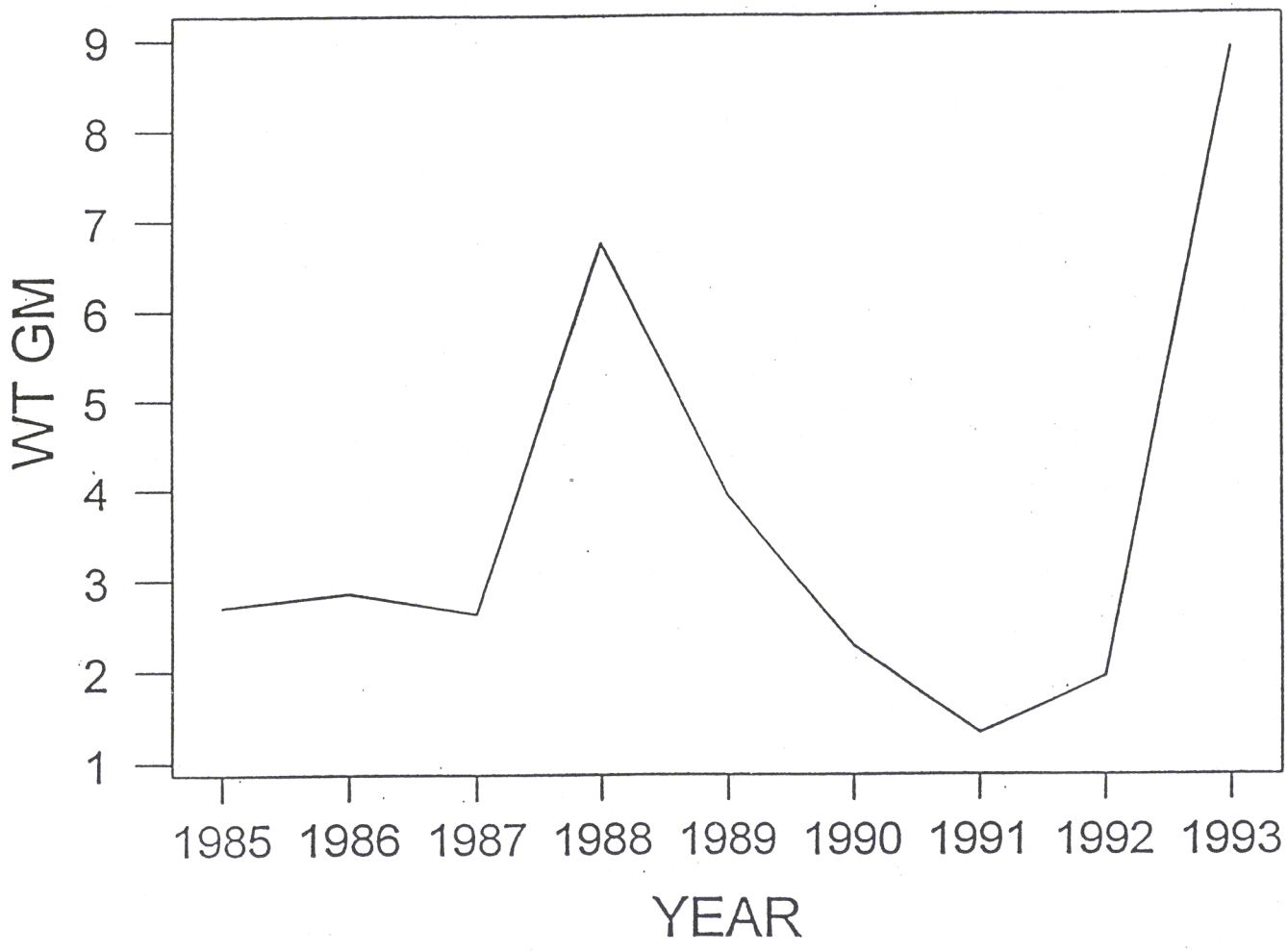


Figure 16. Alewife weighted juvenile index 1985-1993, rivers combined.



WT GM = WEIGHTED GEOMETRIC MEAN

Figure 17. Blueback herring weighted juvenile index 1985-1993, rivers combined.



WT GM = WEIGHTED GEOMETRIC MEAN

nine year midwater survey period, only alewife herring in the Choptank River showed a significant upward trend ($r^2 = 0.50$, $P \leq 0.032$). Preliminary results for juvenile alewife herring production in 1994 have shown a notable increase over the previous nine years in all four river systems.

Since 1973 the blue crab survey monthly catches per trawl of recruit crabs (≤60 mm) were associated with their harvest six growing months later (Figure 18) and catches per trawl of legal-size crabs (>127 mm) were associated with that month's harvest (Figure 19). Instantaneous mortality rates of legal-size crabs were 1.71-2.11, instantaneous natural mortality rates were 0.3-0.4, and instantaneous fishing mortality rates were 1.3-1.8. Fishing mortality rates of male crabs were three to six times higher than that of females.

Data collected by the coastal bay survey from 1972 to 1992 has shown considerable decline in numbers of summer flounder (Figure 20), spot, and Atlantic croaker since 1988. Significant fluctuations in the weakfish population with an increasing trend since 1988 (Figure 21) was also noted. Between 1986 and 1991, coastal bay survey results indicated an increase in species diversity (Figure 22). A possible explanation for this were the relatively mild winters during this six-year period that may have permitted many species to escape winterkill. The shallow coastal bays (average depth 1.0 m) respond quickly to temperature change. During 1994, densities of these species have increased dramatically and are very similar to the densities 20 years ago when production levels were much larger. The small 16 ft. headrope otter trawl nets employed by the survey since 1972 have been very efficient in catching the targeted species. Modifications in net configuration (reducing mesh sizes) and smaller doors has had significant effect on its efficiency. To avoid the pressure wave in front of the net, trawl speed cannot be any greater than 2.5 - 3.0 knots.

Although only one year (1993) of survey data is available, spring bottom trawling the Chester and Choptank Rivers holds promise for indexing age 1 channel catfish and age 0 yellow perch.

Figure 18. Trends in monthly recruit c/f in the summer trawl survey and monthly commercial landings. Recruit c/f for May, June, and July were correlated with landings 14 months later; recruit c/f for August and September were correlated with landings 21 months later. Time lags reflect six growing months. X-axis = Year-class and recruit monthly c/f. Months are in sequence from May (M) through September (S).

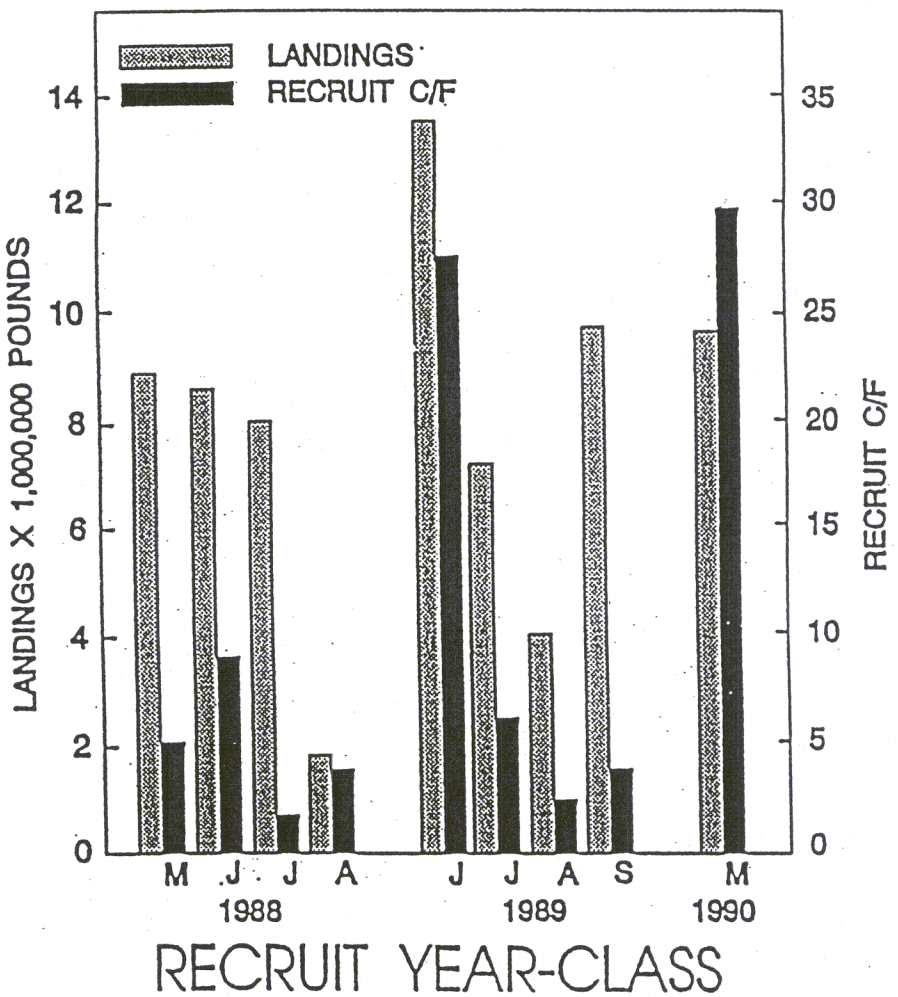


Figure 19. Trends in monthly legal-size c/f in the summer trawl survey and that same month's commercial landings (in million of pounds), 1988-1991.

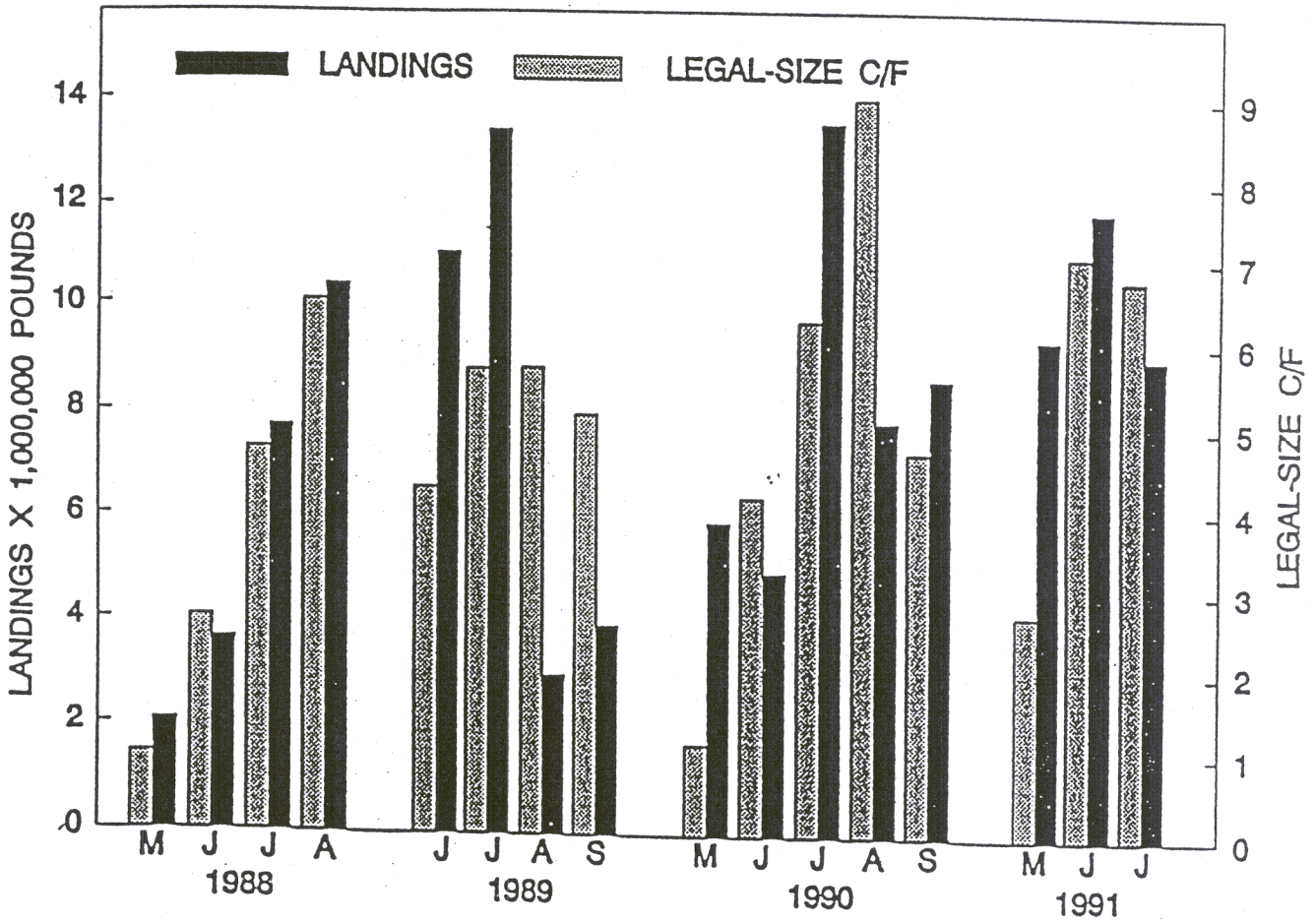


Figure 20. Mean catch per trawl for weakfish in Maryland's coastal bays, 1972-1992.

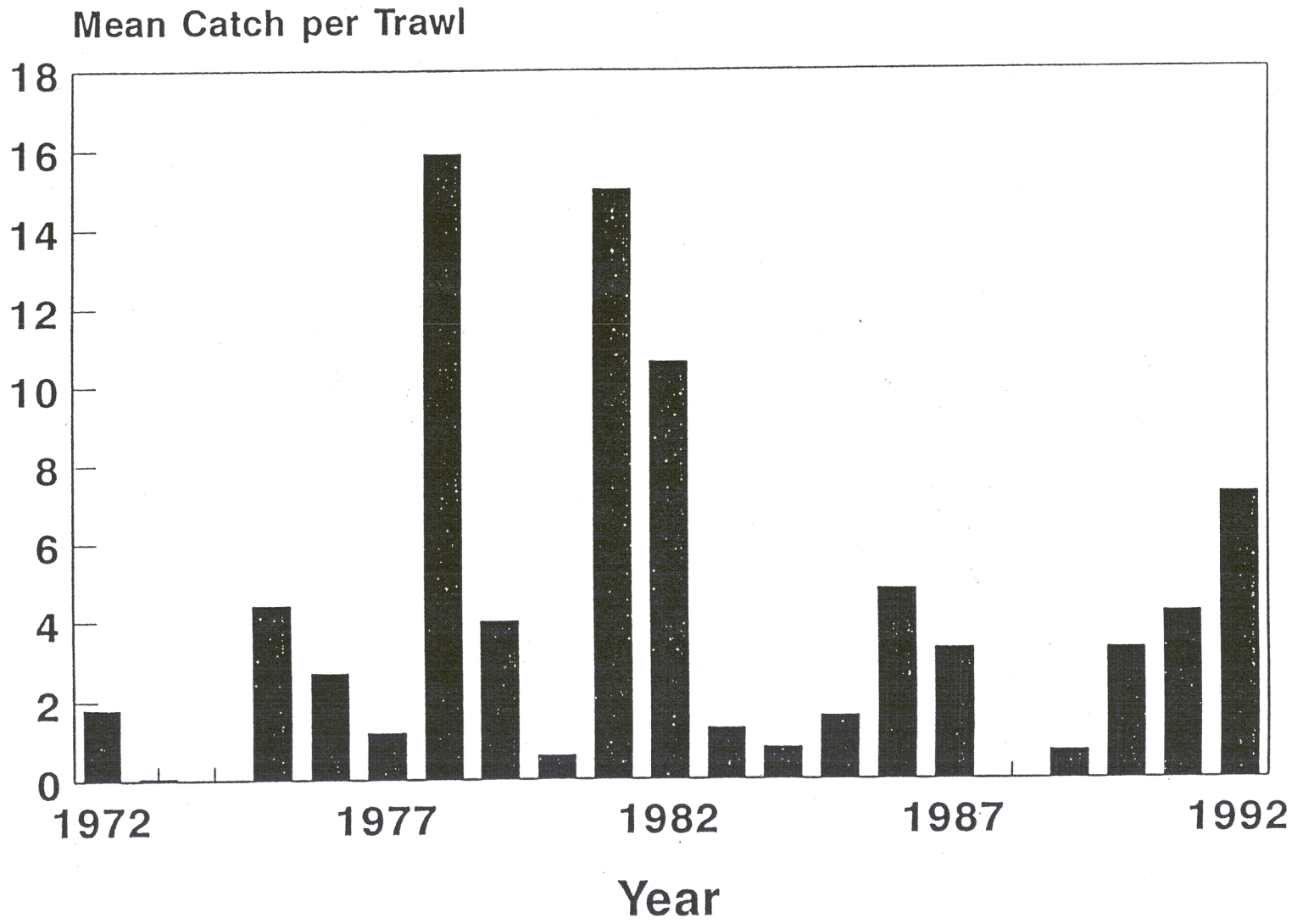


Figure 21. Mean catch per trawl for summer flounder in Maryland's coastal bays, 1972-1992.

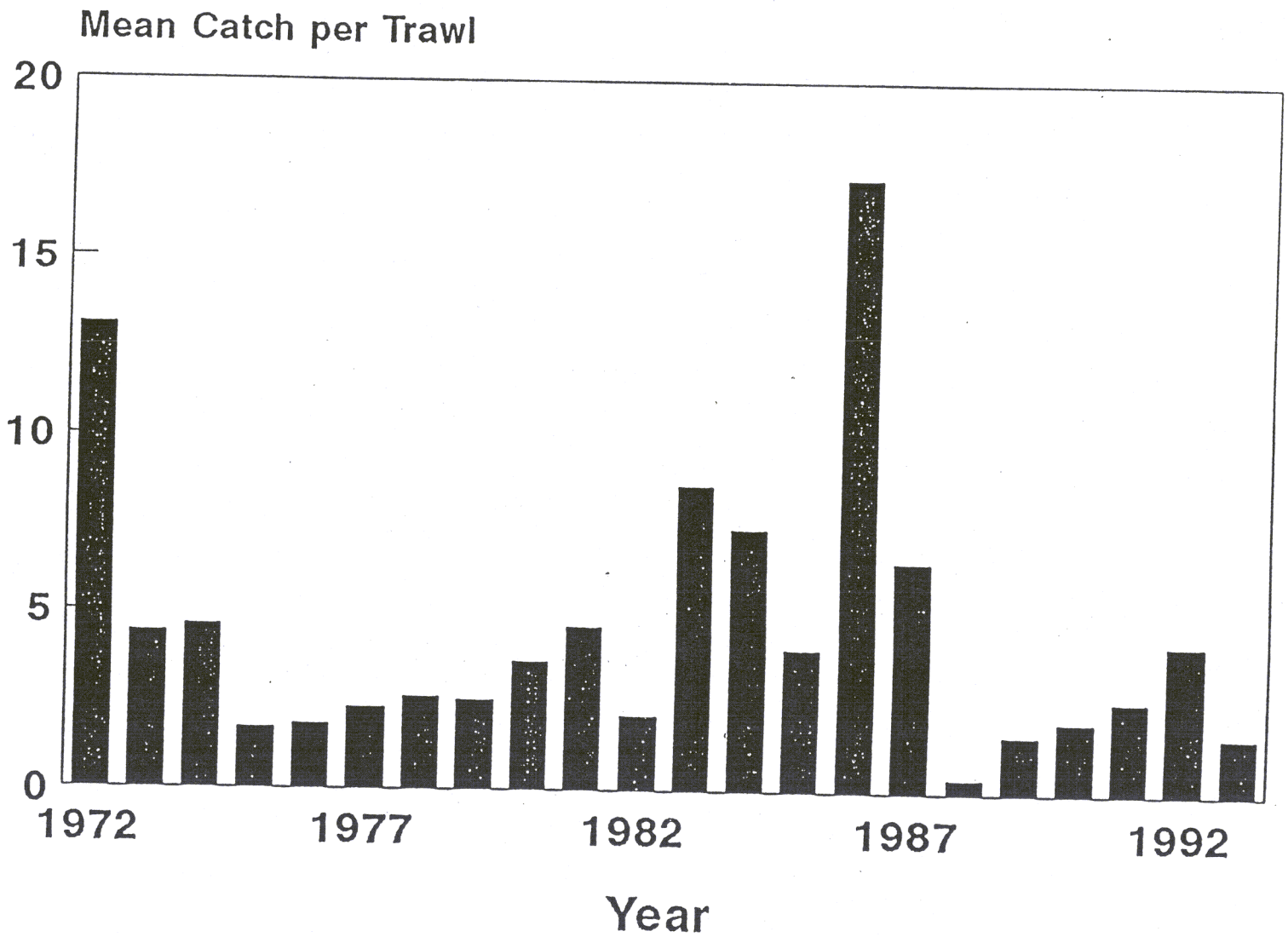
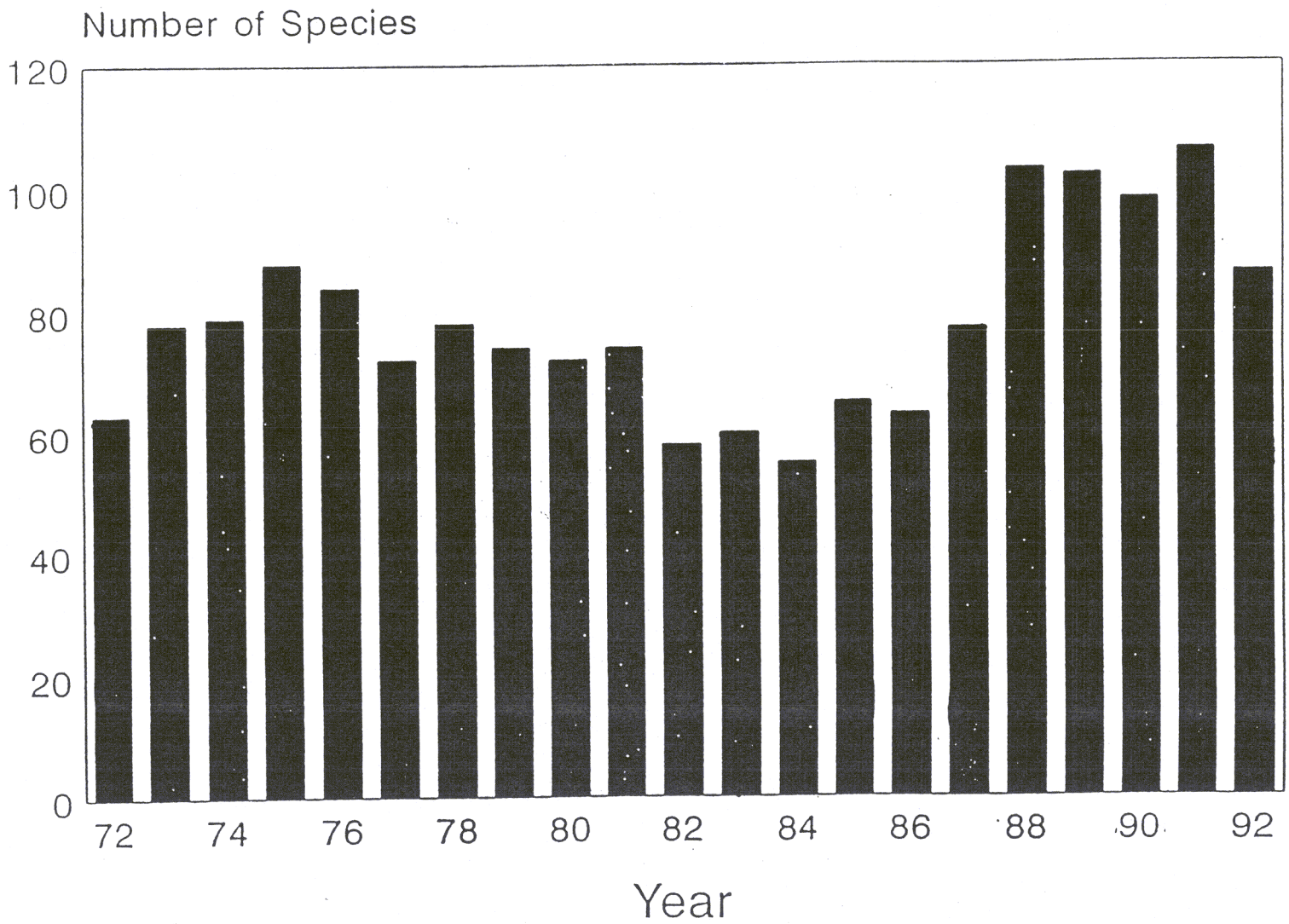


Figure 22. Number of species collected in otter trawls from Maryland's coastal bays, 1972-1992.



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Virginia Institute Of Marine Science's Trawl Survey

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Trawl Survey Objectives

The original premise of the Virginia Institute of Marine Science's (VIMS') Trawl Survey was to monitor and evaluate the commercially important finfish and blue crabs of the Chesapeake Bay Estuary. The major fish species of concern were the sciaenids and summer flounder. Lengths were collected on all, or a portion of all, specimens of each species at each station. Over the years as funding sources, environmental concerns, and state/federal mandates changed, so did the objectives of the program. However, the main underlying goal of providing a sound monitoring program for the fishes of the Chesapeake Bay has always remained intact.

Typically, as funding for certain programs increased or became available, the annual efforts also seemed to increase, reaching a peak in the mid-1970s (Figure 23). This highly active period was short-lived with effort decreasing steadily in the early 1980s as federal and state monies became less available. In 1988, the Chesapeake Stock Assessment Committee (CBSAC) funded an extensive monitoring program of the mainstem Bay. This work and the traditional fixed mid-channel river stations have continued to the present with Wallop Breaux funding.

The present objectives of the project are to provide annual estimates of recruitment success of important finfish species for the major Virginia nursery areas of Chesapeake Bay. These estimates (or indices) are to be of sufficient quality for management purposes. The second major objective ties all previous work together in an attempt to facilitate the development of a comprehensive Bay-wide trawl survey and maximize continuity with historical data sets. Gear evaluations and comparisons are being performed in an attempt to provide a contiguous 40-year database regardless of gear or sampling methodology. The last objective of the present funding stanza is to provide timely summaries of results which detail findings and assist resource managers in decision making processes. Other objectives going beyond our present contract requirements include the age determination of lesser studied species, comparison of generated indices with commercial and recreational landings, as well as other monitoring programs. Table 2 summarizes all work performed on the survey dating back to 1955.

Trawl Survey History

The VIMS Trawl Survey began in 1955 aboard the *R/V Virginia Lee* with a simple fixed station transect from the Chesapeake Bay mouth up the York River to the freshwater interface. The monthly survey design was initiated in April 1956 to monitor the blue crab and commercial finfish species of Virginia. In 1964, sampling was expanded to include the James River, with the Rappahannock River included the following year. The highest proportion of sampling was performed on the *R/V Pathfinder*, with the original *R/V Langley* secondary. The gear was a

Figure 23. VIMS Trawl Survey sampling effort, 1955-1994.

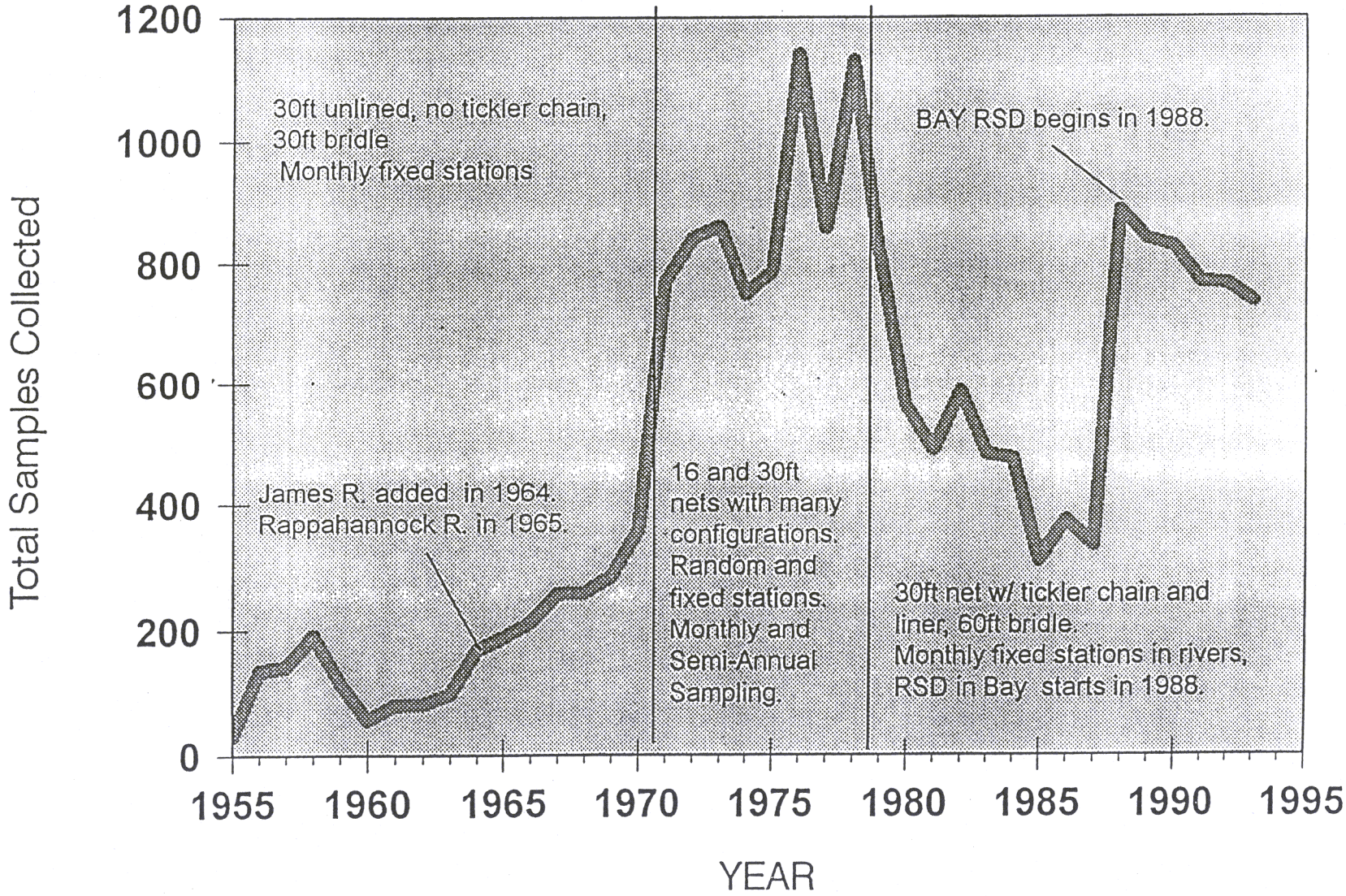


Table 2. Key and sample collection summary of the VIMS Trawl Survey, 1955-1993. Codes are on attached Key.

YEAR	TOTAL	MONTH												SYSTEM							VESSEL								GEAR CODE							STTYPE		TOW TYPE					
		1	2	3	4	5	6	7	8	9	10	11	12	CL	JA	MB	PO	RA	YK	OT	BR	FH	JS	LA	PA	RE	VL	OT	10	33	43	68	70	108	OT	F	R	5	7.5	10	15	OT	DIS
1955	31	0	3	1	3	1	5	14	1	3	0	0	0	6	0	0	0	0	25	0	0	0	0	0	0	0	31	0	31	0	0	0	0	0	0	31	0	0	12	0	17	2	0
1956	135	0	0	0	16	17	0	17	20	17	16	16	16	43	0	0	0	0	92	0	0	0	0	0	0	0	135	0	135	0	0	0	0	0	0	135	0	0	6	1	127	1	0
1957	142	12	16	16	0	12	0	5	16	17	16	16	16	47	0	0	0	0	95	0	0	0	0	0	86	0	56	0	142	0	0	0	0	0	0	142	0	0	44	0	98	0	0
1958	192	16	16	13	16	19	16	15	17	16	16	16	16	55	0	0	0	0	137	0	0	0	0	0	192	0	0	0	192	0	0	0	0	0	0	192	0	0	58	0	134	0	0
1959	117	0	0	0	14	3	16	19	16	16	16	17	0	32	0	0	0	0	85	0	0	0	0	0	117	0	0	0	117	0	0	0	0	0	0	117	0	0	34	0	83	0	0
1960	57	0	0	0	0	16	14	14	13	0	0	0	0	19	0	0	0	0	38	0	0	0	0	0	57	0	0	0	57	0	0	0	0	0	0	57	0	0	10	3	44	0	0
1961	81	6	0	0	4	10	12	8	8	7	8	10	8	15	0	0	0	0	66	0	0	0	0	0	81	0	0	0	81	0	0	0	0	0	0	81	0	0	26	0	55	0	0
1962	83	8	8	8	5	8	8	8	8	5	3	7	7	18	0	0	0	0	65	0	0	0	0	10	73	0	0	0	83	0	0	0	0	0	0	83	0	0	29	0	54	0	0
1963	98	6	8	9	9	7	7	9	9	9	9	9	7	19	0	0	0	0	79	0	0	0	0	23	75	0	0	0	98	0	0	0	0	0	0	98	0	0	37	0	61	0	0
1964	168	23	9	9	8	10	22	18	15	14	15	10	15	25	48	0	0	0	95	0	0	0	0	58	110	0	0	0	168	0	0	0	0	0	0	168	0	1	36	4	127	0	0
1965	188	22	13	17	14	14	14	14	19	14	15	11	21	1	71	0	0	23	93	0	0	0	0	43	145	0	0	0	188	0	0	0	0	0	0	188	0	0	38	1	144	5	0
1966	213	14	21	25	16	17	17	17	23	13	18	15	17	22	70	0	0	8	113	0	0	0	0	183	30	0	0	0	213	0	0	0	0	0	0	213	0	0	51	0	162	0	0
1967	259	14	17	32	17	17	24	23	23	23	23	23	23	23	68	0	18	43	107	0	0	0	0	8	251	0	0	0	259	0	0	0	0	0	0	259	0	0	58	3	192	6	0
1968	261	14	15	16	23	23	23	21	31	23	23	23	26	23	70	0	0	65	103	0	0	0	0	4	257	0	0	0	258	3	0	0	0	0	0	261	0	10	66	2	179	4	0
1969	286	23	23	24	24	24	24	24	24	24	24	24	24	23	72	0	0	83	108	0	0	0	0	0	286	0	0	0	286	0	0	0	0	0	0	286	0	1	86	4	189	6	0
1970	358	17	24	23	24	24	24	51	24	51	23	51	22	23	70	60	0	80	104	21	14	0	0	0	298	0	0	46	304	0	0	0	0	0	54	358	0	3	173	3	176	3	0
1971	772	51	18	51	47	61	63	103	82	74	74	74	74	24	80	126	0	96	417	29	154	0	0	42	334	234	0	8	348	0	24	0	0	0	400	540	232	408	172	1	189	2	0
1972	842	73	73	73	56	56	74	71	85	35	112	80	54	14	86	111	0	87	544	0	73	0	0	139	199	431	0	0	251	0	87	0	0	0	504	497	345	656	96	0	89	1	0
1973	863	54	53	11	56	80	202	91	83	105	105	23	0	88	67	45	0	80	583	0	126	0	0	64	240	433	0	0	0	122	171	0	0	0	570	296	567	743	0	119	0	1	0
1974	748	156	137	75	0	27	26	166	62	55	26	18	0	138	147	0	73	174	216	0	0	0	0	568	105	75	0	0	0	498	175	0	0	0	75	478	270	256	0	37	0	2	453
1975	787	194	128	16	0	18	18	349	18	18	10	18	0	162	148	0	60	194	223	0	174	0	0	453	160	0	0	0	0	535	118	0	0	0	134	118	669	463	0	0	0	2	322
1976	1141	184	141	23	40	40	40	525	40	40	36	32	0	174	340	0	60	318	249	0	210	0	6	491	262	172	0	0	0	426	308	0	0	0	407	308	833	816	0	0	0	0	325
1977	858	0	0	182	0	16	18	493	71	26	26	26	0	113	243	0	8	274	220	0	172	0	0	266	138	282	0	0	0	240	164	0	0	0	454	164	694	753	0	0	0	0	105
1978	1130	94	214	79	0	26	90	396	66	26	26	26	87	171	366	0	78	220	285	10	22	0	96	521	153	179	0	159	0	583	181	0	0	0	366	181	949	551	0	0	16	2	561
1979	813	282	70	124	0	36	42	49	46	37	44	44	39	60	270	0	63	159	260	1	0	0	43	371	336	63	0	0	2	461	0	287	0	0	63	288	525	488	0	0	0	2	323
1980	561	28	48	46	18	50	51	50	50	58	52	52	58	129	146	0	0	115	171	0	0	0	368	0	193	0	0	0	0	140	0	0	421	0	0	363	198	559	0	0	0	2	0
1981	489	43	33	53	17	51	47	52	25	39	42	38	49	52	148	0	18	97	174	0	0	0	341	0	17	0	0	131	1	0	0	0	488	0	0	296	193	483	0	0	0	6	0
1982	587	11	67	80	54	54	40	40	46	51	48	48	48	43	186	0	37	140	181	0	0	0	587	0	0	0	0	0	0	0	0	0	544	0	43	371	216	584	0	0	0	3	0
1983	482	32	54	14	15	40	39	39	38	38	65	50	58	0	162	0	19	118	183	0	0	0	482	0	0	0	0	0	0	0	0	0	465	0	17	367	115	478	0	0	0	4	0
1984	475	19	13	38	45	50	49	47	46	37	49	49	33	0	212	0	21	95	147	0	0	0	475	0	0	0	0	0	0	0	0	0	475	0	0	475	0	470	0	0	0	5	0
1985	310	36	26	26	26	35	12	38	39	27	45	0	0	0	111	0	17	67	115	0	0	0	273	0	0	0	0	37	0	0	0	0	310	0	0	310	0	308	0	0	0	2	0
1986	374	22	24	25	24	37	35	37	37	37	37	36	23	0	135	0	0	117	122	0	0	0	374	0	0	0	0	0	0	0	0	0	374	0	0	374	0	374	0	0	0	0	0
1987	334	23	24	23	24	36	37	33	34	32	34	34	0	0	108	0	0	108	118	0	0	0	334	0	0	0	0	0	0	0	0	0	334	0	0	334	0	334	0	0	0	0	0
1988	889	69	69	62	48	82	82	82	82	82	82	80	69	576	97	0	0	105	111	0	0	0	889	0	0	0	0	0	0	0	0	0	889	0	0	313	576	889	0	0	0	0	0
1989	840	61	61	61	66	76	76	76	76	76	76	76	59	479	108	0	0	124	129	0	0	0	840	0	0	0	0	0	0	0	0	0	840	0	0	361	479	840	0	0	0	0	0
1990	827	61	61	61	61	76	76	77	75	76	69	76	58	473	108	0	0	119	127	0	0	279	548	0	0	0	0	0	0	0	0	0	827	0	0	354	473	827	0	0	0	0	0
1991	768	61	25	61	61	73	73	72	70	73	73	73	53	411	108	0	0	120	129	0	0	768	0	0	0	0	0	0	0	0	0	0	0	768	0	357	411	767	0	0	0	1	0
1992	765	58	25	58	58	73	73	73	73	71	73	73	57	404	110	0	0	124	127	0	0	765	0	0	0	0	0	0	0	0	0	0	0	765	0	361	404	762	0	0	0	3	0
1993	735	25	58	25	56	73	73	73	73	73	73	73	60	370	110	0	0	126	129	0	0	735	0	0	0	0	0	0	0	0	0	0	0	735	0	365	370	735	0	0	0	0	0

Table 2A. Key and sample collection summary of the VIMS Trawl Survey, 1955-1993.

KEY

System:	CL	Lower Chesapeake Bay (Virginia Portion)
	JA	James River
	MB	Mobjack Bay
	PO	Potomac River
	RA	Rappahannock River
	YK	York River
	OT includes:	Atlantic Ocean (AT) - 1971, 78-79
		Piankatank (PK) - 1970-71
Vessel:	BR	W.K. Brooks
	FH	Fish Hawk
	JS	Captain John Smith
	LA	Langley
	PA	Pathfinder
	RE	Restless
	VL	Virginia Lee
	OT includes:	Aquarius (AQ) - 1978, Investigator (IN) - 1970
		Judith Ann (JA) - 1981, Langley II (LN) - 1985
		Sally Jean (SJ) - 1981, Outboard Skiff (SK) - 1970-71
		Three Daughters (TD) - 1978
Gear Code:	010	Unlined, no tickler chain, 30' bridle, 48"x22" otter board doors
	033	Lined, no tickler chain, 30' bridle, 48"x22" doors
	043	Unlined, tickler chain, 30' bridle, 48"x22" doors
30' Gears	068	Lined, tickler chain, 30' bridle, 54"x24" otter board doors
	070	Lined, tickler chain, 60' bridle, 54"x24" doors
	108	Lined, tickler chain, 60' bridle, metal china-v doors
	OT includes 3 configurations of 16 foot nets.	
		Gearcode 035: Lined, no tickler chain. Main Gear used
		Gearcode 009: Unlined, no tickler chain. 19 samples in 1972.
		Gearcode 067: Lined, w/ tickler chain. 60 samples in 1982-83.

Tow Type: OT is tow duration in minutes for those not listed.
DIS is distance rather than duration. Always 0.25 nautical miles.

STTYPE: Station Type, Fixed (F) or Random (R)

All Codes found on table are in Wojcik and Van Engel, 1988. Appendices A - C.

30-ft. unlined semi-balloon otter trawl (VIMS gearcode 010, Table 2). This Ichthyology-Crustaceology Bay-River program continued through August 1972, sharing funding responsibilities with a striped bass tagging study beginning in 1967. This striped bass program also used a 16 ft. version of the gear (VIMS gearcode 035, Table 2) on the Mobjack Bay and Piankatank River starting July 1970. Although both the Ichthyology and Crustaceology Departments participated in these surveys jointly, and protocol were identical, collection numbers and data management were separate for both the crustacean and finfish samples. In 1973, the Crustaceology and Ichthyology Departments began independent surveys. The blue crab group began using an unlined 30 ft. trawl net with attached tickler chain (VIMS gearcode 043, Table 2). The chain was previously shown to increase blue crab catches (Chittenden and Van Engel, 1972). The fixed tributary stations established in 1955 were maintained, often performing a replicate tow, opposite in direction from the first, at selected stations. In addition to lengths and numbers of blue crabs, fish species were also enumerated and sometimes measured. These data have recently been examined for the years 1973 to 1978, and incorporated into the historical trawl survey finfish datasets.

During this same period, the Ichthyology Department was performing a variety of surveys with different levels of intensity and sampling methodology. The monthly striped bass survey continued methods previously used until 1973. The success of the smaller gear on the Mobjack Bay and Piankatank River prompted a random stratified survey of the York River beginning in July 1971. By June 1973, the Ichthyology Department had random stratified surveys on all tributaries as well as the mainstem Bay. Both a 30 ft. trawl net (VIMS gearcode 033, Table 2) and a 16 ft. version (VIMS gearcode 035, Table 2) were used. Due to the intensity of this program, sampling was changed from monthly to semi-annually, similar in design to that used by the National Marine Fisheries Service (NMFS) Groundfish Survey. Sampling was performed during the winter (January to February) and again in June or July. In shallow waters (<3 m) the 16 ft. trawl net was used, while the 30 ft. version was used in deeper strata. Although labor intensive with a very large spatial coverage, the temporal frame was extremely limited, often missing abundance trends of the migratory species common to the Chesapeake estuary system. In May 1979, the two Departments coordinated efforts once again with two gears (VIMS gearcode 033 and 068, Table 2) dominating sampling that year. The 30 ft. lined net with a tickler chain (VIMS gearcode 068,Table 2) was used predominately for fixed tributary station sampling (May to November), and the 30 ft. unlined gear (VIMS gearcode 033, Table 2) for random and Bay sampling (December to April). By 1982 sampling was drastically cut with collections coming exclusively from the *R/V Captain John Smith* utilizing a 30 ft. lined net with attached tickler chain (VIMS gearcode 070, Table 2). The traditional tributary fixed stations were continued with a monthly schedule until 1988.

Beginning in January of that year, a CBSAC-funded Bay-wide random stratified survey was established based on depth and latitudinal region (Chittenden, 1989). Sampling methodology remained constant with the random stratified design in the Bay and the fixed transect of the tributaries to the present. Changes to the design recently include the purchase of a solely dedicated trawling platform, *R/V Fish Hawk*, in August 1990. It replaced the *R/V Captain John Smith* in September 1990, after performing the river survey with side-by-side comparisons. Since the *Fish Hawk* is a much smaller vessel, the larger otter board doors were replaced with smaller more hydrodynamic china-v doors beginning in January 1991 (VIMS Gearcode 108, Table 2). In June

of 1991, a pilot random stratified survey was begun on the York River in collaboration with the fixed station survey. Sampling changes and history are summarized in Table 2 and Figure 24.

Present Survey Design

Field Sampling

All collections are made with a lined 30 ft. (9.14 m) semi-balloon otter trawl (38.1 mm stretched mesh, 6.35 mm cod liner) and towed along the bottom for a period of five minutes during daylight hours. No effort is made to consistently trawl with or against the tidal flow since wind is often a more important factor. However, tows are made parallel to isobaths at constant depth. Catches are sorted to species, enumerated and individual lengths recorded. Relevant hydrographic and atmospheric parameters including depth, salinity, temperature and dissolved oxygen are recorded with each collection. Details of sampling protocols and specific collection information have been summarized in the annual data report series and annual reports to the funding agency (Geer et al., 1994; Colvocoresses and Geer, 1991).

Sampling is performed monthly using a random stratified sampling design in the mainstem bay and a fixed transect design in the tributaries. Exceptions include the winter months of January through March, when very few fish are present in the mainstem waters and only a single cruise in the bay has been made since 1991. Stratification in the mainstem bay is based on depth and latitudinal zones. Trawling sites within strata are selected randomly from the National Ocean Service's Chesapeake Bay bathymetric grid, a database containing depth records measured or calculated at 15 cartographic second intervals. Two to four trawling sites are randomly selected for each strata each month, the number chosen varying seasonally according to observed changes in distribution, with sampling intensity being highest in the most heavily utilized strata.

Sampling in the tributaries is performed at fixed sites located in the river channels and spaced at approximately five mile intervals from the river mouths up to approximately the freshwater interface in each system. These stations have been sampled on a monthly basis almost continuously since 1980 with the present sampling gear, and were previously used in monthly surveys using an unlined 30 ft. trawl beginning in the mid-1950s (York River) or early-1960s (James and Rappahannock Rivers) through 1972. During 1973 to 1979 these locations were not occupied by the Ichthyology Department, however the Crustaceology Department routinely sampled the locations from May to November enumerating fish species caught. Areal weightings for the tributaries were assigned by dividing each river into two approximately equal length "strata" and assuming that the stations in each strata are representative of the channel areas in those reaches. In general, the channel areas were arbitrarily considered to be those areas greater than 12 ft. deep. The exception was the lower Rappahannock, where the fixed stations were referred only to depths greater than 30 ft.

It may be preferable that the mainstem and tributaries be monitored using the same sampling design, and the random stratified design offers numerous advantages over the fixed station design. Although a random stratified sampling scheme has been conceptually developed for the tributaries,

Figure 24.

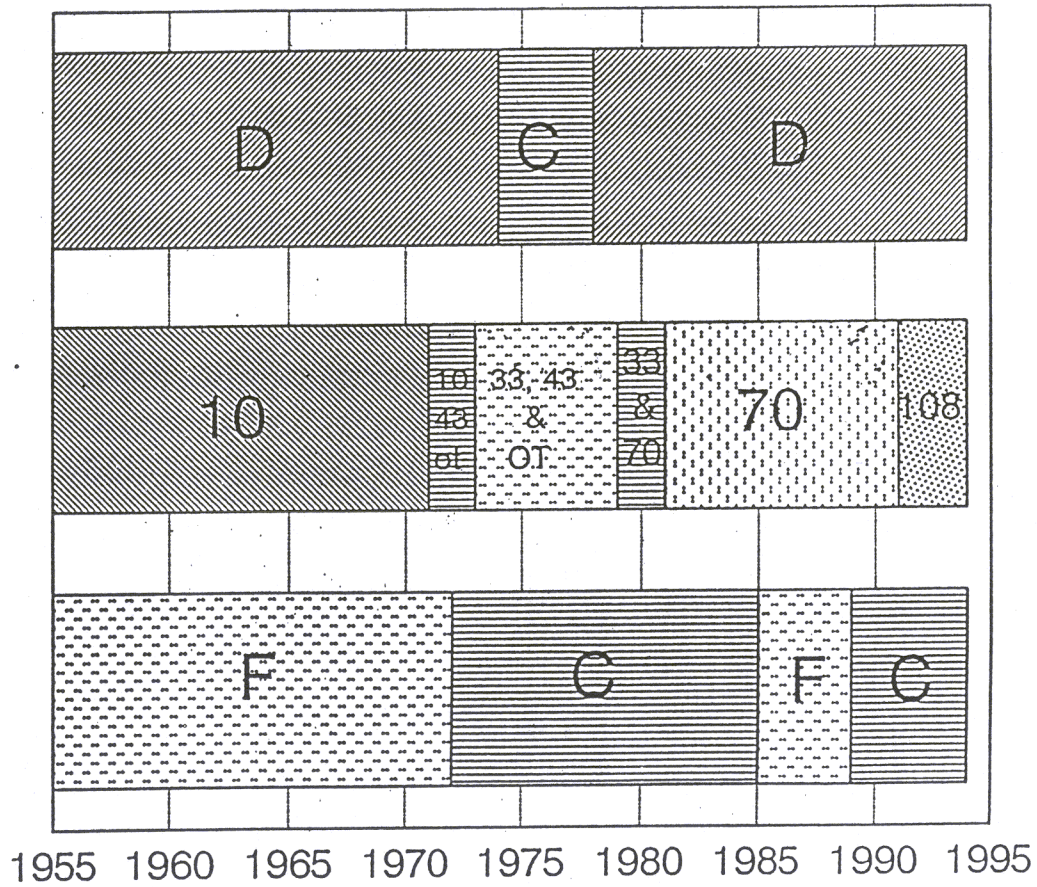
VIMS Juvenile Fish Trawl Survey

Sampling Changes 1955 - 1994

Tow Type
- D = Duration
- C = Duration and/or Distance

Gear Type
- 10 = Unlined/No Tickler
- 33 = Lined/No Tickler
- 43 = Unlined/Tickler
- OT = 16' Nets
- 70 = Lined/Tickler
- 108 = Lined/Tickler/China-V

Sampling System
- F = Fixed
- R = Random
- C = Combination



Gear Type is 30 foot otter trawl if not specified.

comparability of results with those of the fixed station surveys must first be established in order to assure continuity with the historical data set. To that end, a pilot random stratified design survey in one of the Virginia tributaries (the York system, for logistical reasons) was initiated in 1991 and is being conducted in a parallel manner with the fixed transect survey. Gear and sampling protocol are identical. These data are presently being evaluated as to the need for further parallel sampling before initiating a design to incorporate the fixed stations into a random stratified design. Preliminary analysis indicates a good correlation between the deep water strata of the random stratified design with those stations of the fixed transect (Bonzek, per. comm.).

Juvenile Index Computations

Measuring the abundance of migratory species (as are many of the key target species in this project) presents special difficulties, particularly if the timing and duration of migratory behavior is not constant from year to year. Ideally, the abundance of a juvenile finfish population should be measured at that point when it is most fully recruited to the nursery area being monitored. However, in practicality this can only be accomplished if the time of maximal abundance and size of recruitment to the gear can be predicted (and surveys timed accordingly), or surveys can be conducted on such an intense periodicity over the season of potential maximal abundance as to be certain of reasonable temporal coincidence. Neither of these two approaches is possible in the present case. The period of recruitable maximal abundance and the scope of the area being surveyed has proved to be variable between years within species. Couple this with the multi-specific monitoring objectives, precludes temporally intense surveys in the face of finite resources.

Juvenile index calculations are performed by first separating the young-of-the-year (y-o-y) from the older components. This is performed by plotting monthly length frequency information and arbitrarily selecting monthly cutoff values. These values are checked against published literature. Once the age components are created, monthly catch rates are map-plotted and strata-specific abundances and occurrence rates calculated. Numbers of individuals caught are logarithmically transformed ($\ln(n+1)$) prior to abundance calculations and results then back-transformed to the geometric means. Plots and data matrices are then examined for the area-time combinations which appear to provide the best basis for juvenile index calculations. Using this approach it has been possible to identify three or four month periods which consistently capture the months of highest abundance for the species thus far examined (Table 3).

After area-time combinations are selected, annual juvenile indices are calculated as the weighted geometric mean catch per tow. Strata-specific means and variances are calculated and then combined, weighting by stratum areas according to the formulae supplied by Cochran (1977). A more detailed description of these calculations is provided in Colvocoresses and Geer (1991), and Geer et al. 1994).

Database Management

All field data is collected with a small laptop computer (8088 or 80286 processor). Catch information is directly entered into the database by use of electronic measuring boards. These boards allow field crews to record all specific catch information for each station, having it stored

Table 3. VIMS Trawl Survey - Area/Time/Size/Value by Species.

Species-Age	Strata Used: Bay Bottom	Bay Lower	Bay Upper	James Lower	James Upper	York Lower	York Upper	Rapp Lower	Rapp Upper	January	February	March	April	May	June	July	August	September	October	November	December
	VIMS Trawl Survey - Area/Time/Size Values by Species									Month											
	Size Cutoff Values - Darkened Areas Represent Index Months																				
Alewife Y-O-Y										0-150	0-150	0-150	0-160	0-170	0-75	0-90	0-110	0-125	0-135	0-145	0-160
American Shad Y-O-Y										0-170	0-170	0-170	0-180	0-190	0-80	0-100	0-115	0-130	0-145	0-160	0-170
Atlantic Croaker - Y-O-Y										0-100	0-100	0-100	0-110	0-135	0-160	0-180	0-220	0-50	0-80	0-100	0-100
Atlantic Silverside Y-O-Y										0-125	0-125	0-130	0-135	0-140	0-70	0-80	0-90	0-100	0-110	0-120	0-125
Black Seabass Y-O-Y										0-110	0-110	0-110	0-110	0-110	0-150	0-175	0-70	0-85	0-100	0-105	0-110
Blue Crab Juveniles														0-80	0-100	0-105	0-35	0-65	0-65	0-65	0-65
Blue Crab Recruits														80-200	100-200	105-200	36-200	66-200	66-200	66-200	66-200
Channel Catfish Y-O-Y										0-130	0-130	0-130	0-140	0-150	0-50	0-80	0-105	0-120	0-130	0-130	0-130
Northern Puffer Y-O-Y										0-140	0-140	0-140	0-160	0-185	0-50	0-85	0-120	0-140	0-135	0-140	0-140
Scup 1 +										90-170	90-170	90-170	90-170	35-90	40-100	50-125	60-145	75-160	85-170	90-170	90-170
Silver Perch Y-O-Y										0-160	0-160	0-160	0-160	0-165	0-170	0-100	0-130	0-150	0-160	0-160	0-160
Spot - Y-O-Y										0-200	0-200	0-50	0-75	0-100	0-135	0-160	0-180	0-200	0-200	0-200	0-200
Striped Bass Y-O-Y										0-200	0-200	0-200	0-200	0-60	0-80	0-100	0-120	0-135	0-150	0-175	0-190
Sum. Flounder Y-O-Y										0-290	0-290	0-60	0-100	0-140	0-170	0-200	0-225	0-250	0-275	0-290	0-290
Weakfish - Y-O-Y										0-200	0-200	0-200	0-225	0-240	0-90	0-120	0-150	0-180	0-200	0-200	0-200
White Catfish Y-O-Y										0-110	0-110	0-110	0-110	0-120	0-50	0-65	0-80	0-90	0-100	0-110	0-110
White Perch Y-O-Y										0-85	0-85	0-85	0-95	0-35	0-65	0-73	0-80	0-85	0-85	0-85	0-85
White Perch 1 +										86-300	86-300	86-300	96-300	36-300	66-300	74-300	81-300	86-300	85-300	86-300	86-300

Table 3. continued VIMS Trawl Survey - Area/Time/Size/Value by Species.

Species-Age	VIMS Trawl Survey - Area/Time/Size Values by Species																						
	Strata Used									Month													
	Bay			James		York		Rapp		Size Cutoff Values - Darkened Areas Represent Provisional Index Months													
	Bot. m	Lower	Upper	00.17	18.40	00.15	18.40	00.20	21.40	January	February	March	April	May	June	July	August	September	October	November	December
Atlantic Menhaden Y-O-Y										0-50	0-50	0-50	0-50	0-60	0-85	0-100	0-130	0-150	0-170	0-175	0-175
Bay Anchovy Y-O-Y										0-77	0-80	0-80	0-80	0-80	0-80	0-44	0-51	0-56	0-61	0-65	0-70
Blackcheek Tonguefish Y-O-Y										0-110	0-110	0-110	0-110	0-115	0-125	0-130	0-80	0-90	0-100	0-110	0-110
Blueback Herring Y-O-Y										0-110	0-110	0-110	0-120	0-50	0-58	0-65	0-75	0-90	0-100	0-110	0-110
Butterfish Y-O-Y										0-150	0-150	0-150	0-150	0-150	0-60	0-75	0-115	0-125	0-140	0-150	0-150
Gizzard Shad										0-200	0-200	0-200	0-100	0-100	0-100	0-100	0-100	0-150	0-150	0-150	0-200
Harvestfish										0-125	0-125	0-125	0-125	0-125	0-125	0-75	0-100	0-125	0-125	0-125	0-125
Hogchoker										0-60	0-60	0-60	0-64	0-67	0-70	0-80	0-40	0-50	0-55	0-60	0-60
Kingfish Species										0-200	0-200	0-200	0-200	0-200	0-200	0-75	0-125	0-150	0-175	0-200	0-200
Kingfish (Northern)										0-200	0-200	0-200	0-200	0-200	0-200	0-75	0-125	0-150	0-175	0-200	0-200
Kingfish (Southern)										0-200	0-200	0-200	0-200	0-200	0-200	0-75	0-125	0-150	0-175	0-200	0-200
Northern Searobin										0-125	0-125	0-125	0-125	0-150	0-150	0-150	0-175	0-100	0-125	0-125	0-125
Spotted Hake										0-160	0-180	0-200	0-225	0-250	0-275	0-300	0-310	0-325	0-325	0-150	0-150

in the database as well as providing a hardcopy printout. Monthly sampling results in nearly 10,000 length samples, which are almost always completely recorded during the course of a sampling day. This has allowed for increase error checking, resulting in fewer discrepancies in the database.

The process for each month's sampling begins with the initialization of a database shell for each anticipated day's work. This information is transferred to the laptop computer and placed aboard the ship. Communication between the measuring boards and the computer are checked. At the beginning of each day's sampling, an empty database is opened and the necessary cruise, station, and crew information is recorded. The laptop is then secured and all further information is recorded directly from the fish boards. After sampling is completed, the database is closed and copied to a disk with a brief log file describing the day's activities. In the lab, the files are uploaded on the Fisheries Network. Station, hydrographic, atmospheric, and any unmeasured fish are entered into the database. The database is then converted to an ASCII file and SAS error checking programs are run, providing a summary of the day's species composition, station, hydrographic, atmospheric, and cruise information. The summary is checked and errors are corrected, repeating this process until the data is clean.

After completion, the Fisheries Data Management Unit perform second level error checking, then incorporate the data into the historical SAS database. Routine and ad hoc programs are run on the data providing summaries and analyses as requested. This entire process can be completed in one day but routinely involves two to three weeks.

Future plans for database management involve examining relational database systems, providing ship-board real time analysis of data, and moving to a client/server based system. Programs have been written that will allow individuals to select the type of information and output they require simply by answering several questions. The advantage of this type of programming is it allows persons not familiar with the database structure or the programming language of SAS, to create custom output without taking up valuable time of the database managers.

Results

Figures 25 to 27 show the indices for several species of concern. At present, values are only reported back to 1979 because different gears and methodologies previously used, and all comparisons studies are not complete at this time. The graphs show weighted geometric mean catch per trawl both for the tributaries only and the combined bay-river values beginning in 1988. For most species the two complement each other well. Spot have fluctuated considerably over the years with near record lows recorded recently. This might be due to variations in prevailing wind direction and timing during spawning and larval transport (Bodolus, 1994). The Atlantic croaker has proven problematic due to its protracted spawning period. Certain year's distribution of y-o-y is concentrated only in the tributaries, while in some recent years the Bay has shown to be quite productive. However, until this can be further examined, the spatial component of the index will remain the river strata. Weakfish is one species that shows significant disagreement between the river and the Bay-river indices. Summer flounder, after being at high values in 1990 and 1991, have declined to near record lows in 1993. The black seabass spatial component is primarily the

Figure 25. VIMS juvenile finfish stock assessment for spot, Atlantic croaker, weakfish, summer flounder and black seabass.

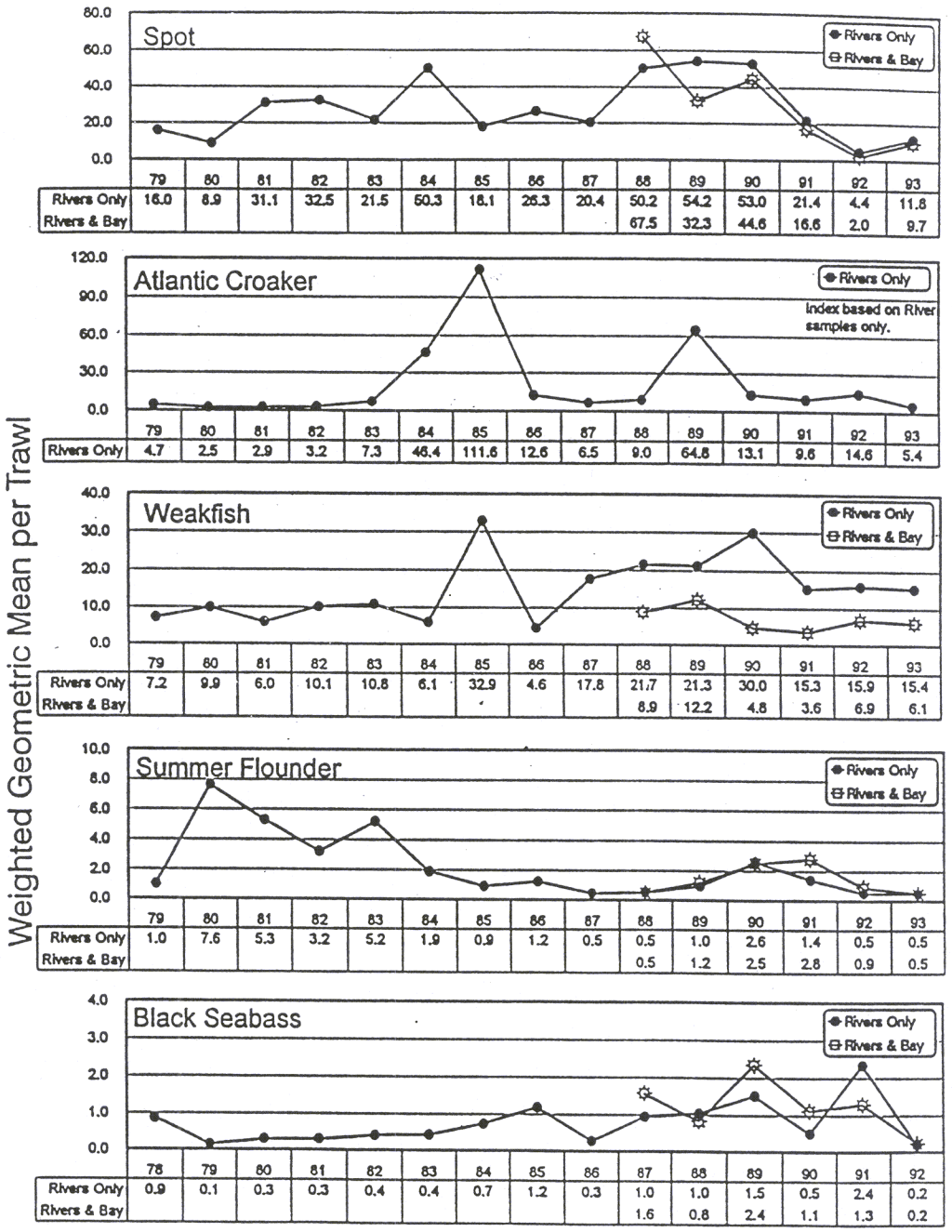


Figure 26. VIMS juvenile finfish stock assessment for northern puffer, silver perch, white perch, striped bass and blue crab.

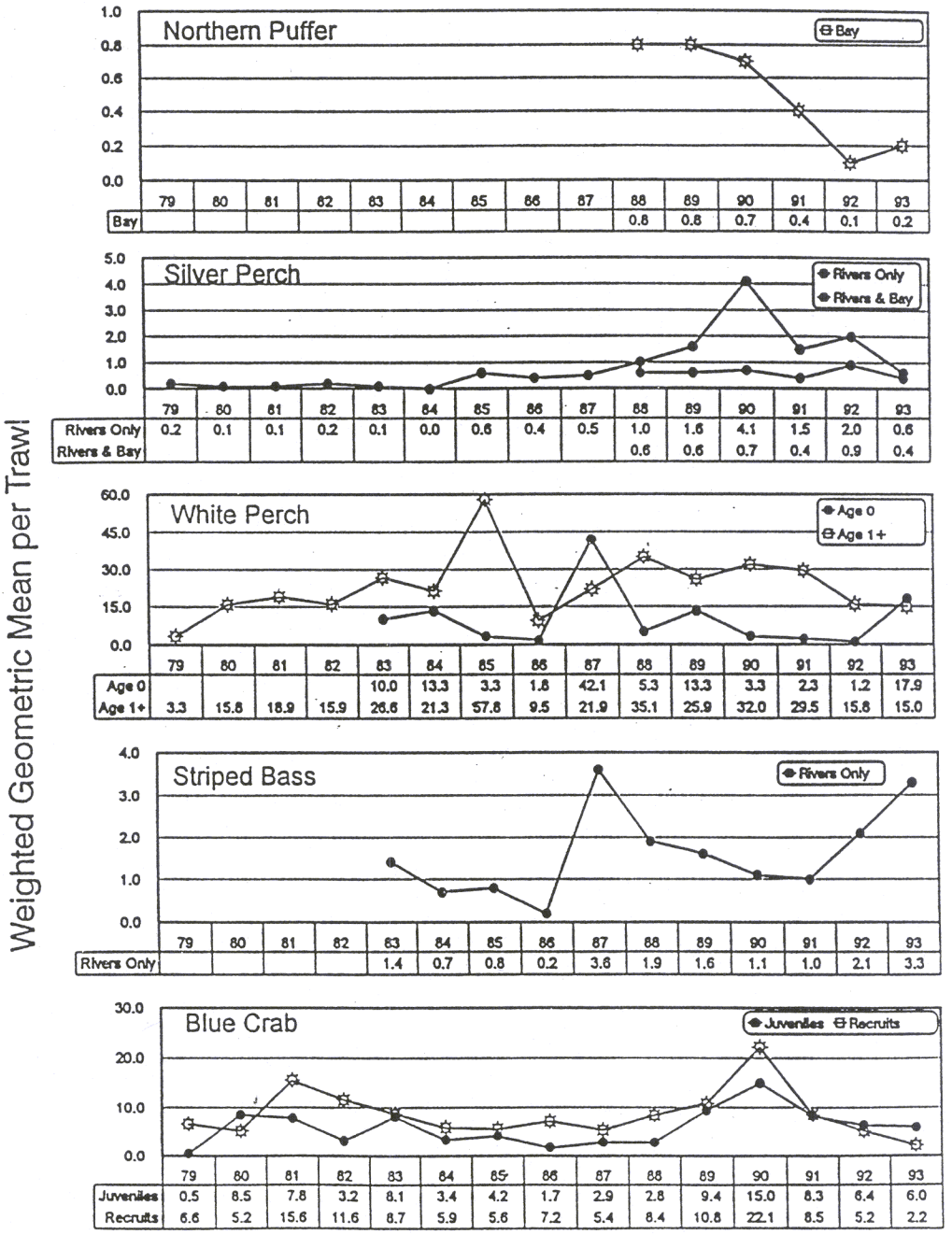
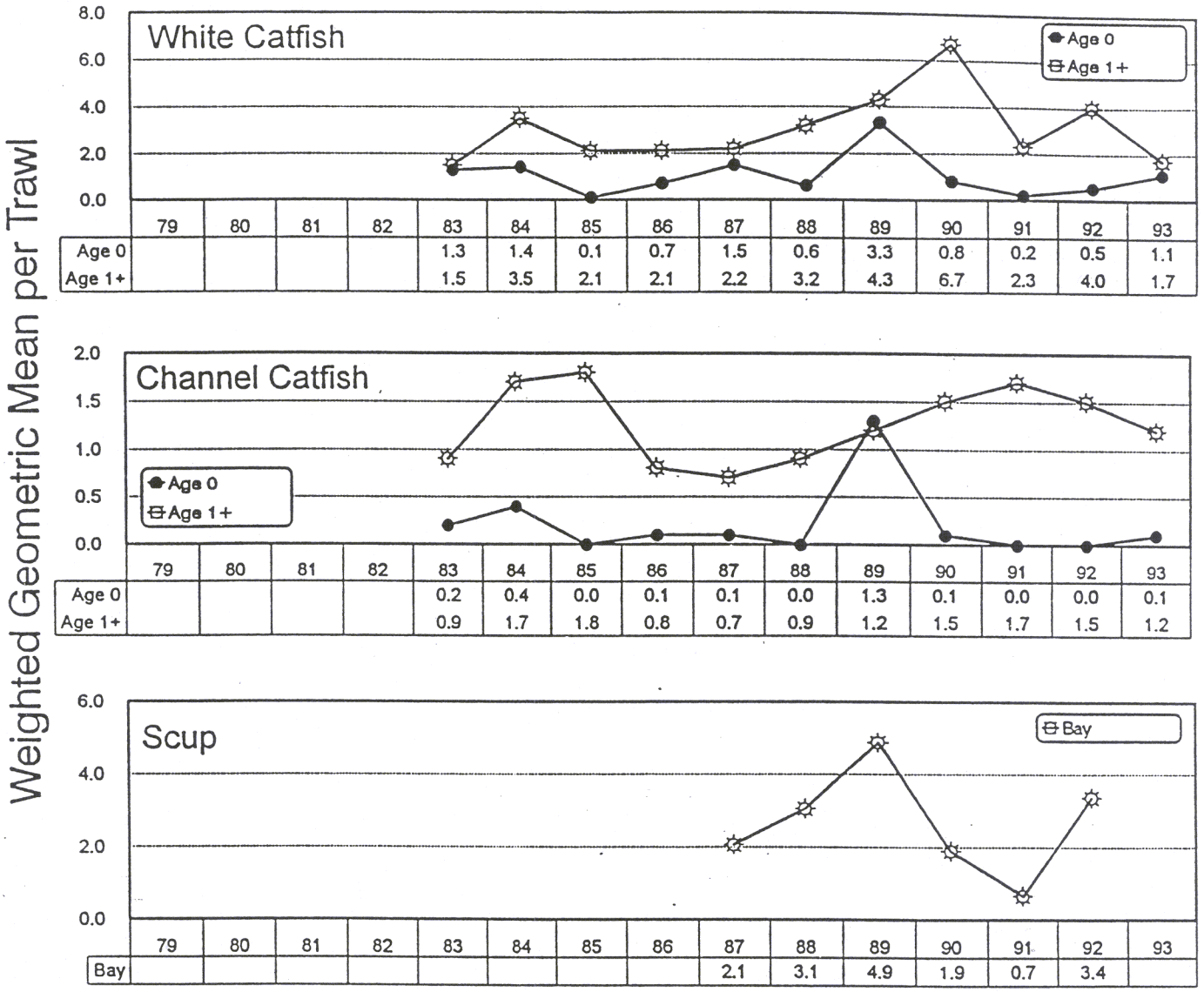


Figure 27. VIMS juvenile finfish stock assessment for white catfish, channel catfish and scup.



	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Age 0					1.3	1.4	0.1	0.7	1.5	0.6	3.3	0.8	0.2	0.5	1.1
Age 1+					1.5	3.5	2.1	2.1	2.2	3.2	4.3	6.7	2.3	4.0	1.7

	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Age 0					0.2	0.4	0.0	0.1	0.1	0.0	1.3	0.1	0.0	0.0	0.1
Age 1+					0.9	1.7	1.8	0.8	0.7	0.9	1.2	1.5	1.7	1.5	1.2

	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Bay									2.1	3.1	4.9	1.9	0.7	3.4	

mainstem bay, with the lower James the lone river strata. As a result, values prior to 1988 are questionable due to the limited sample size. The temporal frame is toward the end of the biological year (May - July), resulting in index values from animals spawned the prior year. Northern puffer is only collected in the mainstem Bay and has been in decline. Silver perch utilize all strata with peak abundances usually occurring in the lower York River. White perch is a species which the gear captures across several year classes. A y-o-y and age 1+ indices are generated from the upper river stratum during winter months. The lack of any type of relationship between the y-o-y values and those of the older component suggest several year classes are being captured. In fact, recently otolith aged specimens were found to be upwards of twelve years. The striped bass values are also from the upper river strata and were near historic highs in 1993. The blue crab values for recruits and juveniles are based upon all river strata for their spatial component. Although on the decline in recent years, there have been periods of comparably low values (1984-1988).

Gear Calibration Studies

The second objective of this project is to examine the older datasets and compare them to that presently being performed. As a result we have performed various gear comparisons the past several years in an attempt to provide some type of continuous online database, and thus make the dataset a useable 40 year file. We were slowed in this work by the acquisition of the Fish Hawk and following trawl door change. Vessel comparisons revealed no significant differences in target species, while the door comparisons provided differences for several species. After those comparisons were completed other major stanzas of the program have begun to be examined. Data are analyzed by combining the replicate tows for each gear at a location then log transforming in a similar fashion as for index calculations. Paired t-tests were performed on both the total catch of a species and the y-o-y component. If a significant difference was found the resultant regression formula was applied to the data. This formula would later be applied to catch information of the related stanza (gear). A first attempt at providing a 40 year index of abundance involved only the fixed river stations, and only the major gear used during a given stanza (all 16ft. gears, random stations, and semi-annual sampling was removed prior to analysis) The resulting indices for spot and summer flounder are shown in Figure 28. Comparisons for gear code 043 have not yet been performed. These values should be considered extremely provisional until further and more detailed analyses can be applied.

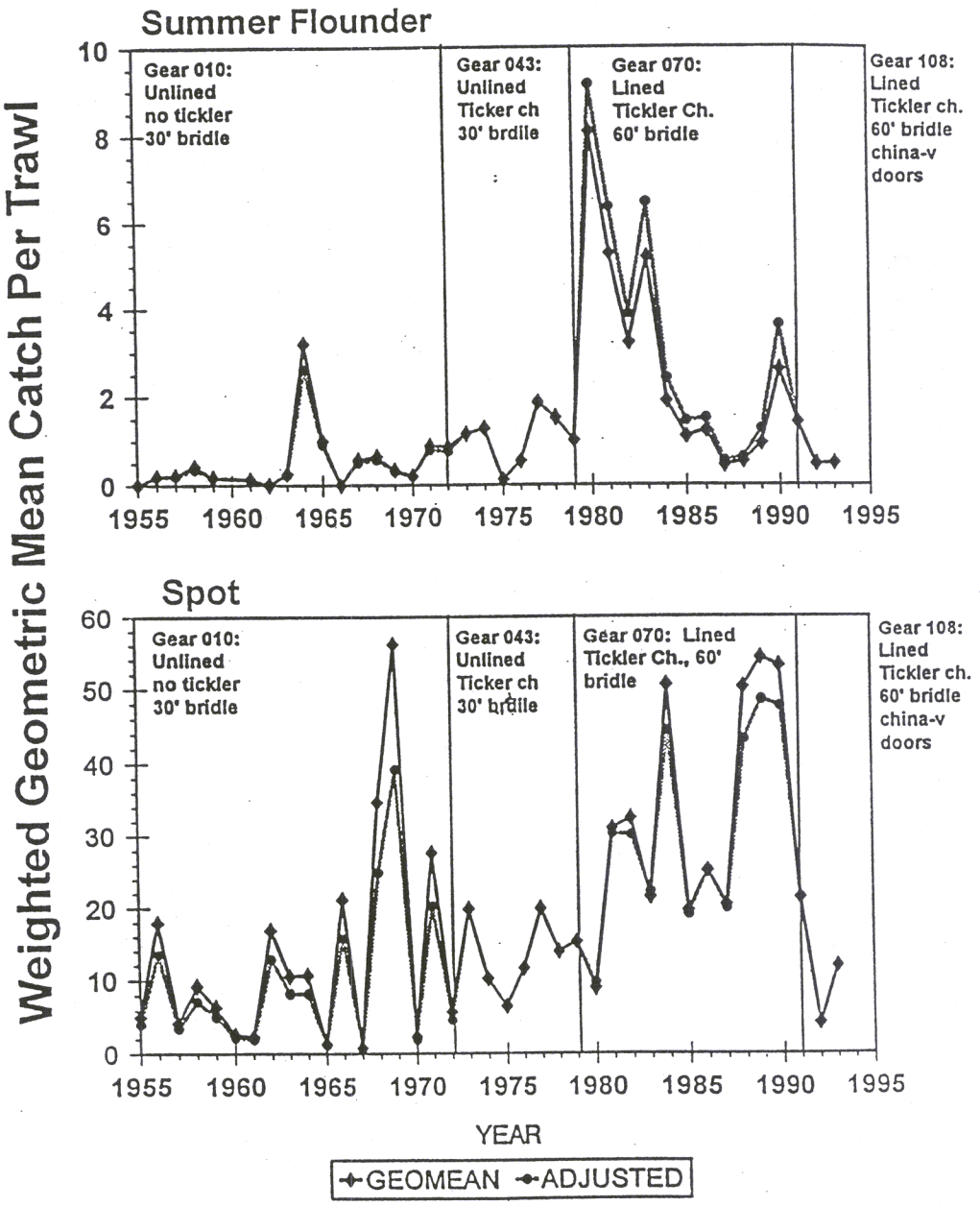
Integration with Other Surveys

There have been only limited attempts to compare the VIMS trawl survey data to other surveys and data sets. A relationship between the trawl survey York River blue crab catch and the subsequent commercial dredge fishery landings produced the following statistical relationship:

$C = 0.4582(A)e^{[-0.0176(A)]}$; where C = dredge fishery landings, A = trawl survey abundance

$r^2 = 0.80$, $P < 0.0005$.

Figure 28. Gear conversions for VIMS juvenile indices.



This Ricker stock-recruit model has been used in management decisions since first published in 1990 (Lipcius and Van Engel, 1990).

Attempts at integrating finfish species have involved the VIMS beach seine survey (July - September) and trawl survey data from December to February. Correlations were found for both y-o-y striped bass and white perch (Geer et al., 1994). This information provides an indicator of year class strength for trawl survey data, and also supports the validity of data collected on both surveys. Recent attempts at comparing trawl data to commercial and recreational landings of important sciaenid species has shown mixed results. Atlantic croaker had a strong correlation between the trawl survey index and Virginia's haul seine landings lagged two years. Similar results were found with recreational landings for both croaker and spot (Kline and Speir, 1993). Other relationships include a strong correlation with the VIMS' juvenile index and the Northeast Fishery Science Center's virtual population analysis for summer flounder; and larval recruitment and juvenile indices (Norcross, 1983; Bodolus, 1994).

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Georgia Department of Natural Resources' Shrimp and Crab Trawl Survey

by
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Georgia Department of Natural Resources

The Georgia Department of Natural Resources (DNR) is responsible for managing the State's marine fisheries resources. The two major commercial fisheries are the penaeid shrimp fishery which is the most valuable in terms of total dollars generated, and the blue crab fishery which actually produces a greater volume in pounds. In 1993, Georgia's shrimp fishery produced approximately five million pounds ($18 million), while the blue crab fishery produced approximately eight million pounds (three million dollars).

The commercial shrimp fishery is typical of the South Atlantic shrimp fishery in that it is prosecuted by a fleet of primarily small and medium-sized trawling vessels (typically wooden craft ranging from 30 to 80 ft. in length).

Commercial trawling activities are generally conducted in nearshore oceanic waters of both state territorial waters (from the beaches to the three-mile limit) and the open ocean waters of the federal Exclusive Economic Zone. Almost all trawling activity takes place within seven miles of shore.

Although DNR has authority to open six of Georgia's larger sounds to commercial shrimp trawling during the fall (September through December), since 1976 such openings have been infrequent and abbreviated. Utilization of Georgia's sounds as a management tool for the shrimp fishery is currently being evaluated.

Inasmuch as South Atlantic penaeid shrimp stocks are an annual crop; and they have different spawning seasons and, consequently, reach commercial size during different seasons of the year, monthly trawl assessment/monitoring activities are necessary to prepare sound management recommendations.

The methodology and manner of Georgia's current trawl study are described below. Georgia's fishery-independent trawl data set is complete for all months back to 1985, and all stations and systems are inclusive. Prior to 1985, quarterly monitoring was conducted and some stations were added and others omitted. All of these data are available upon request from Georgia's Coastal Resources Division.

Trawl assessment sampling is conducted monthly in Georgia's six commercially important estuarine systems: Wassaw, Ossabaw, Sapelo, St. Simons, St. Andrew and Cumberland. Each system is divided into three separate sectors: (1) large creeks and rivers; (2) open sounds; and (3) nearshore ocean waters -- state's territorial waters from the beaches to three miles offshore. In each sector, two fixed or permanent trawl stations were established making a total of six stations

per estuarine system, and 36 stations coastwide. All trawl stations are at water depths of less than 40 ft. A list of these station locations is attached (see Table 4).

Sampling cruises are typically scheduled and conducted during the first neap tide cycle during the first half of the month for standardization where possible. Although some deviation occasionally occurs due to inclement weather, breakdowns, special emergency details, and other unforeseen events, field sampling is normally completed within the first two weeks of each month.

Trawl tows are 15 minutes at each station, with time calculated as bottom time from the moment the winch was "dogged-off" until the bag was retrieved. Sampling is conducted aboard the Department of Natural Resources' larger research vessels the *R/V ANNA*, a 60-ft. St. Augustine style shrimp trawler built in 1968, and the *R/V COBIA*, a 44-ft. fiberglass Thompson trawler built in 1974. Sampling gear consists of 12.2 m (40 ft.) flat otter trawls with 4.8 cm (1 7/8 in.) stretch-mesh webbing for the body and bag. Trawl doors measure 5 ft. x 30 in. and employ a 3/16 in. tickler chain. The trawl is naked in that it has no Turtle Excluder Device (TED) or finfish excluders. Previous mensuration studies indicate a spread of approximately 28 ft.

At each station, catches are deposited on deck in a culling table where shrimp and blue crabs are sorted by species and quantitative measurements taken. The metric system is used for all length measurements, but weight measurements are again measured in pounds and ounces as this is the industry standard. Pounds per hour of trawling values are used to represent catch per unit of effort (CPUE) information for all species per each trawl sample. A representative sample of 30 shrimp is measured. Lengths are measured in millimeters (mm), but weights are taken in pounds and ounces and recorded to the nearest tenth of a pound, as this is the industry standard for marketing shrimp as either heads-off or heads-on counts of shrimp per pound. If less than 30 individuals are caught, all are measured. Records are maintained for each commercially important penaeid shrimp species on forms providing for sex, total length (mm) from tip of rostrum to tip of telson, state of ovarian development, the occurrence of diseased individuals, and the total weight and number of individuals per pound (heads-on). Number per pound count size is determined by obtaining the average number of whole individuals in a random three-pound subsample. In small samples where less than three pounds of a particular species are collected, number per pound count sizes are calculated by dividing the total number of individuals collected by the total weight of the sample. In samples where only one specimen is collected, or when total weights represent one ounce or less, a length/weight conversion table prepared from previous commercial fisheries investigations is used to obtain heads-on counts (Table 5). Ovarian development is classified and recorded in five distinct stages of maturity (King, 1948): UN = undeveloped; D = developing; Y = yellow; R = ripe; and S = spent. The presence or absence of spermatophores is also recorded.

At each station a representative sample of 30 blue crabs is also examined and measured. If less are taken, all are measured. Blue crab data recorded include: sex, carapace width (measured as the distance in mm between tips of the major spines), ecdysis stage, maturity, total number, and total weight. Ecdysis stages are recorded in five classifications: hard, pre-molt, peeler, soft and paper. Female maturity stage is determined by the shape of the abdominal apron, with triangular

Table 4. Assessment trawl station locations sampled each month as part of Georgia's Resources Assessment Survey. Latitude and longitude coordinates from NOAA chart.

Estuary	Sector	Station Location	Midpoint Location Latitude/Longitude
	Creek	Halfmoon River	31 58.2'N/80 57.6'W
	Creek	Wilmington River at Sister Island	31 59.8'N/81 00.2'W
Wassaw	Sound	Mouth of Bull River	31 57.0'N/80 56.0'W
	Sound	Wassaw Sound at Saltpond	31 55.6'N/80 58.3'W
	Offshore	North Channel off Little Tybee Island	31 54.9'N/80 54.9'W
	Offshore	South Channel off Wassaw Island	31 54.6'N/80 55.0'W
	Creek	Vernon River at Burnside River	31 55.4'N/80 05.5'W
	Creek	Florida Passage at Cane Patch Creek	31 49.6'N/81 09.5'W
Ossabaw	Sound	North Side of Racoon Key	31 51.7'N/81 04.1'W
	Sound	South Side of Racoon Key	31 50.2'N/81 03.0'W
	Offshore	Channel East of Racoon Key	31 48.1'N/80 59.5'W
	Offshore	Channel East of Ossabaw Island	31 47.4'N/81 00.0'W
	Creek	Wahoo River Near Mouth	31 35.5'N/81 12.5'W
	Creek	Mud River at Intracoastal Waterway	31 29.0'N/81 18.2'W
Sapelo	Sound	North Side of Dog Hammock	31 31.6'N/81 17.0'W
	Sound	Lower Sound north of High Point	31 31.5'N/81 14.8'W
	Offshore	Channel near north end of Blackbeard	31 32.0'N/81 09.5'W
	Offshore	Channel east of Blackbeard Beach	31 31.5'N/81 10.5'W
	Creek	Frederica River at Mackay River	31 11.8'N/81 25.0'W
	Creek	Back River at Little River	31 09.3'N/81 26.8'W
St. Simons	Sound	St. Simons Range Towers at Frederica River	31 08.9'N/81 25.2'W
	Sound	Lower Jekyll Cove at Dubignon	31 06.2'N/81 25.8'W
	Offshore	Offshore of St. Simons Sound Entrance	31 06.5'N/81 21.5'W
	Offshore	Channel East of North Jekyll Beach	31 06.0'N/81 20.5'W
	Creek	Jointer Creek Near Mouth	31 02.8'N/81 28.2'W
	Creek	Floyd Creek Near Mouth	30 56.3'N/81 26.2'W
St. Andrew	Sound	Satilla River at Todd Creek	30 55.8'N/81 29.3'W
	Sound	Cumberland River at Cumberland Wharf	30 58.4'N/81 30.5'W
	Offshore	Channel North of St. Andrew Sea Buoy	30 59.6'N/81 25.0'W
	Offshore	Channel Southwest of North Breakers	30 57.0'N/81 19.0'W
	Creek	Brickhill River below Power Cable	30 51.8'N/81 28.3'W
	Creek	Crooked River South Branch	30 49.3'N/81 30.0'W
Cumberland	Sound	Cumberland Sound at Seacamp Dock	30 45.0'N/81 28.6'W
	Sound	Cumberland Sound at Dungeness Dock	30 46.0'N/81 28.4'W
	Offshore	Offshore from mid-Cumberland Beach	30 53.3'N/81 23.0'W
	Offshore	Cumberland Beach (Lake Whitney/Stafford Shoals)	30 52.7'N/81 23.5'W

Table 5. Total lengths and mean number per pound (heads-on)count size for white shrimp in Georgia. Lengths measured from tip of rostrum to tip of telson.

Length Versus Mean Count Size for White Shrimp

Length in mm	Heads-On No/Lb	Length in mm	Heads-On No/Lb	Length in mm	Heads-On No/Lb	Length in mm	Heads-On No/Lb	Length in mm	Heads-On No/Lb
51	480	71	173	91	81	111	44	134-135	24
52	452	72	166	92	78	112	42	136-137	23
53	426	73	159	93	75	113	41	138-139	22
54	403	74	152	94	73	114	40	140-141	21
55	380	75	146	95	71	115	39	142-144	20
56	360	76	140	96	68	116	38	145-146	19
57	341	77	135	97	66	117	37	147-149	18
58	323	78	130	98	64	118	36	150-152	17
59	306	79	125	99	62	119	35	153-155	16
60	291	80	120	100	60	120	34	156-158	15
61	276	81	115	101	58	121	33	159-162	14
62	263	82	111	102	57	122	33	163-166	13
63	250	83	107	103	55	123	32	167-171	12
64	238	84	103	104	53	124	31	172-176	11
65	227	85	99	105	52	125-126	30	177-182	10
66	217	86	96	106	50	127	29	183-188	9
67	207	87	93	107	49	128	28	189-192	8
68	198	88	89	108	48	129-130	27		
69	189	89	86	109	46	131-132	26		
70	181	90	83	110	45	133	25		

From: Stevens, Stuart A., and Andrew Kvaternik. In preparation. Length-weight relationships for white shrimp in Georgia waters. 7 pp.

aprons indicating immature or virgin females, and rounded aprons indicating mature females. Development of the "sponge" or egg mass is classified by color as either yellow, orange, or dark brown to indicate maturity of the eggs.

Environmental information recorded at each trawl sample station include: station location, tide stage, tidal amplitude, wind direction and speed, surface air and water temperatures (^{o}C), dissolved oxygen in mg/1, and surface water salinity in parts per thousand (ppt). Moon phase is also recorded. Although these data are routinely collected, correlative analyses between tide stage, tidal amplitude and wind direction have not been compared with CPUE rates.

CPUE values (recorded to the nearest tenth of a pound per hour of trawling) for each 15 minute trawl station are calculated by simply multiplying the total weight of the species collected in each sample by four to obtain CPUE values. Mean CPUEs for the two stations within each sector of each estuarine system are calculated by simply adding the CPUE values of the two individual stations in each sector and dividing by two. CPUE values of each individual estuarine system are calculated by simply adding the mean CPUE values for the three separate sectors (creeks, sounds, and offshore waters) and dividing by three. Cumulative coastwide mean CPUE values for individual sectors as well as individual systems are calculated by adding the six specific means or averages and dividing by six. Monthly CPUE values are compared with historical database averages to evaluate current stock status and to prepare prompt administrative fishery management recommendations. Comparisons of stock status are made between individual sectors, estuaries, and for all areas combined to evaluate the success of fishery management decisions.

Count sizes, however, are reported as weighted means at all levels of reporting -- by sectors, systems and coastwide means. Weighted mean count sizes derived from assessment sampling are used to project mean ex-vessel commercial market grade or count sizes which would be expected as a result of management actions such as season openings or extensions.

Additional spot check sampling is also conducted seasonally as needed to obtain supplemental data critical to the formulation of management decisions or to evaluate unusual environmental events such as droughts or winter kills. Spot checks are made in the same manner as the normally scheduled trawl sampling but are not necessarily made at established trawl stations. Consequently, supplemental spot check sampling is not included as part of regular reporting analyses, but rather serves as supplemental information for the preparation of immediate management decisions.

Trawl assessment monitoring, including station locations, equipment, and data gathering criteria are closely aligned with the methodology of previous trawl studies in Georgia (Music 1979; Shipman et al. 1983; Music et al. 1986; Music et al. 1988; and Music et al. 1991) which serve as the historical database from which current findings can be compared directly with long term records. Georgia's historical assessment studies date back to 1970, but sampling regimes have varied slightly between individual studies. Consequently, those particular data are not included in historical comparisons.

Review of the History and Development of the Sampling Design Used by the SEAMAP–South Atlantic Shallow Water Trawl Survey

by

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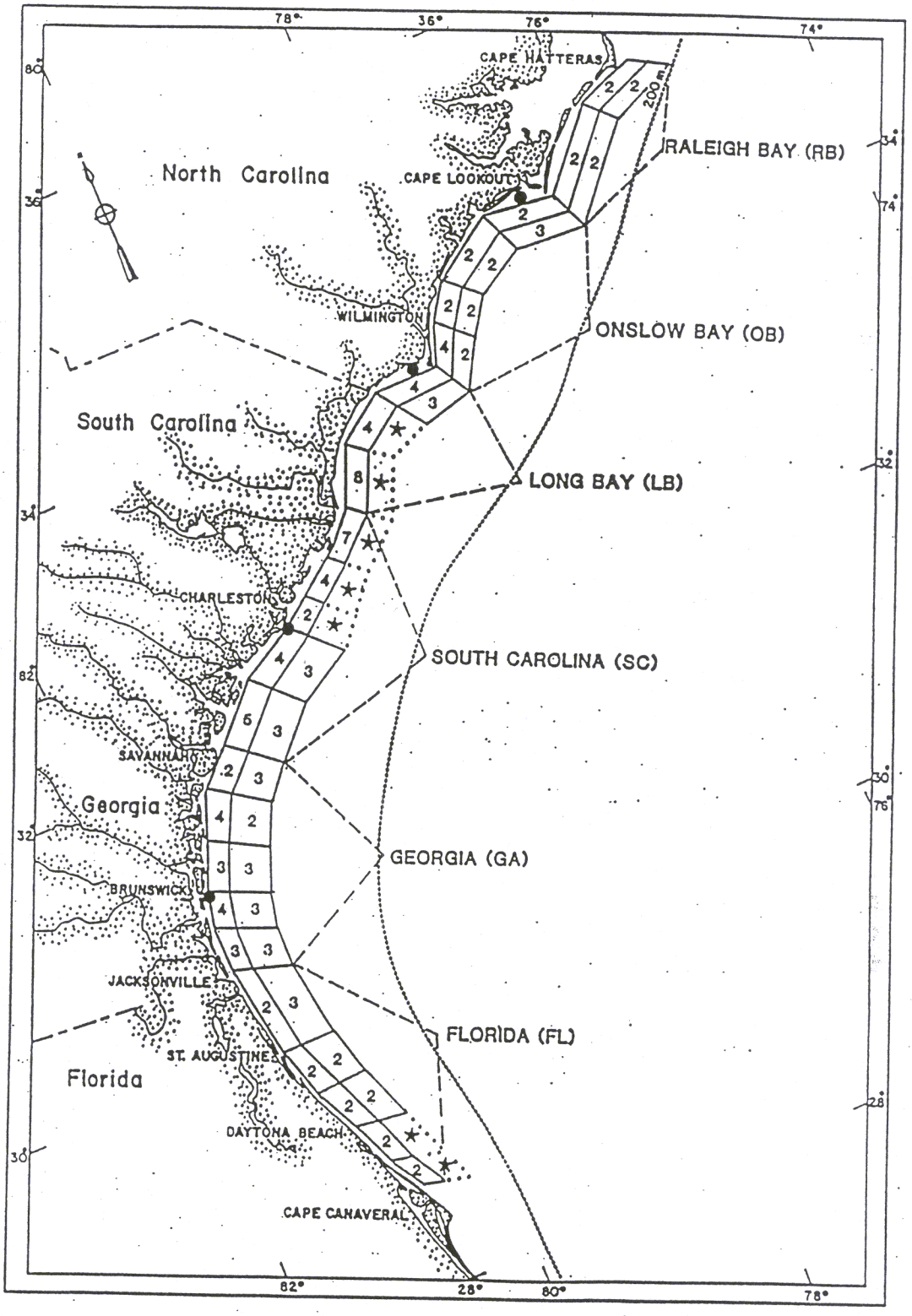
The Southeast Area Monitoring and Assessment Program (SEAMAP) was established by the National Oceanic and Atmospheric Administration-National Marine Fisheries Service (NOAA–NMFS) as a cooperative State/Federal/University program for the collection, management, and dissemination of fishery-independent data in the southeastern United States. The SEAMAP–South Atlantic program was established in 1983 and initiated the Shallow Water Trawl Survey in 1986 with the cooperation of North Carolina, South Carolina, and Georgia. The SEAMAP–Gulf of Mexico program was established in 1981 and SEAMAP–Caribbean was initiated in 1988. The three components operate separately, under the control of their own managing committees which meet annually to coordinate and plan activities and budgets. The South Carolina Department of Natural Resources Marine Resources Division (MRD) carries out field sampling for the SEAMAP–SA Shallow Water Trawl Survey in the South Atlantic Bight.

The goal of the Shallow Water Trawl Survey is to provide data on the distribution, abundance, and community composition of fishes and decapod crustaceans in the nearshore waters of North and South Carolina, Georgia, and Florida, with emphasis placed on selected species of commercial or recreational importance. The first three years of the survey were considered to be the pilot phase. The first samples were collected in November and December 1986, using a stratified random sampling design. Since the NMFS–MARMAP program had previously collected seasonal trawl data in the South Atlantic Bight, their stratified random sampling design was adopted with some minor modifications. The SEAMAP survey included all of the strata sampled by MARMAP from Cape Fear, North Carolina to Cumberland Island, Georgia in depths from 4.6 to 9.1 m (Figure 29) and six additional strata were established off North Carolina between Cape Fear and Cape Hatteras. This resulted in 19 total strata (seven off North Carolina, seven off South Carolina, and five off Georgia), which were subdivided into nautical mile squares from which five sites were randomly chosen. Areas with known obstructions were avoided. Each state sampled its own waters aboard its own research vessel. Samples consisted of 20 minute tows with 35 ft. (10.7 m) high–rise nets. In addition to a trawl tow, a Neuston tow and hydrographic and atmospheric data were also taken at each site. Trawl samples were sorted to species with each species weighed and the individuals counted and measured.

In 1987, several changes were made in the trawl survey sampling design. Sampling from three different vessels introduced considerable bias into the data. Scheduling and weather problems caused some difference in effort among the three states, and different areas and levels of taxonomic expertise among scientific crews also introduced error. Perhaps the biggest problem was that the vessels themselves were very different in configuration and in the type of gear that could be towed efficiently. Thus, the sample design was modified in 1987 so that all sampling was conducted

Figure 29. Chart of the SEAMAP sampling area.



from SCMRD's trawler, the *R/V Lady Lisa*. This vessel was chosen for the task because it was best suited for extended sea duty and was capable of pulling paired 75 ft. (22.9 m) falcon trawls. Biologists from SCMRD constituted the primary scientific crew and were assisted on board by biologists from North Carolina and Georgia.

New objectives were also included in the scope of work for years two and three of the pilot survey. These were to determine patterns or trends in community composition, abundance, and biomass with respect to latitude, location (near inlets, near beaches and further off the beaches), season, and light phase (day versus night). To accomplish these objectives, fixed stations were established approximately equidistant throughout the sampling region near Cape Lookout, North Carolina; Cape Fear, North Carolina; Charleston, South Carolina; and Brunswick, Georgia. At each station three sampling sites were defined to evaluate locational differences among areas influenced by an inlet, near the beach (~4 to 5 m deep), and off the beach (~9 to 10 m deep). On each cruise, one sample was taken at each site per station during day and again at night.

This design was utilized again in 1987 and 1988 with 24 collections made on each of five cruises from August through November in 1987 and on eight cruises from May to November in 1988. Trawls were towed for 20 minutes at each station. Commercially and recreationally important target species (Table 6) were sorted out, weighed, and measured. Nontarget species were separated into major taxa, such as decapods, stomatopods, finfish, elasmobranchs, cephalopods, and miscellaneous invertebrates. Each group was collectively weighed and a species list was compiled.

The fixed sampling design provided us with some interesting information that helped determine the final survey design. Important conclusions were that: there was a strong latitudinal gradient, with biomass greatest at the Cape Fear station; there was a seasonal component to biomass, with an increase in fall; there was no significant difference was found among sites at each station; and biomass was greatest at night.

Although a fixed station design clearly has merit, a decision was made in 1989 that the stratified random design was a better design for building a long–term database than a fixed station design. The stratified random design has considerable merit in that it allows for calculations of variance, spatial coverage is improved and estimates of the mean are unbiased. Sampling in 1989, therefore, followed the design used in 1986, with some minor modifications, among which was an extension of the sampling range to include northern Florida down to Cape Canaveral.

In spring 1989, sampling was conducted at night. However, examination of mackerel data from the 1987 to 1988 sampling regime indicated a significant difference in size and abundance between day and night collections. These data were an important consideration in the change to sampling only daylight hours in summer 1989 and thereafter.

In 1989, stations were randomly chosen from the contiguous strata used in 1986 from Cape Hatteras, North Carolina to Brunswick, Georgia and the five additional strata established between Brunswick, Georgia and Cape Canaveral, Florida (Figure 29). Depth of these strata ranged from 4.6 to 9.1 m as before. Outer or deeper strata with depths ranging from 9.1 to 18.2 m were

Table 6 . Target Species for SEAMAP Shallow Water Trawl Survey.

FINFISH

Archosargus probatocephalus
Brevoortia smithi *
Brevoortia tyrannus *
Centropristis striata *
Chaetodipterus faber
Cynoscion regalis
Leiostomus xanthurus
Menticirrhus americanus
Menticirrhus littoralis *
Menticirrhus saxatilis *
Micropogonias undulatus
Mycteroperca microlepis
Paralichthys albigutta *
Paralichthys dentatus
Paralichthys lethostigma
Peprilus paru *
Peprilus triacanthus *
Pogonias cromis
Pomatomus saltatrix
Sciaenops ocellata
Scomberomorus cavalla
Scomberomorus maculatus

DECAPOD CRUSTACEANS

Penaeus aztecus
Penaeus duorarum
Penaeus setiferus
Callinectes sapidus

* Target species added in 1990.

established adjacent to the inner or shallow strata along their entire length. We then had 24 inner and 24 outer strata with 53 stations in each depth zone. Stations were proportionally allocated to each stratum based on its surface area. Each of these stations was sampled once during each seasonal cruise.

Sampling protocol established in 1989 is still followed. Collections are taken on three seasonal cruises; spring (mid–April to early–June), summer (mid–July to mid–August) and fall (early–October to mid–November). Samples are collected by towing twin 75 ft. (22.9 m) high–rise mongoose trawls for 20 minutes behind the R/V *Lady Lisa*, a 75 ft. double–rigged St. Augustine Shrimp Trawler. Each net is processed individually, but data from the two nets are combined for summary analyses. Commercially, recreationally, or numerically important fish and decapod species selected by the SEAMAP–SA Committee (Table 6) are counted, weighed, and measured. All other fish, elasmobranchs, decapod and stomatopod crustaceans, and cephalopods are sorted to species, counted, and weighed. Biomass is noted for all other benthic and planktonic invertebrates and algae. Sex, gonadal development, mating condition, and disease symptoms are noted for *Penaeus* spp., the commercially important shrimp in the southeastern U.S. For blue crab, sex, maturity, presence of eggs, missing appendages, and disease symptoms are noted.

In years subsequent to 1989, deeper strata were sampled only in the southern portion of the South Atlantic Bight in the spring in order to collect additional white shrimp data and in the northern portion of the Bight in the fall for additional brown shrimp data. Due to the paucity of specimens in collections from outer strata, it was felt that additional collections from the inner strata should be emphasized; therefore, in 1990, 25 stations were added to the inner strata and outer stations were reduced to 27 in spring and 16 in fall. The number of stations in an inner stratum then ranged from two to eight. Sampling protocol remained unchanged.

The SEAMAP Shallow Trawl program is primarily a data collection effort with summary analyses done by project personnel. Trends in abundance and biomass have been examined seasonally and latitudinally both within a year and among years for combined species and individual species. Length–frequencies of some target finfish species (primarily the mackerels and the commercially important sciaenids) have also been examined. Seasonal and regional abundance, sex ratio, and data on ovarian and spermatophore development of penaeid shrimps have been analyzed. These data are reported each year in our annual reports. In–depth analysis of data collected by the survey is outside the scope of our present assignment, and, therefore, is the responsibility of those accessing the data for their own specific purposes.

Two finfish species in our collections that have been a particularly important priority have been the king and Spanish mackerels. Length–frequency distributions allow us to determine seasonal changes in size (Figure 30), which is useful for defining recruitment periods. Regional length–frequency distributions (Figure 31) indicate the areas in which recruitment is heaviest or size differences occur. We also compare abundance, expressed as number of individuals per tow (CPUE) or density (number of individuals per hectare), among regions and seasons (Figure 32).

Figure 30. Seasonal length-frequencies of Scomberomorus cavalla collected in inner strata during 1993.

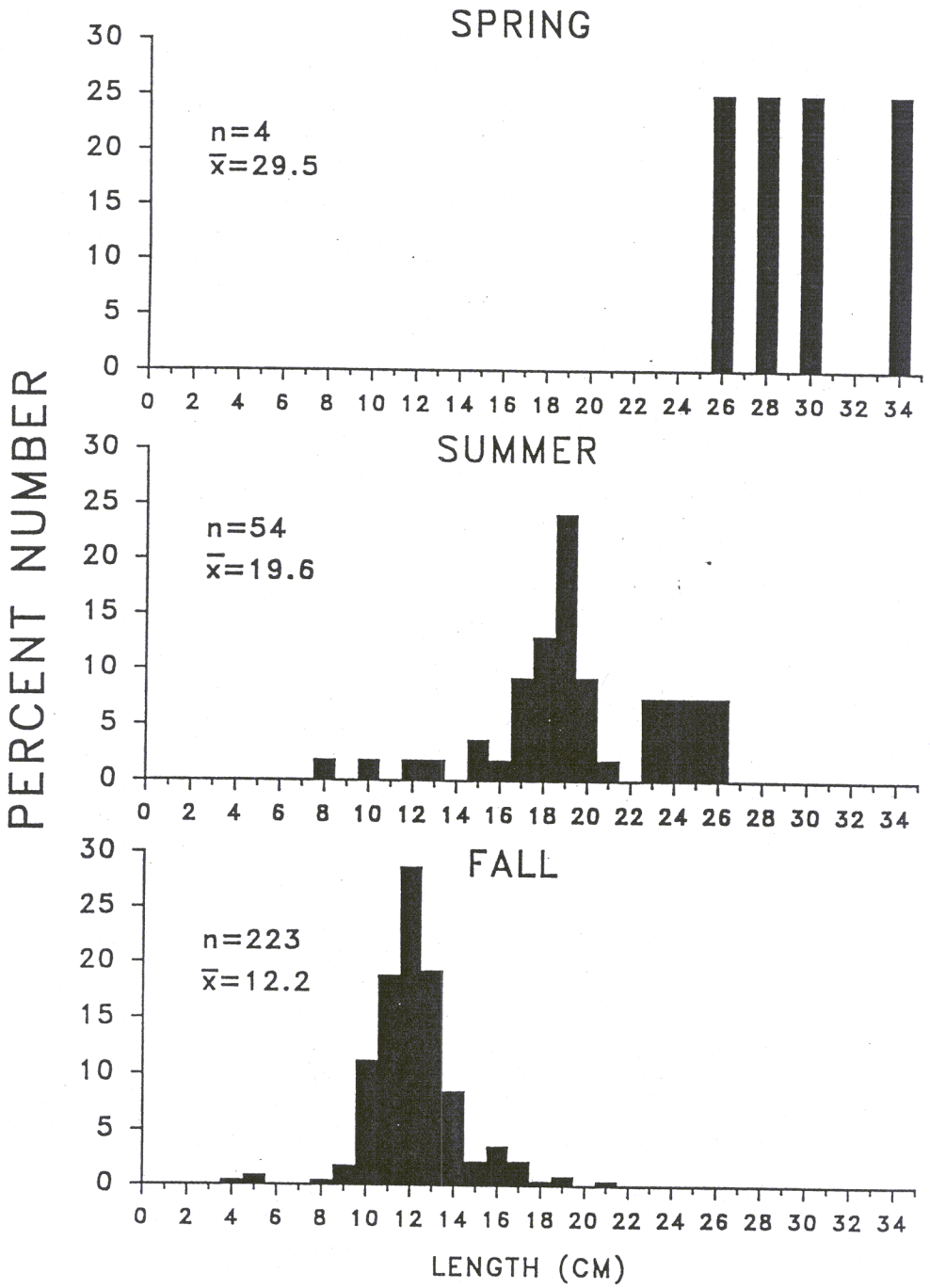


Figure 31. Regional length-frequencies of Scomberomorus maculatus collected in inner strata during 1993.

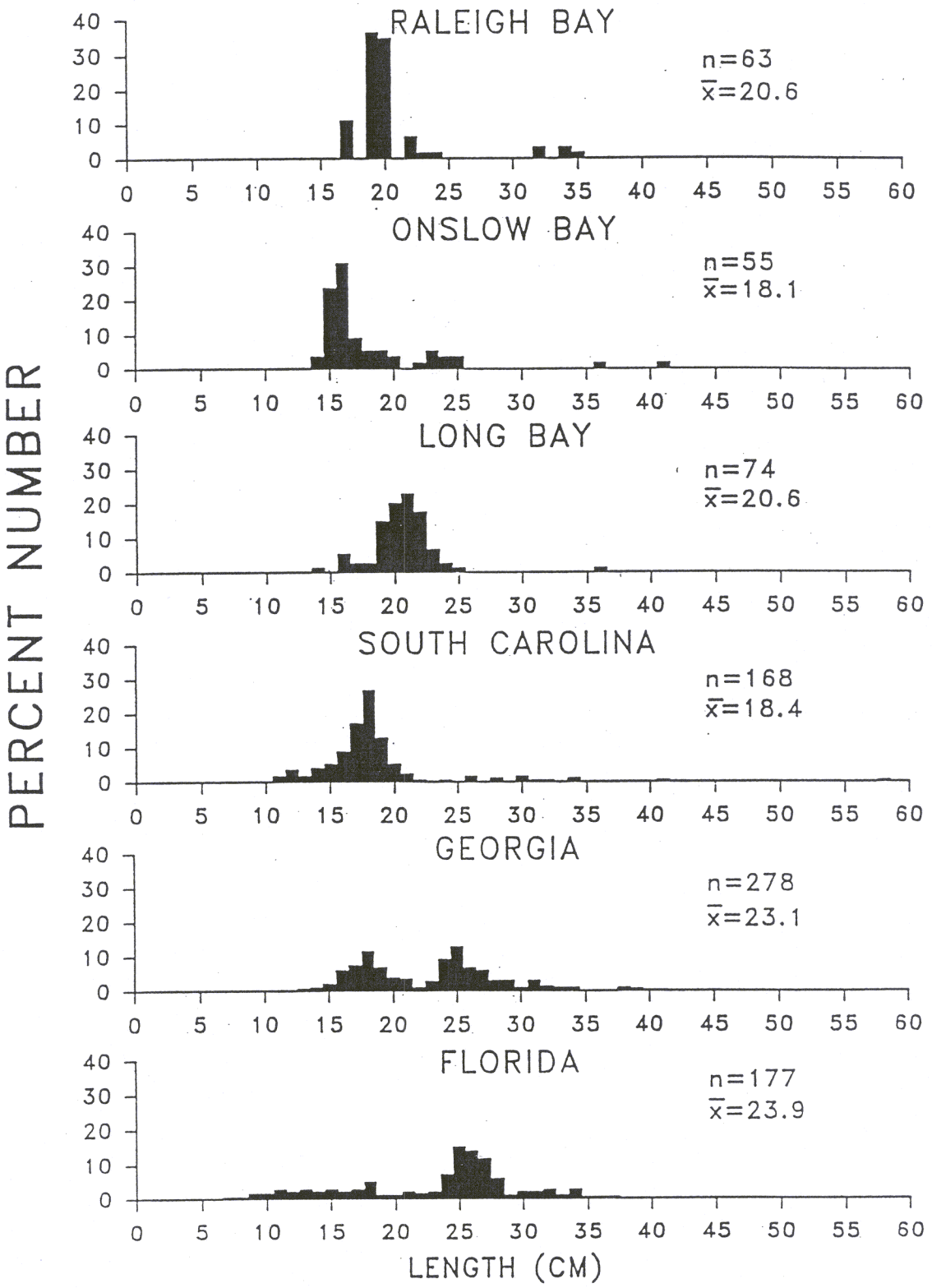
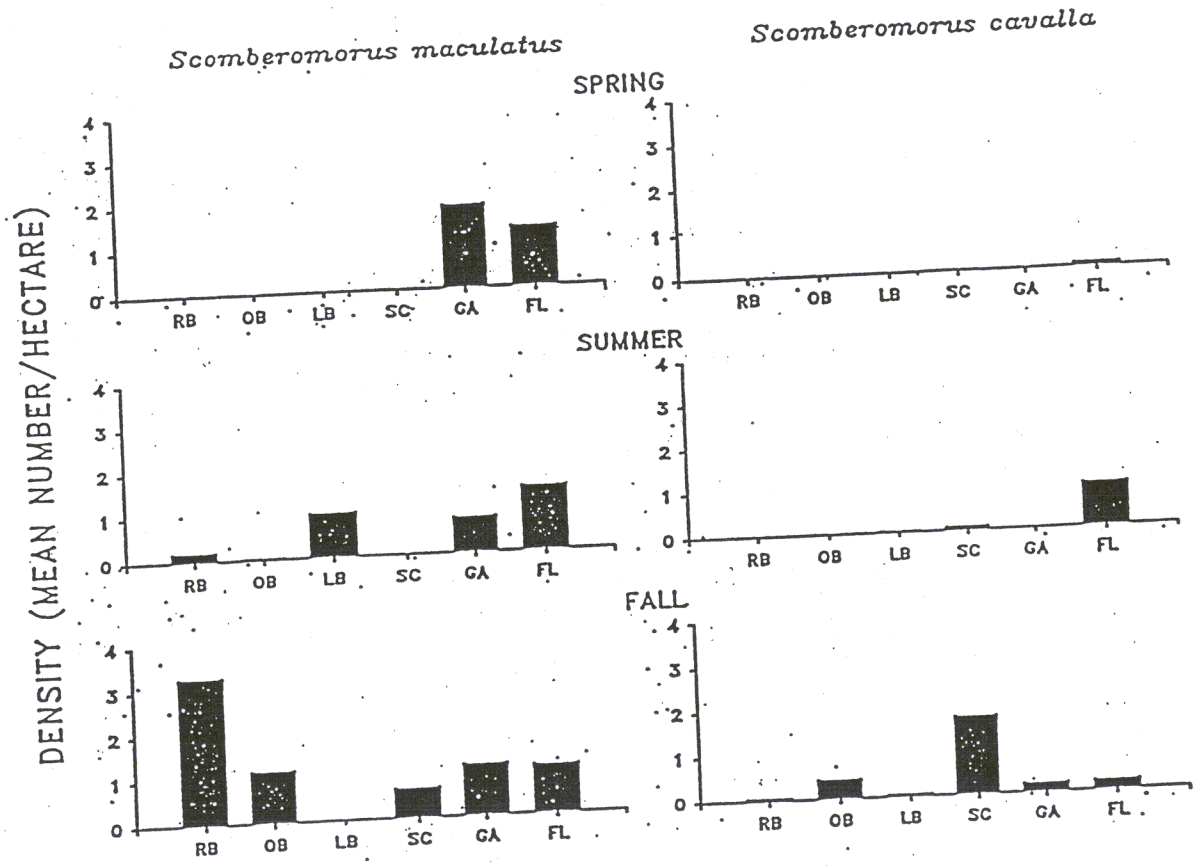


Figure 32. Regional and seasonal densities of mackerel taken in inner strata in 1993.



Abundance plots of commercially important shrimps indicate seasons (Figure 33), regions, and depths (Figure 34) of greatest density. Additional data collected on penaeid species allow us to determine seasonal patterns of reproductive condition. Data on reproductive stage (Figure 35) was originally collected in order to locate spawning aggregations.

Many cooperative projects have been conducted by the MRD/SEAMAP staff and by other investigators, primarily graduate students. Data are supplied to various universities, management councils, NMFS, and other state natural resource agencies. Because we view our mission as not only one of data collection but as providing a ship of opportunity, we comply with requests for collection of specimens and to take volunteer field personnel on sampling trips, when possible. Many specimens have been preserved and brought back to assist scientists and graduate students on research projects or thesis projects.

We also have opportunities to collect additional data on species of interest to management groups. Currently, eight species of finfish, three species of penaeid shrimp, and blood and tissue samples from coastal sharks are preserved and brought back to graduate students, MRD staff, and the NOAA Southeast Fisheries Center. One of the SEAMAP staff is also collecting life history information on some of the coastal shark species.

SEAMAP staff provide summary reports for distribution and, when the opportunity arises, present data in oral presentations and published reports. We do not do detailed analyses but rely upon transfer of data to the NMFS database and use of those data by others for management plans, for stock assessment, and many other purposes.

All of the data collected by field efforts of the SEAMAP–SA Shallow Water Trawl Survey is proofed, edited, and sent to the NMFS–SEAMAP Data Manager. It is then sent to the NMFS computer in Miami and is currently available to any manager or researcher who requests it. This database was created and the method for dissemination established so that requesters can gain access to the raw data via the NMFS computer; however, there are other avenues of dissemination via reports, as already mentioned. Requested data are provided directly to members of cooperating states or to the Atlantic States Marine Fisheries Commission.

A long–term database on coastal species in the South Atlantic Bight can be useful to researchers and fishery managers throughout the area. The SEAMAP program encourages use of these data and would be glad to assist with any coastal projects which would benefit from the sampling regime.

For a list of SEAMAP-SA contacts and related publications see Appendices B & C.

Figure 33. Regional and seasonal densities of Penaeus setiferus taken from inner in 1993.

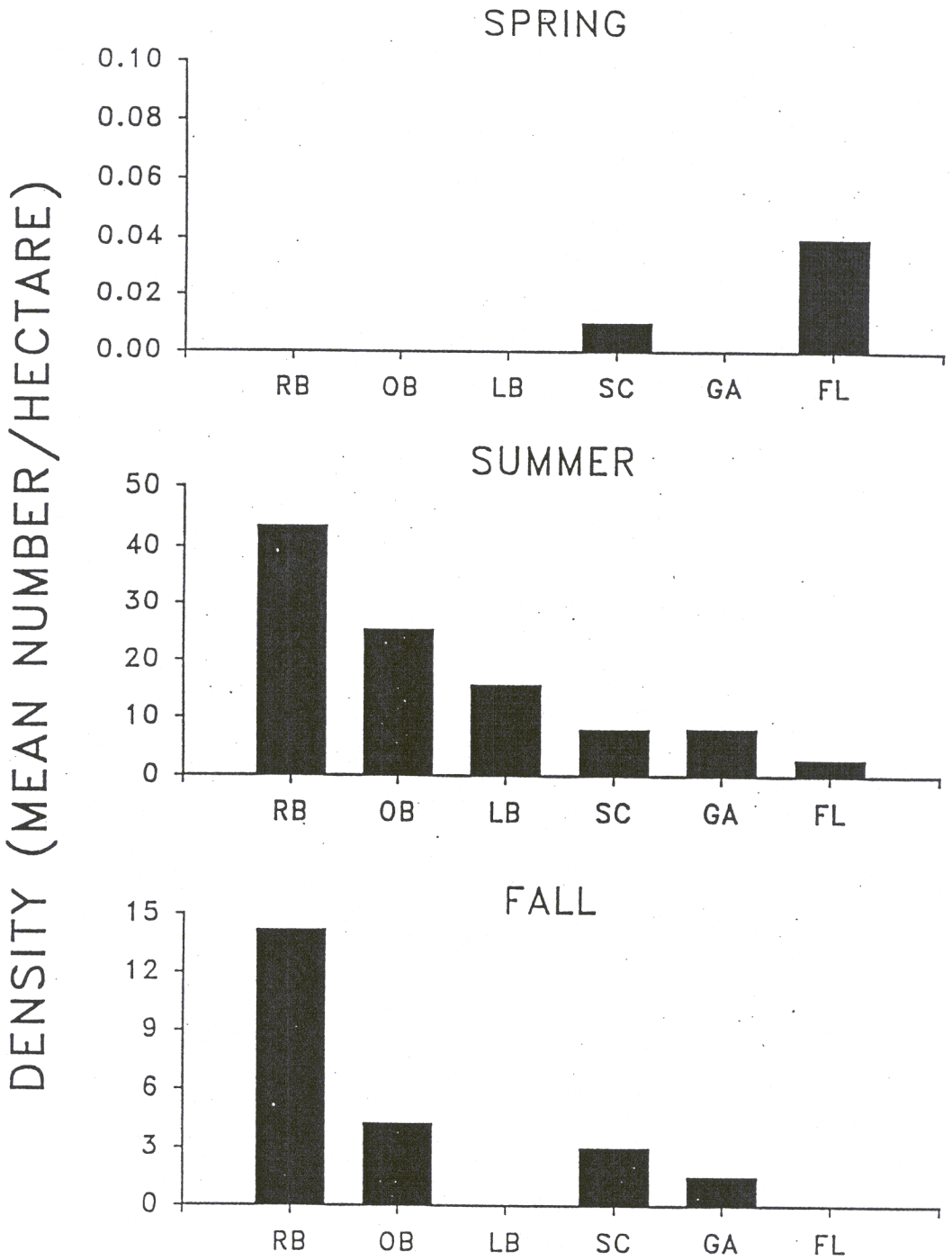


Figure 34. Abundance of Penaeus setiferus among depth zones during Spring 1994.

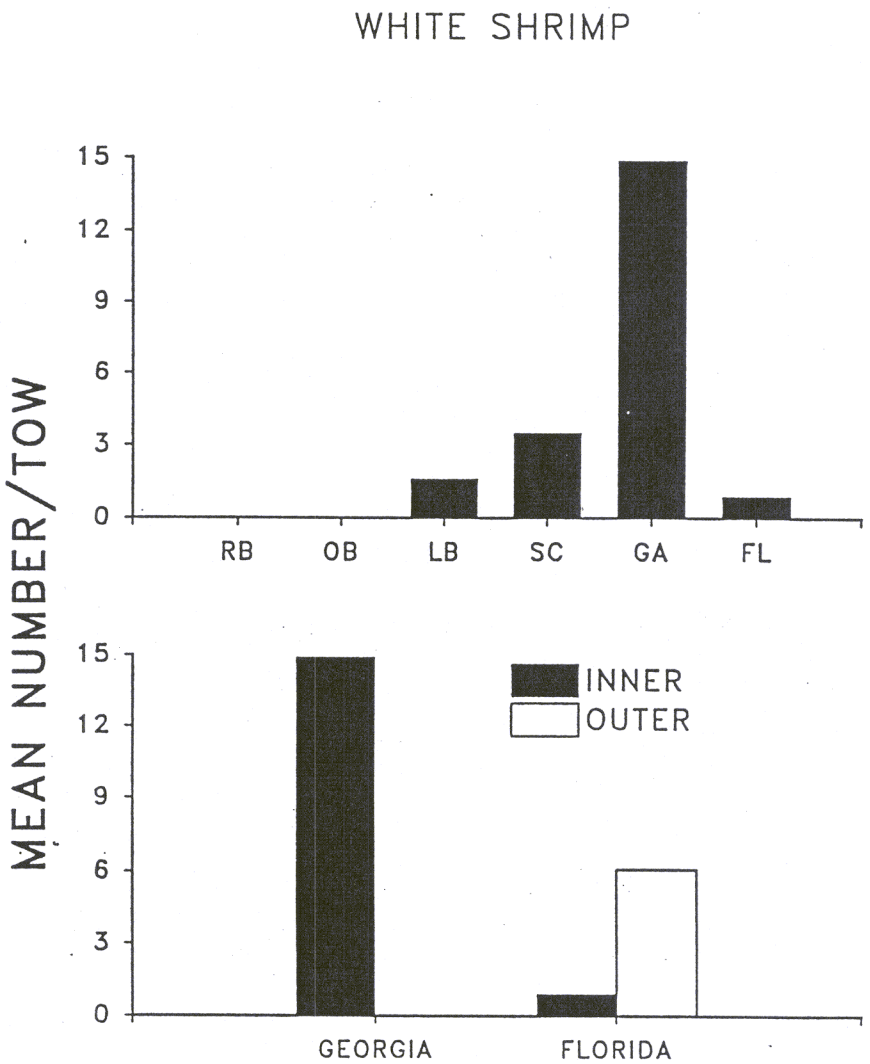
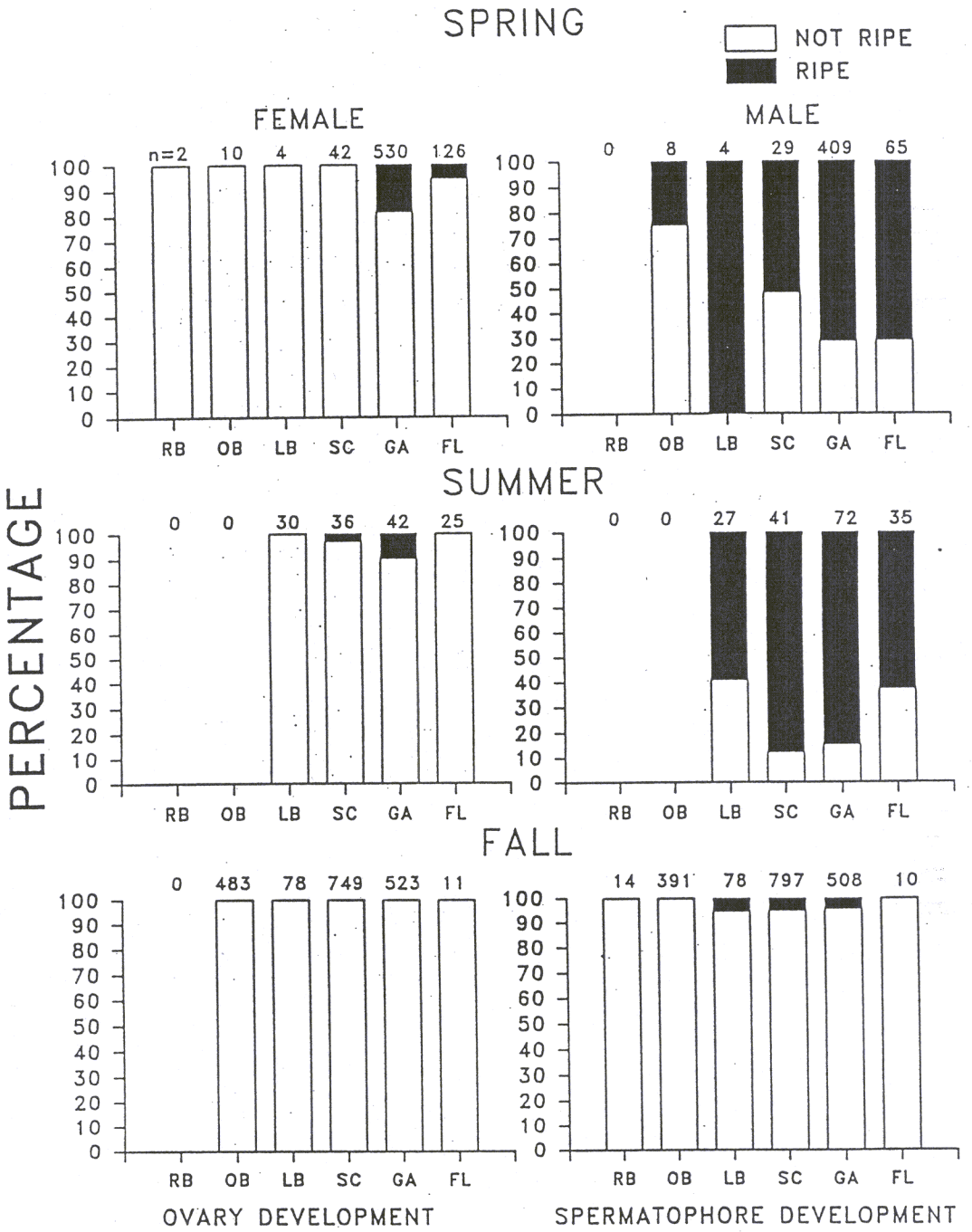


Figure 35. Gonadal development of white shrimp in 1993.



North Carolina's Current Trawl Surveys

by
Katy H. West and Chris J. Wilson
North Carolina Division of Marine Fisheries

Juvenile Striped Bass Survey (1955 - ongoing)

In 1955, Dr. W. W. Hassler of North Carolina State University initiated a trawl survey to determine the relative success of young-of-the-year (y-o-y) striped bass recruiting to the forming year class in Western Albemarle Sound. In 1982, North Carolina Division of Marine Fisheries (NCDMF) initiated its own survey by using the same methods and stations used by Dr. Hassler. The two surveys ran concurrently from 1982 to 1987. After 1987, NCDMF was the sole conductor of the survey.

From July through October trawl samples are taken every two weeks at seven fixed stations (Figure 36). A semiballoon trawl with a 18-ft head rope, 0.75-in. stretched mesh body and 0.50-in. stretched mesh codend is pulled for 15 minutes at a towing speed of approximately 80 yards per minute by small (18 to 20 ft.) work vessels. The trawling depth varies between 6 to 10 ft. The codend was changed from 0.25 in. to 0.50 in. in 1984. All striped bass are measured to the nearest millimeter (mm) fork length. Other species captured are identified and counted. Wind direction and velocity, depth, air and water temperatures are recorded for each sample.

The annual striped bass juvenile abundance indices are given in Table 7. These indices have been used for coastwide stock assessments and determining optimum water flow for the Roanoke River during the spawning season.

Brown Shrimp Survey (1973 - ongoing)

The goals of the spring brown shrimp survey are to gather information on shrimp populations for forecasting and assessment purposes and to collect data needed to provide management recommendations. Approximately 110 fixed stations are sampled during late May through early June to collect juvenile brown shrimp and environmental data. The fixed trawl stations are located in the shallow (2-10 ft.) upper reaches of dead-end creeks or bays with highly organic, coarse silt bottoms. Daylight samples are collected with a 10.5-ft. headrope, 0.25-in. bar mesh body, and 0.125-in. bar codend otter trawl during one minute tows. All shrimp are counted and a sample of 30-60 shrimp are measured. Surface and bottom temperature and salinity are taken with each sample. During 1973-1977, tow times and gear varied. The above procedures were adopted in 1978.

Survey data is compiled by bay system and distributed to area fishermen (Table 8). Survey indices have been correlated to early spring environmental conditions as well as being a fair predictor of the subsequent commercial harvest. Shrimp size data is also used to determine openings/closings of specific areas to harvest.

Figure 36. North Carolina juvenile striped bass survey stations.

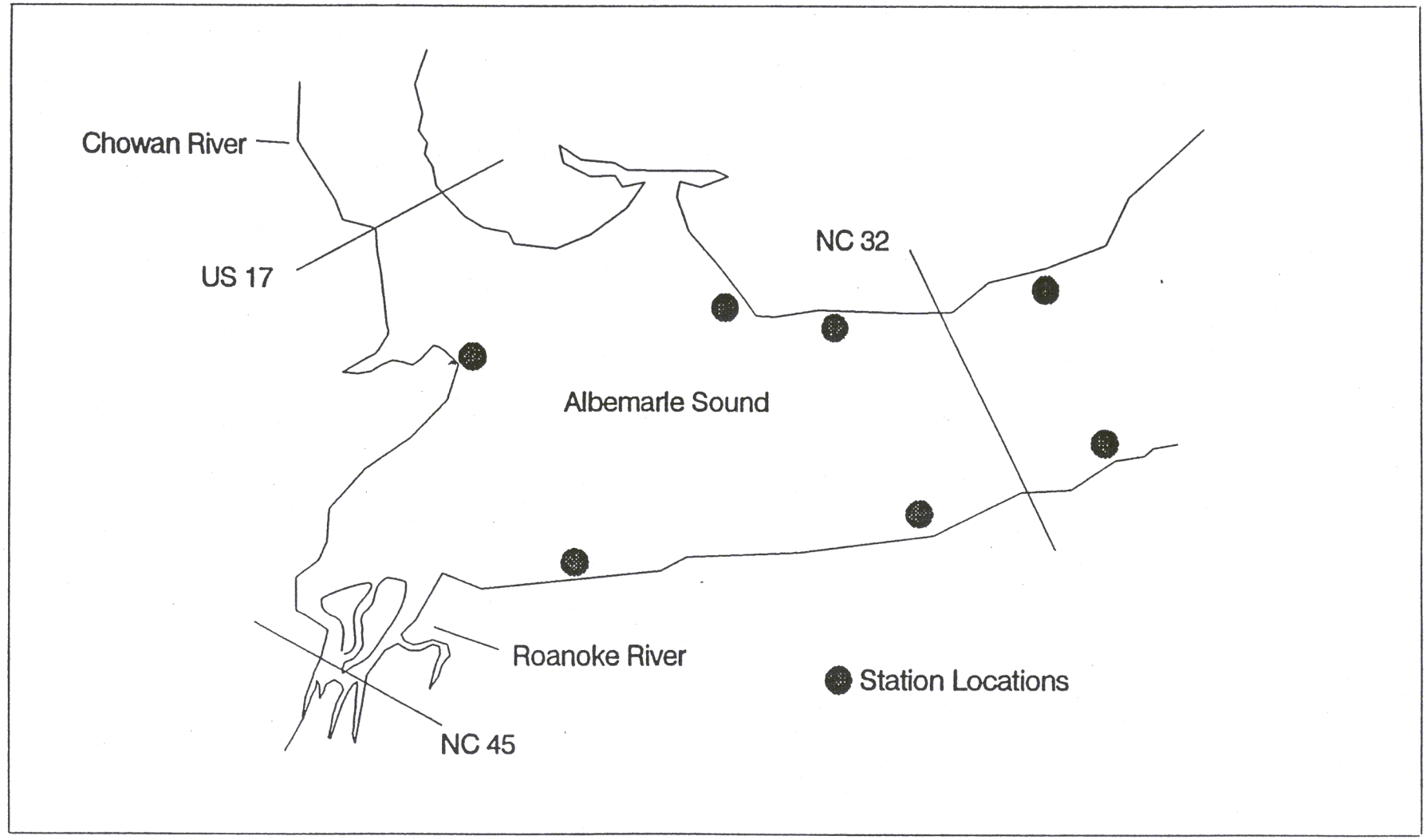


Table 7. North Carolina juvenile striped bass trawl survey index, Western Albemarle Sound, CPUE - catch per tow.

Year	CPUE	Year	CPUE	Year	CPUE
1955	3.3	1968	6.6	1981	0.1
1956	19.1	1969	3.0	1982	3.8
1957	5.7	1970	12.5	1983	0.8
1958	0.2	1971	2.9	1984	0.4
1959	23.9	1972	2.5	1985	1.2
1960	5.9	1973	2.0	1986	0.1
1961	10.3	1974	5.5	1987	0.1
1962	7.9	1975	10.8	1988	4.1
1963	4.8	1976	10.5	1989	4.3
1964	3.1	1977	3.6	1990	1.4
1965	10.1	1978	0.6	1991	0.9
1966	3.5	1979	0.6	1992	2.6
1967	23.4	1980	0.5	1993	44.5

Table 8. North Carolina brown shrimp survey best catch per minute, salinity and commercial landing, 1983-1994.

	Best Sample Number Per Minute											
	83	84	85	86	87	88	89	90	91	92	93	94
Hyde County												
Abel Bay	35	41	202	123	46	101	252	153	80	88	17	50
Spencer Bay	18	77	287	186	101	269	521	159	147	213	25	106
Rose Bay	6	75	451	272	25	453	90	94	50	43	17	5
Swan Quarter	17	87	251	277	29	165	239	131	40	28	25	48
Oyster Creek	55	87	891	198	20	53	153	236	230	205	3	45
Juniper Bay	122	217	241	221	149	638	513	234	112	201	65	142
Wysocking Bay	102	143	534	349	124	412	461	276	373	673	39	254
Douglas Bay	12	84	408	179	35	145	350	273	211	77	17	152
Far Creek	174	87	420	168	72	156	366	362	295	292	74	203
Long Shoal	221	119	506	135	27	184	139	227	143	189	9	164
Stumpy Point	6	2	250	50	-	-	16	8	20	0	0	14
North Creek	1	0	167	45	19	7	5	12	6	43	-	5
Satterwaite Creek	1	-	71	19	2	24	38	7	44	20	-	1
Fortescue Creek	5	3	98	84	8	65	73	26	35	62	-	15
Average	76	102	419	210	63	258	309	215	168	201	29	117
Pamlico County												
Goose Creek	30	3	45	70	6	5	4	20	35	14	1	2
Oyster Creek	70	60	300	45	6	0	23	109	197	69	1	7
Mouse Harbor	130	65	290	155	17	254	165	318	178	108	5	98
Porpoise Bay	365	15	295	285	13	91	261	269	119	144	3	68
Middle Bay	300	5	450	90	54	266	305	408	52	86	5	24
Jones Bay	15	15	505	125	101	169	298	145	164	49	8	23
Gales Creek	105	10	50	25	11	70	55	95	17	16	0	23
Bay River	5	0	140	80	1	21	30	58	49	24	3	35
Ball Creek	20	5	100	30	0	3	10	43	61	6	0	7
Bonner Bay	10	5	80	40	2	10	18	68	215	26	11	55
Swan Creek	55	25	360	135	16	26	113	223	-	87	19	92
Broad Creek	35	10	260	215	21	103	30	218	80	55	9	23
Greens Creek	0	5	265	175	3	71	17	28	26	29	4	18
Average	88	17	242	113	19	84	102	156	101	55	5	37
Craven County												
Clubfoot Creek	35	75	350	520	27	325	33	68	333	192	360	257
Issac Creek	25	85	110	15	3	161	26	29	32	15	97	49
Godfrey Creek	5	65	195	45	6	4	30	-	49	21	37	14
Jonequin Creek	25	85	110	15	2	30	27	0	58	106	44	10
Horton Bay	70	15	280	35	4	63	43	3	45	6	-	19
Parsons Creek	40	40	475	25	58	20	13	74	12	1	-	5
Indian Canal	90	235	270	255	12	97	2	42	19	1	52	21
Golden Creek	90	185	60	20	6	56	54	96	34	35	20	12
Henrys Creek	70	105	125	45	13	71	4	64	3	3	3	2
Codduggen Creek	30	535	465	30	75	96	455	166	4	40	17	1
Average	48	143	244	101	21	94	69	60	60	42	63	39
Core Sound												
Cedar Is. Bay	30	210	200	200	67	94	166	-	364	97	71	49
E. Thorofare Bay	180	365	270	375	320	87	136	1094	155	211	847	0
Jarretts Bay	425	190	40	210	44	191	95	177	67	88	136	57
Oyster Creek	72	345	325	170	108	421	137	31	363	107	172	77
Nelson Bay	200	300	160	140	22	157	155	8	65	147	-	1
North River	-	25	115	485	66	170	109	33	335	158	126	86
Newport River	-	40	75	35	57	51	467	150	273	176	330	159
Average	182	211	169	231	101	167	181	248	232	141	240	61

Table 8. continued North Carolina brown shrimp survey best catch per minute, salinity and commercial landing, 1983-1994.

	Best Sample Number Per Minute											
	83	84	85	86	87	88	89	90	91	92	93	94
Average Salinity (ppt)												
Hyde County	9	9	19	21	13	16	13	11	16	21	10	16
Pamlico County	8	9	14	18	11	16	12	11	15	16	9	15
Craven County	18	10	14	21	10	14	13	12	12	11	7	14
Core Sound Area	23	30	25	33	23	23	27	27	22	16	21	26
Brown Shrimp Landings (Headsoff, million lb)												
Pamlico Sound Area	.07	0.3	4.8	1.5	0.3	1.9	1.9	2.1	2.8	0.9	0.8	
Neuse River	.1	.1	.4	.1	.01	.06	.02	.02	.05	.04	.09	
Core Sound	0.2	0.3	0.4	0.3	0.1	.38	.32	.19	.38	.34	.56	

Estuarine Trawl Survey (1978-ongoing)

In 1971, NCDMF initiated a statewide estuarine trawl survey. The initial primary objectives of the survey were to identify primary nursery areas and produce annual recruitment indices for economically important species such as spot, Atlantic croaker, weakfish, flounders, blue crab, and brown shrimp. Other objectives included monitoring species distribution by season and bay area and providing data for evaluation of environmental impact projects. Various gears and methodology have been used in the survey since 1971. In 1978 and 1989, major changes and standardization in sampling occurred. In 1978, tow times were set at one minute during daylight hours. In 1989, an analysis was conducted to determine a more efficient sampling timeframe to produce juvenile abundance indices with acceptable precision levels for the target species. A set of 105 core stations were identified, sampling would be conducted in primary nursery areas in May and June only, except for July sampling for weakfish, and only the 10.5-ft. headrope trawl would be used. The development of juvenile indices for target species was stated to be the primary objective, realizing other objectives have been or could be met with historical data.

The current survey is conducted in primary nursery areas throughout the state (Figure 37) with a two-seam otter trawl that has a 10.5-ft. headrope, .25-in. bar mesh wings and body, a 0.125-in. bar mesh codend, 6-ft. bridle, and 18 by 30 in. doors. The net is towed for one minute by small (18 to 26 ft.) outboard boats at approximately 75 yards per minute. Boats towing speeds are calibrated prior to each sampling season. For sample workup, the economically important species are counted and a subsample of 30-60 individuals of each age group are measured (nearest mm). The remaining species are identified and counted. The bottom type, depth, and bottom and surface temperature and salinity are recorded at each station. The presence of submerged aquatic vegetation is also noted.

Juvenile abundance indices with proportional standard errors (PSE) generally less than 20 are computed and published annually for southern flounder, spot, Atlantic croaker, blue crab, brown shrimp, and weakfish (higher PSE) (Table 9). The finfish indices have been provided to the Atlantic States Marine Fisheries Commission's stock assessment work groups. The survey data has been used to characterize nursery area habitat and help designate new nursery areas. Classification analyses according to species composition and abiotic variables produced distinct station groupings. Salinity was the key abiotic factor. NCDMF biologists routinely use survey data in their habitat alteration comments to document level of utilization of an area by fish and crustaceans.

Pamlico Sound Survey (1987 - ongoing)

In 1987, based on the SEAMAP Shallow Water Trawl Survey design, the NCDMF established a random stratified survey of Albemarle and Pamlico Sounds (Figure 38). The survey was initially designed to provide a long term fishery-independent database for the waters of the Pamlico

Figure 37. North Carolina estuarine survey 10.5 ft. headrope trawl stations.

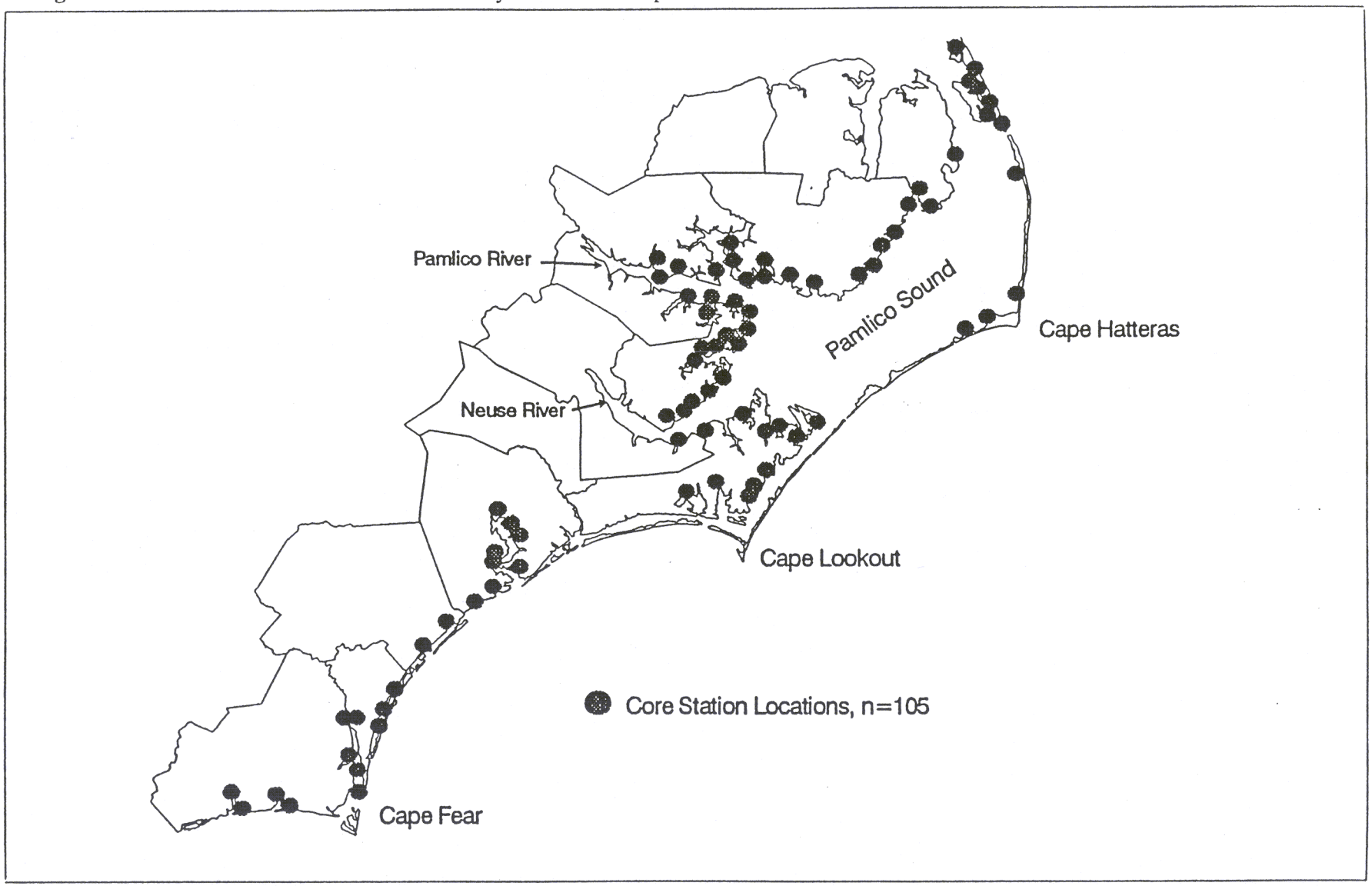


Table 9. North Carolina estuarine trawl survey juvenile abundance indices for spot, southern flounder, croaker, blue crab, weakfish and brown shrimp, 1979-1994.

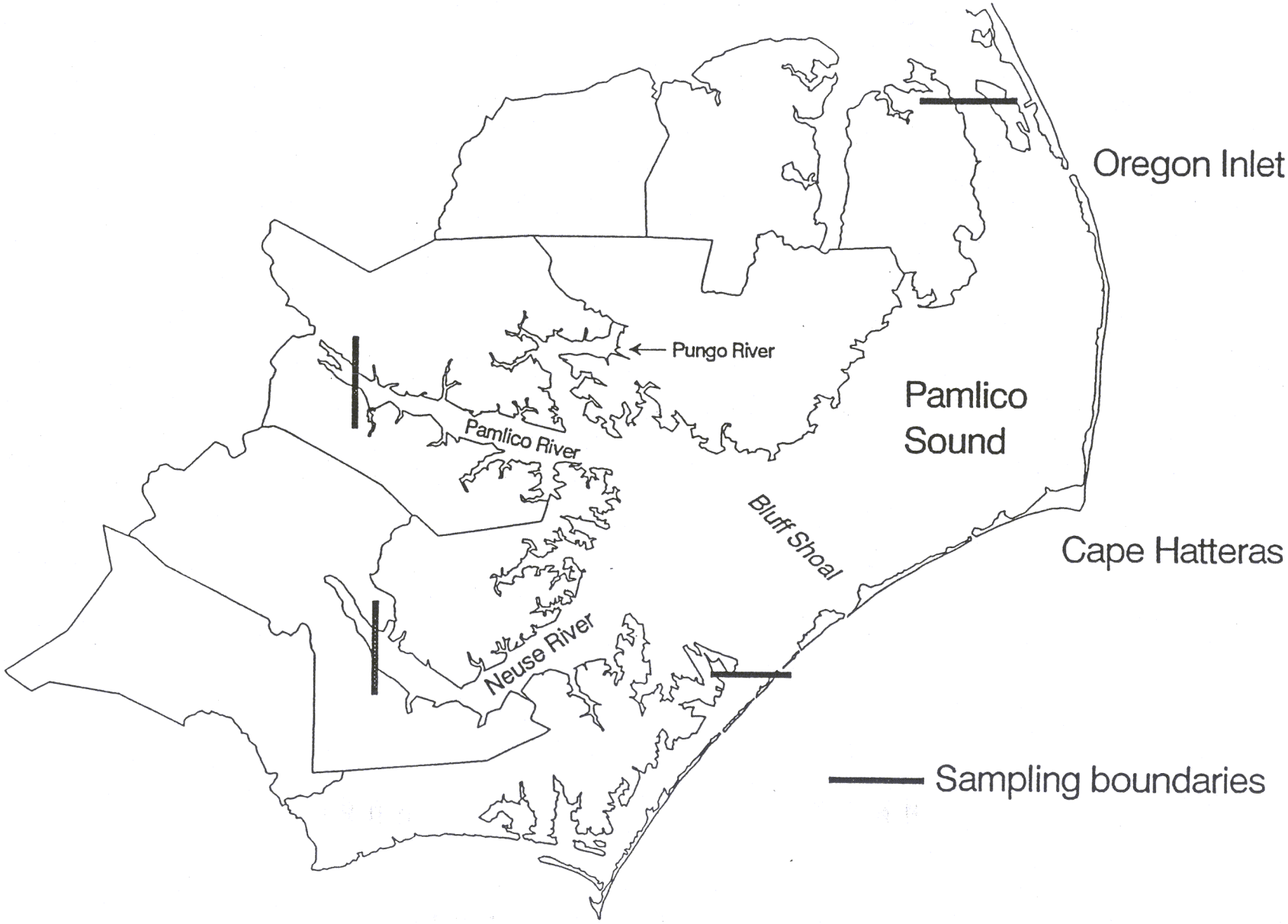
	Spot (*Leiostomus xanthurus*)					Southern Flounder (*Paralichthys lethostigma*)				
Year	N	Arith. mean	PSE	Geo mean	PSE	N	Arith. mean	PSE	Geo mean	PSE
79	136	212.49	8	117.90	2	136	1.51	15	0.78	11
80	145	93.20	12	48.62	3	145	2.23	15	1.10	10
81	144	211.96	8	117.17	2	144	1.78	13	0.95	10
82	154	230.82	8	111.77	3	154	3.58	13	1.84	7
83	182	119.00	9	45.26	3	182	1.59	15	0.75	10
84	187	171.57	9	85.02	2	187	2.60	18	1.03	13
85	193	149.02	8	68.43	3	193	0.91	16	0.45	12
86	202	129.81	8	59.60	3	202	3.58	13	1.47	8
87	204	254.87	10	109.85	2	204	2.08	13	0.93	9
88	207	228.70	8	114.63	2	207	2.73	14	1.09	9
89	204	164.95	9	65.92	3	204	2.49	15	1.08	9
90	204	179.39	9	89.48	2	204	5.07	12	2.16	7
91	205	81.55	10	28.06	4	205	1.09	15	0.52	12
92	210	142.02	8	59.96	3	210	2.34	12	1.03	9
93	197	350.82	8	163.86	2	197	2.93	13	1.23	9

	Croaker (*Micropogonias undulatus*)					Blue Crab (*Callinectes sapidus*)				
Year	N	Arith. mean	PSE	Geo mean	PSE	N	Arith. mean	PSE	Geo mean	PSE
79	136	47.90	11	22.94	4	136	3.79	11	2.13	7
80	145	63.41	8	36.78	3	145	4.30	12	2.53	6
81	144	16.69	10	6.99	6	144	8.93	13	4.56	5
82	154	49.37	11	21.58	4	154	7.42	10	3.85	5
83	182	93.23	10	40.66	3	182	7.29	12	3.50	5
84	187	60.49	11	23.08	4	187	8.71	11	4.61	5
85	193	28.22	14	8.81	5	193	8.92	8	5.13	4
86	202	22.12	19	6.60	5	202	5.38	13	2.69	5
87	204	52.68	28	9.01	5	204	9.41	22	3.92	5
88	207	25.54	15	6.53	6	207	10.31	13	3.98	5
89	204	24.92	22	5.32	6	204	4.54	14	2.04	6
90	204	19.27	12	6.67	5	204	7.60	11	3.54	5
91	205	8.75	16	3.04	6	205	5.31	11	2.56	6
92	210	20.55	13	6.06	6	210	4.28	12	1.96	7
93	197	56.84	17	14.68	5	196	7.78	17	2.58	7

Table 9. continued

	Weakfish (*Cynoscion regalis*)					Brown Shrimp (*Penaeus aztecus*)				
Year	N	Arith. mean	PSE	Geo mean	PSE	N	Arith. mean	PSE	Geo mean	PSE
79	102	0.47	32	0.21	26	136	27.39	16	6.96	7
80	108	0.64	30	0.25	25	145	47.52	16	9.04	7
81	108	2.69	23	0.84	16	144	20.81	20	3.91	9
82	109	1.72	32	0.47	20	154	28.14	16	5.43	8
83	108	1.20	38	0.37	21	182	14.93	33	2.06	11
84	108	1.04	48	0.24	29	187	22.55	20	3.28	9
85	104	1.50	34	0.45	21	193	79.05	11	24.66	4
86	104	3.52	33	0.77	18	202	39.87	18	7.79	6
87	106	0.89	33	0.31	23	204	12.50	22	1.74	10
88	107	0.91	34	0.26	28	207	21.42	15	3.76	8
89	108	0.92	25	0.38	20	204	29.55	19	4.42	8
90	106	0.54	38	0.19	29	204	44.54	15	9.16	6
91	102	0.58	31	0.24	25	203	49.13	11	12.52	5
92	107	0.56	54	0.24	36	208	26.81	19	3.60	8
93	105	0.18	62	0.06	51	197	22.85	19	2.27	11

Figure 38. Pamlico Sound trawl survey sample frame.



Sound, Eastern Albemarle Sound and the lower Neuse and Pamlico Rivers. Specific survey objectives are:

1. to determine and monitor the distribution, relative abundance and size composition of fish, shrimp, and crabs in the survey area and how they vary temporally and spatially;

2. to ascertain fishery-independent estimates of mortality and population size to compare to commercial fishery samples and landings data;

3. to determine which species utilize (and to what extent) the sound during their early life development and identify nursery areas for those species (e.g. *Cynoscion* spp., *Paralichthys dentatus*, etc.);

4. to determine if catch rates of various species are correlated with indices of juvenile abundance derived from the juvenile trawl survey;

5. to determine if species distributions are correlated with each other [or with some other measured parameter(s)]; and

6. to monitor the movement of organisms out of the nursery area into the open waters of Pamlico Sound where they are available for commercial exploitation.

Modifications were made to the original survey design in the spring of 1990 and included the following. The Albemarle Sound shallow and deep strata were eliminated. The decision to omit the Albemarle Sound was based on: (1) the eastern Albemarle strata end of Albemarle Sound was not indicative of the entire Albemarle Sound; and (2) manpower restrictions precluded the addition of a third week which would be needed to sample all of Albemarle Sound. An analysis was performed to investigate the effect of deleting the Albemarle Sound strata on target species abundance estimates. The analysis revealed that there was no significant difference in trends and PSE for target species even with the elimination of the Albemarle Sound strata. A Pungo River stratum was added and the sampling area of the Pamlico and Neuse River strata was increased. The decision to add the Pungo River and expand the Pamlico and Neuse Rivers was based upon recent declines in the river fisheries as well as disease problems. This expansion allowed for a total coverage of the Pamlico estuary in water greater than six ft. The March and December sampling was also eliminated due to manpower restrictions. The previous three full years of data would be sufficient to evaluate seasonal changes in distribution.

Currently, sampling occurs the first to third weeks in June and September utilizing the *R/V Carolina Coast*, a 44-ft. double-rigged trawler. Two 30-ft. mongoose trawls with 24 by 28 in. doors, 0.875-in. bar mesh body, and .75-in. bar mesh codends are towed for 20 minutes (2.5 knots) at 50 to 53 randomly selected one minute grids. Grids are selected from seven strata based on depth and geographic location. The seven strata are Neuse River, Pungo River, Pamlico River, Pamlico Sound West [shallow (<12 ft.) and deep (>12 ft.)], and Pamlico Sound East (shallow and deep). Each strata has no less than three stations. Stations are optimally allocated among the strata based upon all the previous sampling in the same time frame in order to provide the most accurate

abundance estimates (PSE <20) for the target species. Due to their economical importance, the target species are: weakfish, spot, Atlantic croaker, southern flounder, summer flounder, bluefish, southern kingfish, blue crab, and penaeid shrimp.

The contents of each net are combined and processed as follows. All finfish, elasmobranchs and crustaceans are sorted to species, counted and weighed (kg). Target species are measured (30-60 individuals) to the nearest millimeter. Remaining invertebrates and algae are weighed and the contents of each group recorded. Extremely large samples are subsampled by separating out everything except Atlantic croaker and spot. The remaining sample (everything but Atlantic croaker and spot) is processed as previously described. Half of the Atlantic croaker and spot are counted, weighed and measured (30-60 individuals). The remaining Atlantic croaker and spot are weighed. Environmental data taken include surface and bottom temperature and salinity, wind speed, and wind direction.

Annual arithmetic or geometric mean number of individuals per tow are compiled for an index of juvenile abundance (Table 10). Quarterly length frequency distributions were examined to determine the size range for y-o-y of each species. The y-o-y size ranges for each species were as follows: Atlantic croaker (TL) <120 mm in June and <200 mm in September; weakfish (FL) <140 mm in June and <200 mm September; spot (FL) <110 mm in June and <130 mm in September; summer flounder <130 mm in June and <230 mm in September; and southern flounder <160 mm in June and <230 mm in September. The Pungo River stratum was excluded from the yearly comparisons because it was not sampled throughout the entire span of the survey.

Summer flounder indices for June and weakfish indices for September have been used to tune the coastwide virtual population analyses for these species. An evaluation of the survey database is planned in the coming year to determine if the survey objectives are being met. In addition, since the NCDMF survey is a component of the overall Southeast Area Monitoring and Assessment Program (SEAMAP), the evaluation will utilize data from the South Carolina SEAMAP coastal trawl survey.

Database Management System

Fishery-independent (estuarine trawl samples, etc.) and dependent (catches subsampled from long haul, winter trawl, pound net, etc.) data are collected by NCDMF on a seasonal/monthly basis. Data from these very diverse collections are coded on a set of standardized forms and maintained in a masterfile database stored on an IBM mainframe computer.

Data elements regularly recorded include the following: program identification, date, location, gear, water temperature, salinity, collection weight, species identification, and length of individual. Specific programs may also record additional data elements such as station number, tow duration, sediment type, depth, air temperature, dissolved oxygen, pH, weather, current speed, additional data on individuals collected (weight, age, tag number, annulus measurements), etc. The specific coding procedures/protocols for each program are listed in reference materials which are called "program documentation." The biologists working on a project/program are responsible for updating and providing the program documentation. The documentation is updated at least

Table 10. North Carolina Pamlico Sound survey juvenile indices for summer and southern flounder, spot, Atlantic croaker, weakfish and blue crab, 1987-1994.

	Summer Flounder					Southern Flounder			
Year	N	Arith. mean	PSE	Geo. mean	PSE	Arith. mean	PSE	Geo. mean	PSE
87	96	11.8	12	4.7	6	2.5	30	0.9	16
88	94	2.7	22	1.1	12	2.1	29	0.6	16
89	90	4.3	14	2.2	10	0.7	20	0.4	18
90	99	7.5	16	3.0	9	3.3	16	1.5	12
91	100	3.6	17	1.9	8	2.6	20	1.1	12
92	97	9.1	13	3.9	7	4.5	15	1.8	10
93	100	5.5	17	2.0	11	3.5	20	1.0	15

	Spot					Atlantic Croaker			
Year	N	Arith. mean	PSE	Geo. mean	PSE	Arith. mean	PSE	Geo. mean	PSE
87	96	42.7	18	8.9	9	85.3	15	15.0	8
88	94	323.1	14	65.7	4	165.9	17	39.1	5
89	90	181.3	11	48.8	4	137.0	13	27.7	7
90	99	523.4	12	167.9	4	273.8	16	90.6	4
91	100	190.6	14	54.0	5	162.3	9	75.5	4
92	97	169.7	16	32.2	5	252.2	17	45.7	6
93	100	324.2	15	76.6	6	503.1	14	99.1	5

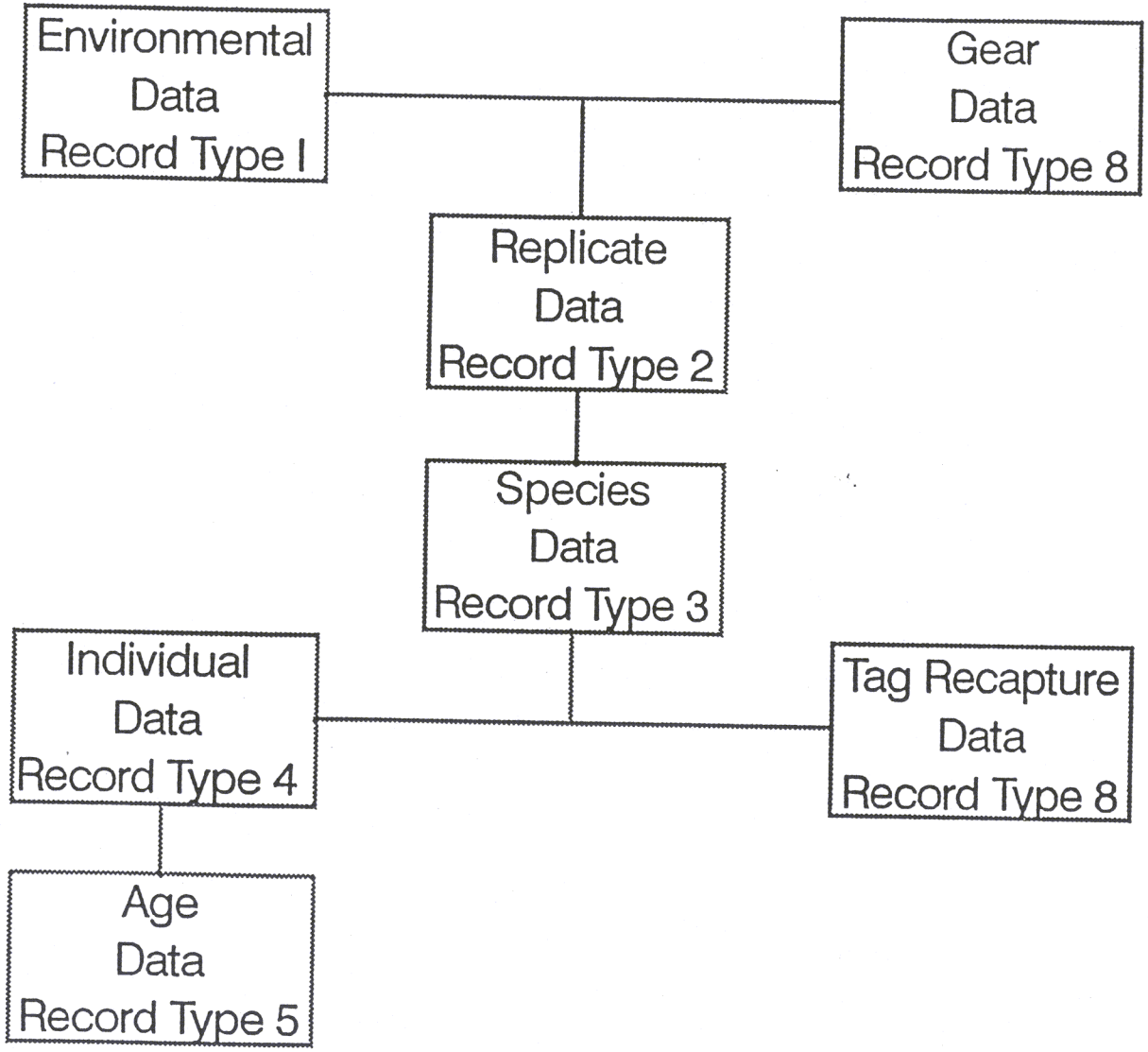
	Weakfish					Blue Crab			
Year	N	Arith. mean	PSE	Geo. mean	PSE	Arith. mean	PSE	Geo. mean	PSE
87	96	5.8	49	0.4	26	69.7	18	21.7	5
88	94	54.5	23	4.5	14	30.7	16	11.9	6
89	90	6.8	24	1.3	18	46.2	18	13.9	6
90	99	25.4	24	2.3	16	157.2	17	57.1	3
91	100	18.7	31	1.7	17	138.6	15	33.9	5
92	97	22.4	22	3.2	14	61.8	16	22.1	5
93	100	4.8	34	0.9	18	62.9	16	22.3	5

annually and contains the following as a minimum: background, objectives, sampling techniques, gear information, and station locations. The data stored on the database are essentially useless without complete and current documentation.

Recorded data elements are organized into a hierarchical file structure composed of seven record types (Figure 39): environmental and station; gear; replicate; species; individual; tag; and age. A set combination of fields that is unique to a collection and the records contained in that collection is called control informations. It is these fields that enables several records from a collection to be linked. Flat records (a single record that contains data from various levels of the hierarchy) can be easily created using SAS software and specifying the appropriate control information.

Data management programmers are responsible for maintaining the masterfile, assigning codes and standards, creating SAS flat file program subsets for analysis by the biologists. Each office has access to the database through the state computer network. Small data files may be downloaded to personal computers. Biologists are responsible for developing their own SAS programs for analysis. Data management staff provide assistance when needed. The common file format and variable names facilitates data access and analysis across numerous programs.

Figure 39. North Carolina biological masterfile hierarchical structure composed of seven record types.



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The Florida Marine Fisheries–Independent Monitoring Program: Trawl Survey Component

by
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Introduction

Since 1983, the Florida Department of Environmental Protection[1] has been developing a systematic and continuing program to monitor marine commercial and recreational fisheries and collect and integrate essential information for the management and enhancement of Florida's marine resources. An integral component of this effort has been the development of a long–term marine fisheries–independent monitoring program. Systematic scientific field surveys, aimed at assessing the pre–fishery recruitment of resource species which use estuarine and near–coastal areas as nursery areas, comprise a major component of this effort. These surveys presently use a multi–gear sampling approach, of which sampling with bottom trawls is a significant portion of the total effort (approximately 40 percent). Other gears used include seines, gillnets and dropnets.

Purpose

The monitoring of juvenile and sub–adult populations prior to their exploitation in the fisheries provides significant advantages over the traditional methods of monitoring changes in fish stocks with data gathered from commercial and recreational sources. Fishery–dependent data are often difficult to interpret due to changes in fishery regulations, reporting biases, and changes in the manner in which a fishery is pursued due to technological advancements or economic conditions. Assessment of population size at pre–fishery life stages not only avoids the direct impact of inconsistent fishing pressure but also provides stock estimates of much greater predictive utility, allowing proactive rather than reactive formulation of fishery management policies. Use of a rigorous scientific collection program to generate the stock assessment data assures uniformity of fishing methods and detailed, site specific catch and effort data. Extensive collection–specific information on environmental and biological variables, generally not available for fishery–dependent data, is routinely generated during scientific collection programs. Such data allows evaluations of species interactions, habitat dependencies and the effect of environmental influences on the fishery recruitment processes.

The overall objective of Florida's Marine Fisheries–Independent Monitoring Program is to generate long–term abundance information for fishery resource species and establish relationships between juvenile abundance and future fishable stocks. The ability to predict future adult population sizes will enable resource managers to have appropriate harvest regulations in place at

[1] Effective July 1, 1993 the Florida Department of Natural Resources (DNR) was merged with the Department of Environmental Regulation to form the Department of Environmental Protection (DEP). The Florida Marine Research Institute was previously in the DNR.

the time the fish become vulnerable to the fishery. Because the necessary data are obtained from a comprehensive scientific field survey effort, the program also achieves a secondary but very important objective of providing a large scale, long–term biological and ecological monitoring program in this critical area of Florida's marine environment. The resultant data set is suitable to a large variety of scientific studies, many of which address items of direct concern regarding fundamental ecological processes and relationships within this environment. Thus, although the survey is primarily designed to collect population information for a suite of species of primary concern (Table 11), complete processing of the entire finfish catch and a significant portion of the invertebrate catch is done to maximize the utility of the data set for general ecological monitoring purposes and to provide data on possible inter–specific relationships between species of immediate interest and the remainder of the macrofaunal community.

History and Timeframe

Florida's Marine Fisheries–Independent Monitoring Program was implemented in the spring of 1989, when a regular monitoring program was established in Tampa Bay after several years of exploratory sampling and survey design formulation. Originally developed with funding provided by a Wallop–Breaux federal grant, the program is now primarily supported by state funds generated from the sale of saltwater fishing licenses. The program is intended to be sustained on a continuing basis and to be eventually expanded to monitor all major estuarine and coastal nursery areas in the state. Routine monitoring programs were fully established in the northern half of Charlotte Harbor in the spring of 1989, in the northern portion of the Indian River Lagoon in the spring of 1990, and in the western Panhandle region (Choctawhatchee Bay and Santa Rosa Sound) in the spring of 1993. The program is currently in the process of implementation in Florida Bay, situated between the Everglades and the Florida Keys, which presently is considered a severely stressed system. Exploratory sampling has been conducted in the Cedar Key area on the north central west coast and the program will be expanded into this region as well over the next few years. Plans for additional program expansion tentatively include the northeast coastal region (Jacksonville) and the Apalachee Bay area (Figure 40).

Design and Methodology

Sampling Design

The Florida Marine Research Institute's (FMRI) Fisheries–Independent Monitoring Program uses a multi–gear, complex sampling design approach. The regular monitoring effort has two major components, a fixed station survey conducted monthly and a stratified–random design survey conducted semiannually. The fixed station survey is designed to monitor growth and seasonal changes in relative abundance, while the semiannual survey is intended to assess relative population sizes during periods of peak recruitment (spring and fall) and generate comprehensive distributional information. Both surveys use multiple gear types, including seines, trawls, gillnets and dropnets. In addition to the two surveys, there is an ongoing program of gear testing and gear calibration. Additional gears evaluated and tested to date include blocknets, stopnets, purse seines, roller frame trawls, trammel nets, and large (91-244 m long) seines. Variations in construction and deployment techniques of the program's standard gears have also been examined.

Table 11. Selected Species List

27 species of finfish

8 *Sciaenidae* (drums)
- black drum (*Pogonias cromis*)
- red drum (*Sciaenops ocellatus*)
- spotted seatrout (*Cynoscion nebulosus*)
- sand seatrout (*Cynoscion arenarius*)
- southern kingfish (*Menticirrhus americanus*)
- Gulf kingfish (*Menticirrhus littoralis*)
- northern kingfish (*Menticirrhus saxatilis*)
- spot (*Leiostomus xanthurus*)

3 *Mugilidae* (mullets)
- striped mullet (*Mugil cephalus*)
- white mullet (*Mugil curema*)
- fantail mullet (*Mugil trichodon*)

3 *Lutjanidae* (snappers)
- red snapper (*Lutjanus campechanus*)
- grey (mangrove) snapper (*Lutjanus griseus*)
- lane snapper (*Lutjanus synagris*)

2 *Elopidae* (tarpons)
- ladyfish (*Elops saurus*)
- tarpon (*Megalops atlanticus*)

2 *Serranidae* (sea basses)
- red grouper (*Epinephelus morio*)
- gag grouper(*Mycteroperca microlepis*)

2 *Carangidae* (jacks)
- Florida pompano (*Trachinotus carolinus*)
- permit (*Trachinotus falcatus*)

2 *Scombridae* (mackerels)
- king mackerel (*Scomberomorus cavalla*)
- Spanish mackerel (*Scomberomorus maculatus*)

1 *Centropomidae*
- snook (*Centropomis undecimalis*)

1 *Pomatomidae*
- bluefish (*Pomatomus saltatrix*)

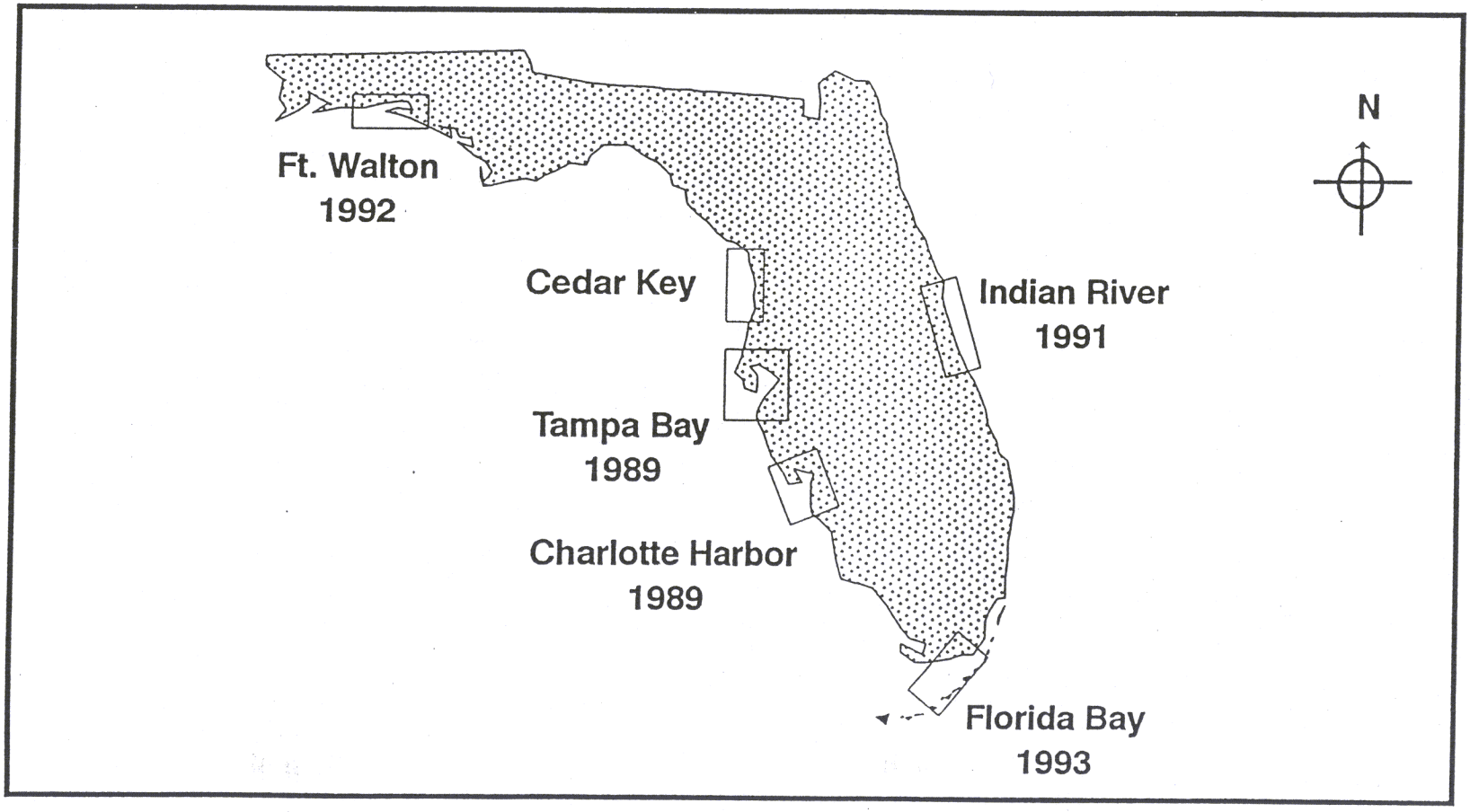
1 *Rachycentridae*
- cobia (*Rachycentron canadum*)

1 *Sparidae*
- sheepshead (*Archosargus probatocephalus*)

1 *Bothidae*
- Gulf flounder (*Paralichthys albigutta*)

8 species of crustaceans
- 4 shrimp (*Penaeus aztecus, braziliensis, duorarum, setiferus*)
- 3 stone crabs (*Menippe adina, mercenaria, nodifrons*)
- blue crab (*Callinectes sapidus*)

Figure 40. Map of estuarine systems where Florida's Fisheries Independent Monitoring Program has established, or will establish, field labs.



Fixed sampling sites are chosen to sample a variety of habitat types, provide general geographic coverage, and to sample important nursery areas in order to monitor growth of particular species. Fixed station sampling effort currently varies between the different bay systems. Overall effort is currently greatest in Florida Bay (28 stations including 14 trawl sites and expanding, Figure 41) where concerns about general ecological changes, which may be associated with modifications of fresh water delivery schedules through the heavily hydrologically engineered south Florida watersheds, have mediated for an intensified monthly sampling schedule. Monthly fixed station sampling in Tampa Bay is done at 22 sites including 10 trawl stations (Figure 42). In the Charlotte Harbor and western Panhandle systems six trawl sites are sampled each month within respective totals of 14 and 12 fixed stations (Figures 43 & 44). The Indian River Lagoon system samples 18 fixed stations including five trawl sites (Figure 45). Most non–trawl fixed stations are shallow water sites sampled with 21–m long, 3.2–mm mesh minnow seines using several different deployment techniques (offshore, beach, and boat set). Except for two gillnet sites in the Indian River system, all current fixed station sampling is done during daylight hours.

The random–stratified sampling efforts conducted during the spring and fall surveys are much more intense. Sampling is based on a 1 x 1 minute cartographic grid system (Figure 46) overlaid on each estuarine system. The grid system is divided into 4–6 "zones" (strata) delineated primarily for geographic and logistical criteria but which also define areas of greater biological and hydrographic homogeneity than the systems as a whole (Figures 42-25, random sampling has not yet been initiated in the Florida Bay system). Within each zone 10 trawl sites, 14 seine sites, two dropnet sites and two gillnet sites are sampled during each season. Sampling with the seines and trawls is done during day, night, and dusk and dawn crepuscular periods, while dropnetting is done exclusively during day sampling and gillnetting during the evening and night. Of the ten trawl sites occupied within each zone, three each are done during the day and night and two each are done during each of the two crepuscular periods ($\pm$ 1 hour of sunrise and sunset). The dawn and daytime sampling is done during a single sampling trip, while a different sampling trip is conducted to accomplish the evening and night sampling.

The initial sampling grid for each trip (day and night) is selected randomly from all possible grids within the zone to be sampled. If a selected grid does not contain sufficient appropriate habitat for the chosen gear (such as inadequate areas of the required depth (>1.5 m) for trawling), a counterclockwise spiral method is used to identify the closest suitable starting grid within the zone. Within a selected grid a more precise starting location is selected using the same procedure on a 10 x 10 cell microgrid (Figure 47), i.e. one of the 100 cells is randomly chosen. If the microgrid is not suitable for sampling, the counterclockwise spiral method is again applied. Subsequent grids occupied during a given sampling trip are selected using the spiral selection method. A given grid may be sampled only once per sampling season with a given sampling gear; therefore if any grid selected for the second trip in to a zone was already sampled during the first trip, it will be passed over during the spiral selection process until a suitable unsampled grid is selected.

Figure 41. Map of Florida Bay fixed stations.

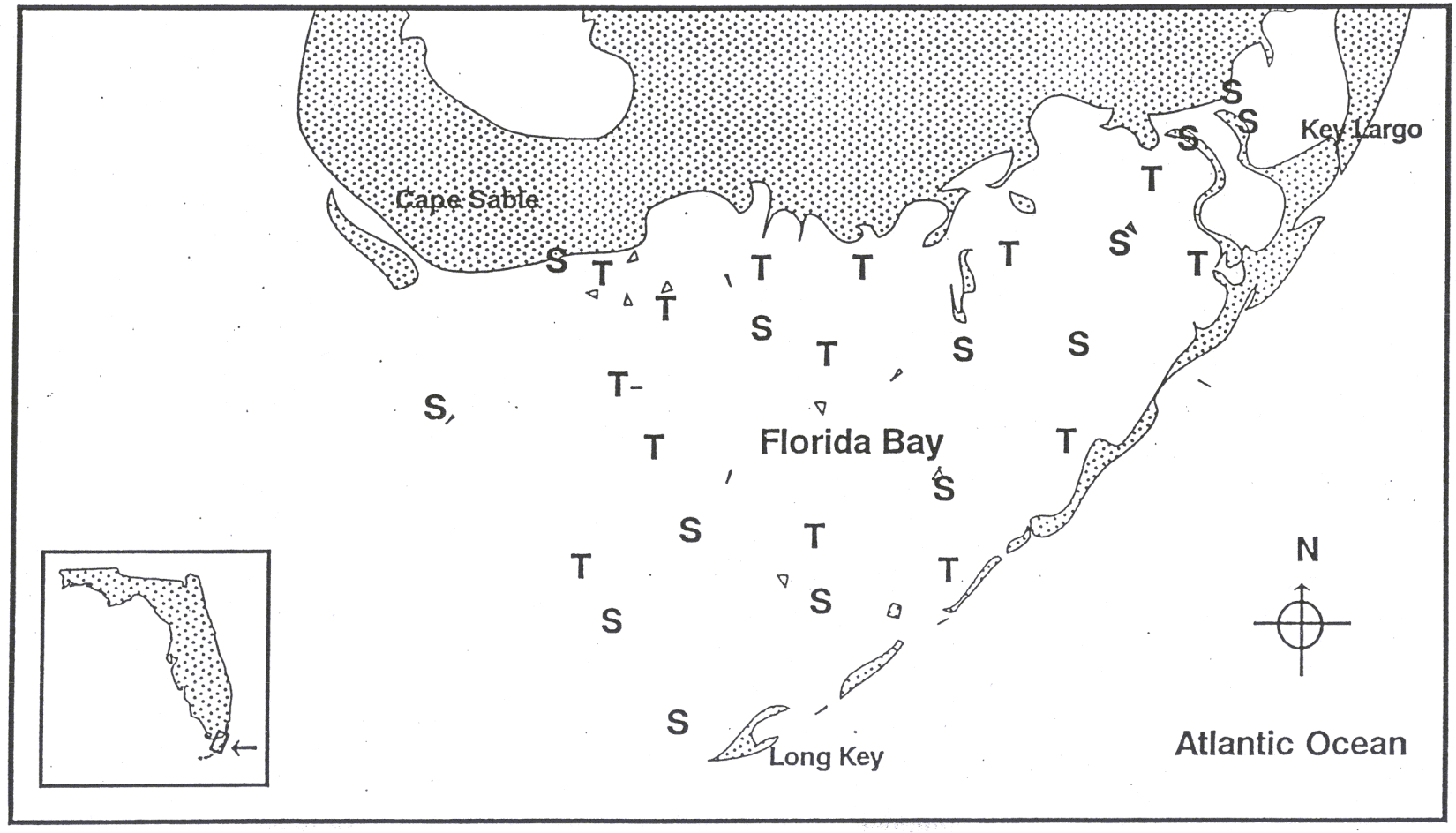


Figure 42. Map of Tampa Bay sampling zones and fixed stations.

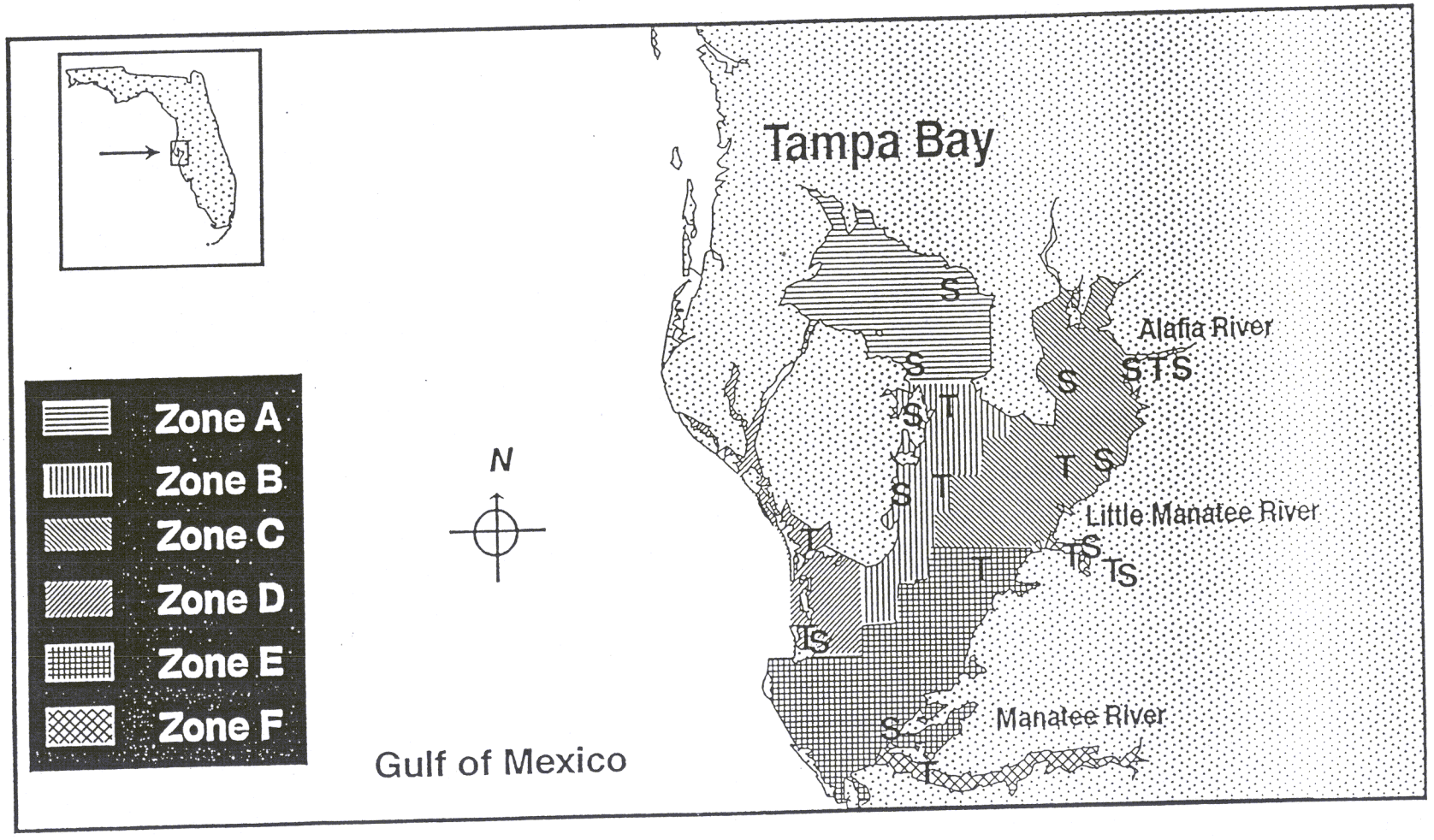


Figure 43. Map of Charlotte Harbor sampling zones and fixed stations. Fixed seine stations are designated by S, and fixed trawl stations are represented by T.

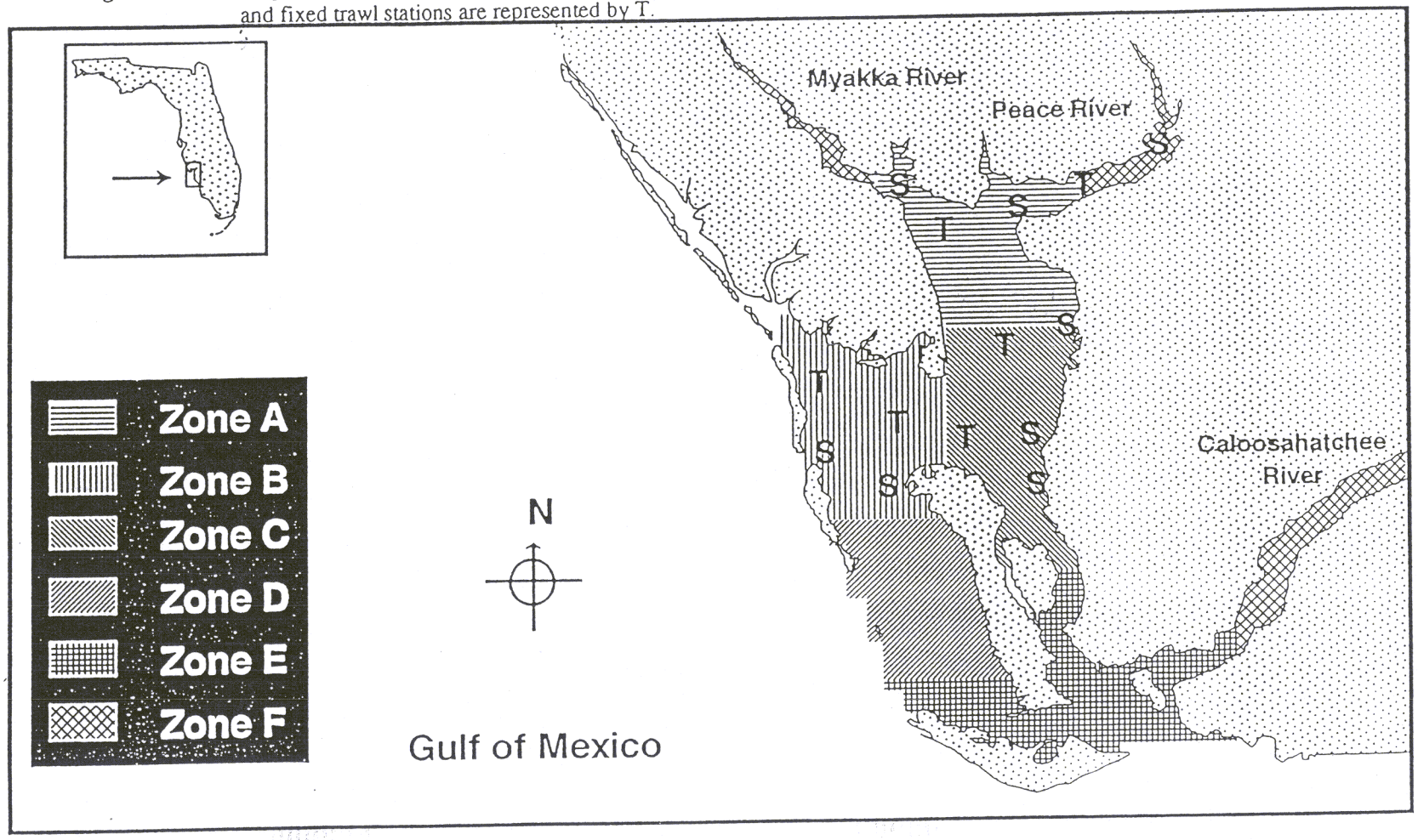


Figure 44. Map of Ft. Walton sampling zones and fixed stations. Seine fixed stations are designated by S, and fixed trawl stations are represented by T.

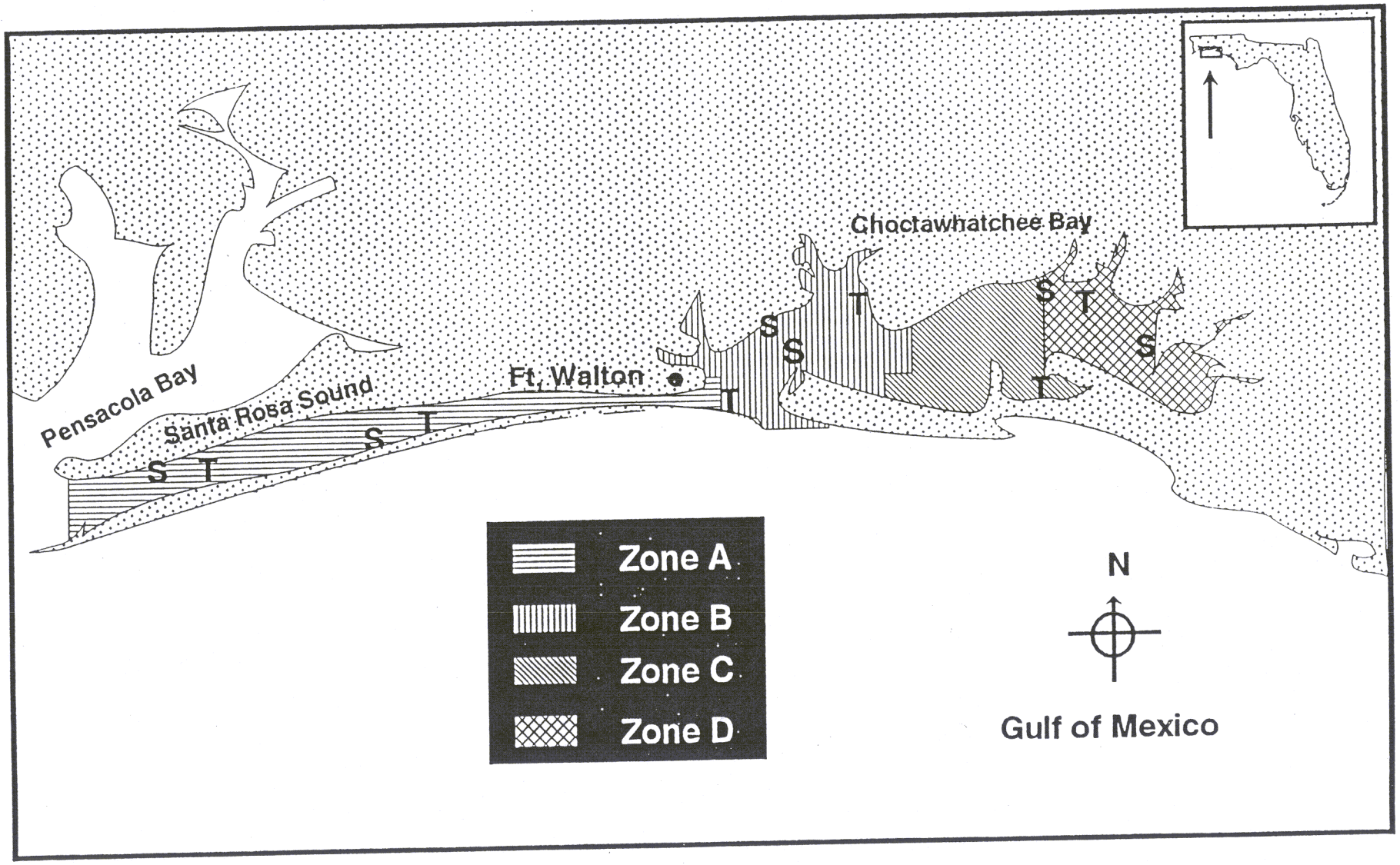


Figure 45. Map of Indian River sampling zones and fixed stations. Fixed seine stations are designated by S, fixed trawl stations are represented by T, and fixed gillnet stations are designated by G.

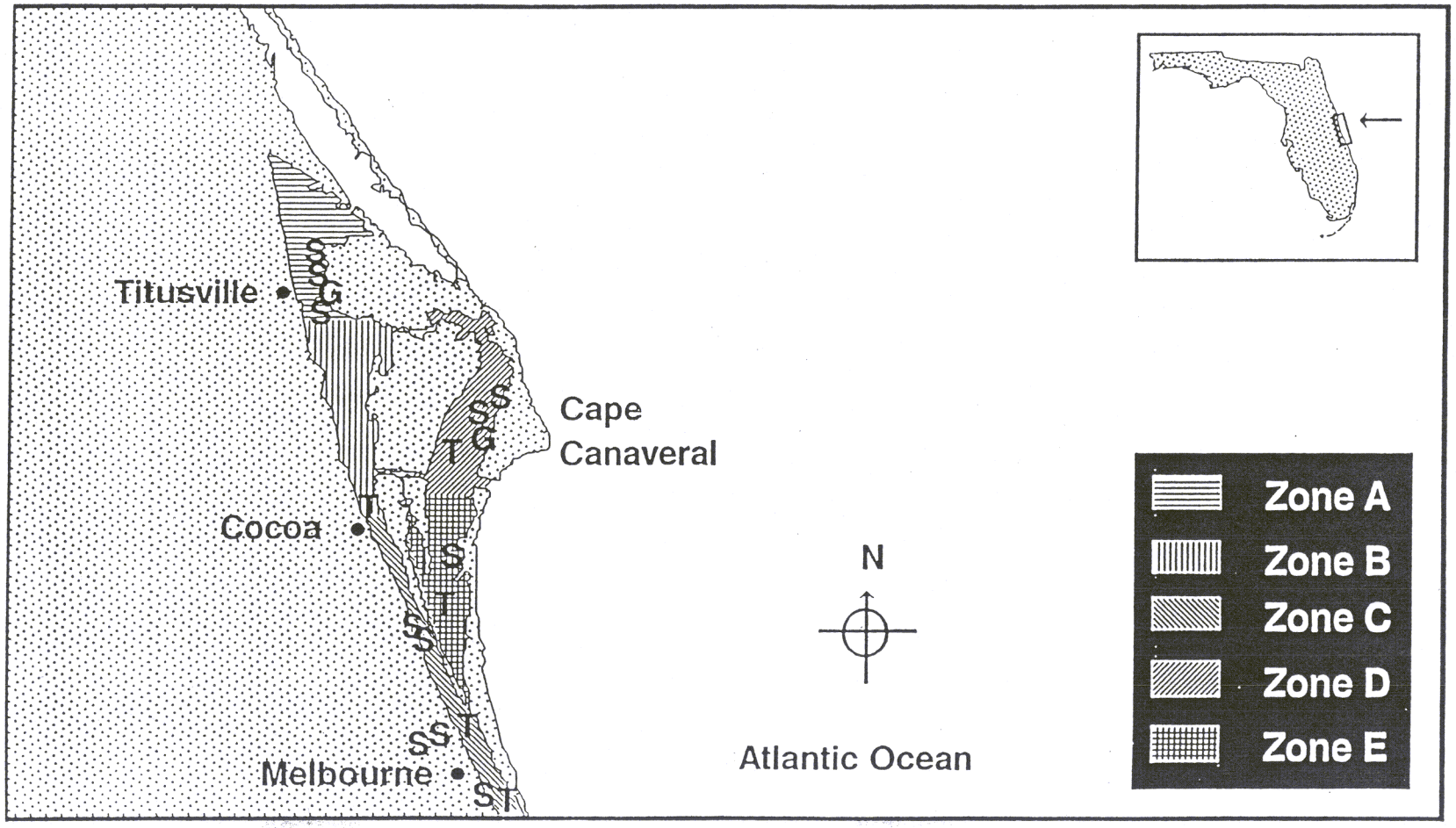


Figure 46. Map depicting the grid system for a small section of the Tampa Bay estuary. Hatched grids are part of Zone A, while the remaining grids are part of Zone B..

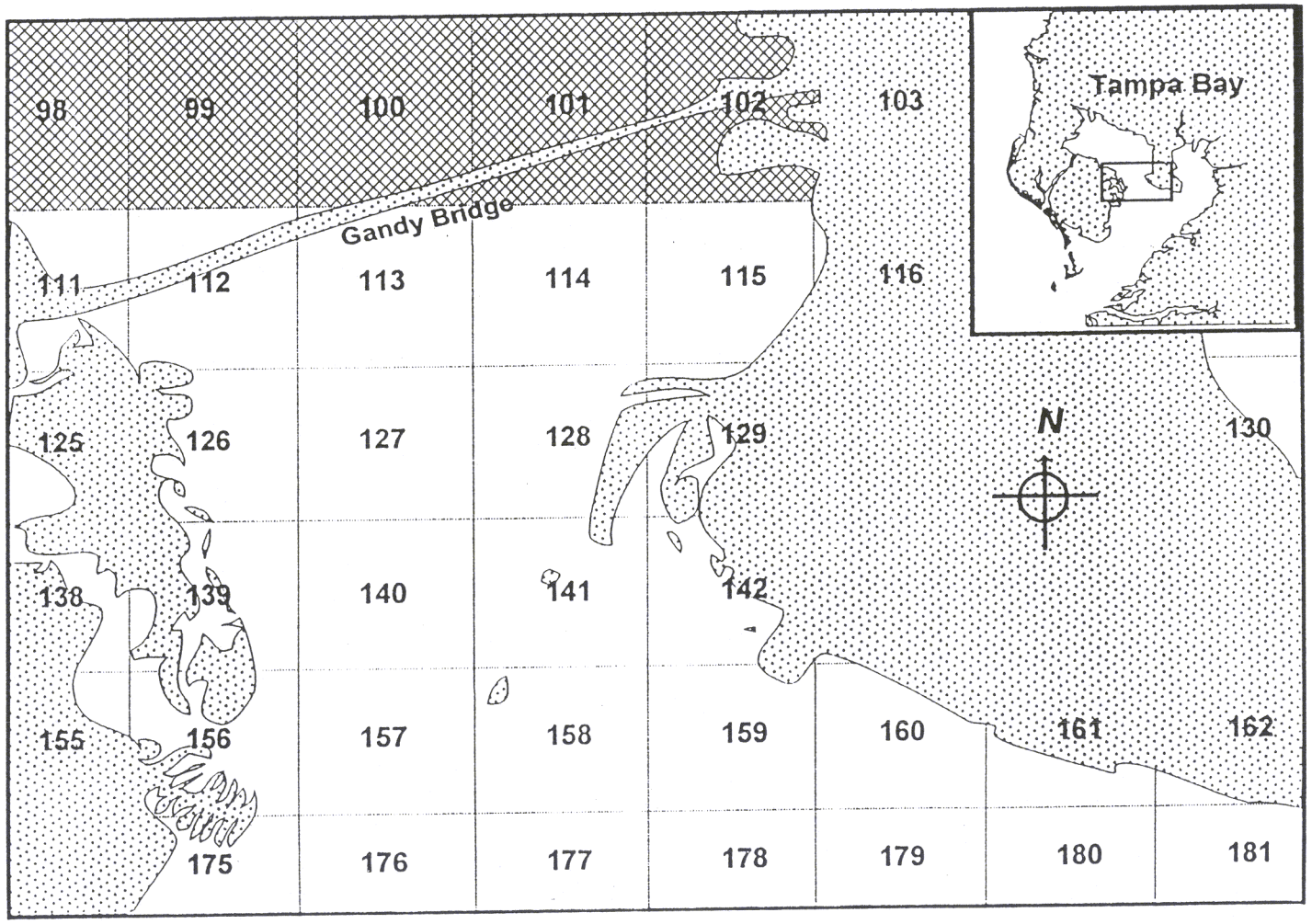


Figure 47. Each grid is divided into 100 microgrids. As with the grid to be sampled, the microgrid to be sampled is randomly selected before the sampling trip begins.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Sampling Methodology

Specifications and deployment techniques for the trawl gear used is given in detail below; however, since the trawling component is only part of a coordinated multi–gear sampling program, brief descriptions of the other standard gears used at present will be given as well.

Trawl: A two–panel 6.1–m otter trawl made of 38–mm stretch mesh #9 (body) and #18 (bag) nylon twine. The 3.1–m long bag is lined with 3.2–mm knotless #35 Delta nylon mesh. The headrope and footrope are 9.5–mm PolyDac with 1.2–m legs between net and doors; headrope is fitted with four 63–mm x 38–mm PVC foam floats and footrope is rigged with a 6.4–mm chain. The trawl is fished with 0.46–m x 0.91–m, weighted 9.5–mm plywood otterboards fitted with four–leg chain yokes. A 7.7–m–long 6.4–mm tickler chain is rigged between the two doors. The trawl bridle is constructed of a 30.5–m piece of 9.5–mm polypropolene rope shackled to both door yokes and rigged through a pulley attached to a swivel connected to a 7.7–m–long single 19.1–mm nylon rope tow line. The total warp length is slightly over 45–m. Trawling is done from 6.1–7.6–m mullet skiffs powered by 100 hp forward well–mounted outboard engines. Since no hydraulics are available, nets are deployed and retrieved by hand, with the vessel backing down on the net during retrieval. Towing speed is approx. 1.5 knots with tow times of either 10 minutes (large bays with relatively clean bottom) or 5 minutes (rivers and smaller bays where large amounts of bycatch are present). Bottom distance covered is recorded using LORAN or GPS, and is generally about 327 m for a 10 minutes tow. Tows are usually made in a linear direction into the current. In shallow water (<1.8 m) an arc course is followed to prevent the trawl from directly sampling the area over which the prop has passed. The boat is turned so that approximately 1/3 of a complete turn is executed during the tow period. Trawls are normally intended to be employed in waters too deep for seines (> 1.8 m), but tidal fluctuations can require the use of arc tows in areas which are normally too deep to seine. Three spatially discreet replicate tows are made at each visit to a sampling site, generally done end–to–end if topography allows maintenance of nominal depth.

Seine: A nylon–mesh, center–bag drag seine, 21–m–long by 1.8–m deep, 1.8–m x 1.8–m x 1.8–m bag made of knotless 3.2–mm #35 Delta mesh. Rigged to 2.4–m PVC brails (endpoles) which are hauled by hand. The net is deployed in three different manners depending on sampling site topography:

(1) **Beach set** (gradually sloping shores) – net set out perpendicular to shore with inshore brail at water's edge and offshore brail 15.5–m offshore, then manually pulled parallel to shore for a distance of 9.1–m against any current. The inshore brail is then set in place while the offshore seiner continues in semicircular direction until shore is reached. Net is then closed and landed on shore.

(2) **Boat set** (steeply sloped shorelines) – one end of net is set on shoreline from boat, then boat is maneuvered to deploy net in a semicircle back to shoreline. Net is then closed and landed on shore.

(3) **Offshore set** (shallow flats away from shoreline) – net is deployed perpendicular to and facing into current with brails spaced 15.5–m apart. Net is then manually pulled a distance of 9.1–m, after which the net is closed to the center. A third pole is then set where the ends have been drawn together and the net is pulled around the pole at a 90 deg. angle while a member of the sampling crew keeps both wings pressed firmly against the pole as they are pulled around. Once the bag is reached, the pivot pole is quickly passed under the net and raised to the surface. The bag is then slowly inverted and catch transferred to buckets.

Generally, three spatially discreet replicate sets are made at each visit to a seine sampling site, regardless of the deployment method.

Gillnet: Multi–panel, variable mesh monofilament floating nets, 1.8–m deep by 198–m–long. The first panel is a 15–m–long panel of 50–mm mesh (# 208 mono). The remaining four panels are each 45.7–m–long with mesh sizes of 76–mm, 102–mm, 127–mm and 152–mm (# 208 mono) stretch mesh joined in ascending order. Nets are deployed in a fixed manner (both ends anchored) perpendicular to the shoreline with the nearshore end on or as near to the shoreline as possible while still maintaining adequate water depth to open the nearshore panel. Nets are set four per sampling site spaced at about 45–m intervals. Two nets are set with the smallest mesh end onshore, while the other two are set with the smallest mesh offshore. Order of deployment is generated randomly. All four nets are set as quickly as possible at the beginning of sample period. Retrieval of the nets is begun 90 minutes after the setting of the first net.

Dropnet: A 1 x 1 m square sealed, 25.4–mm PVC floating frame and 1 x 1 m square stainless steel frame joined by a knotless 3.2–mm #35 Delta nylon mesh tube, with a 6.4–mm chain sewn within the steel frame seam for added weight. Three dropnets rigged with fine cable harnesses, spaced 0.75 m apart, are suspended 2 m above the surface from a boom system mounted on the boat. The boat is pushed slowly into an undisturbed area and the nets are simultaneously released. The catch is removed from the nets through the surface opening by a repetitive sweeping protocol using a rigid frame "internal seine" and dipnets. Sampling with this gear is restricted to waters < 1 m deep and is generally only done over vegetated bottom.

Sample Processing

Catches removed from all types of gear are placed in buckets or tubs filled with water until they can be processed. Bycatch type is noted, quantified by volume and recorded. All fishes and selected macroinvertebrates are identified, enumerated, and representative length frequencies taken. Small samples of species that cannot be positively identified in the field are placed on ice and returned to the laboratory for processing. Additionally, representative samples of the catch from each repetition series are brought back to the lab for verification of field identifications. All other organisms are returned to the water after processing.

Ancillary Data

Hydrographic data, atmospheric and sea conditions, and observations concerning bottom type and shoreline morphology (if applicable) are recorded for each collection. Sampling vessels are equipped with depth finders, LORAN or GPS, and Hydrolab Surveyor series water quality instruments. Temperature, salinity, pH, dissolved oxygen and conductivity are recorded at each sampling site, including both surface and bottom when depth permits discrete observations (>1 m). During extended sampling procedures, observations are recorded periodically at each site. Direct observations of bottom type and shore vegetation are recorded during seining operations and when possible during trawling operations, including species composition and estimated percent cover of any bottom vegetation.

Database Management System

Field data are coded and entered into a customized, computerized dBASE–IV database within two weeks of sampling. Proofing and editing are performed immediately thereafter and data are archived via computer link onto the DEP mainframe computers in Tallahassee. Data subsets are converted into SAS datasets for most analytical applications.

Results

The time series of data collected thus far is insufficient for the validation of juvenile indices. A continuing effort is underway to critically examine the data for specific species to identify the data subsets most appropriate for the construction of representative indices of relative abundance. Numerous investigations into the distributional, habitat use and growth information generated from this survey have been conducted, including Gulf flounder (1991 Annual Report), snook (1992 Annual Report), and spotted seatrout (1993 Annual Report). General trends in relative abundance for species of management concern (redfish, spotted seatrout, striped mullet, sheepshead, Gulf flounder and blue crabs) have been analyzed and reported to the appropriate management bodies.

Availability and Dissemination of Reports

Annual reports are prepared which contain discussion of overall results, extensive tabular data summaries, and results of more detailed analyses of results for selected species (Florida's Fisheries–Independent Monitoring Program Annual Report; available for 1989 to 1992, 1993 in prep.) Requests should be made to:

Fisheries–Independent Monitoring Program/Juvenile Fish Research Staff
Florida Marine Research Institute
100 8th Avenue SE
St. Petersburg, FL 33701–5095
Ph. (813) 896–8626 (Suncom 523–1011)
Fax (813) 896–0166

Integration of Survey

To date, the data from the Florida Fisheries–Independent Monitoring program has not been integrated with any other trawl surveys. The program's gillnet data, however, have been integrated with other surveys by the Gulf States Marine Fisheries Commission and Mote Marine Laboratories.

SESSION II: COOPERATIVE DATA MANAGEMENT SYSTEMS

Data Collection and Management: Developing Multi-agency, Cooperative Programs

by
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State and federal marine resource management agencies are well into a new era in fisheries management. Gone are the days that decisions can be made by educated guesses and other less informed means. Today's fisheries in general are being fished at or near their maximum yields or are being overfished. Decisions made by managers are scrutinized by an abundance of people, from the fishermen in the field to members of Congress who become involved at the behest of their constituency. Today's litigious society often places fishery management actions in the court room, forcing us to rely on a judge to make what should be a professional decision. Other factors have contributed to the complexity of fisheries management, not the least of which are a variety of management measures designed to alter fishing behavior and control fishing mortality. They include quotas and closures, individual fisherman shares (ITQs) in fisheries, social and economic considerations, specific gear requirements, among others. Our current systems have proven to be unable to keep up the pace, even though there are significant technological advances that greatly increase our capability. Fixes have been ad hoc, designed to address specific data needs at specific times, and vary greatly from region to region and program to program. When all these items are combined, they result in the need for more and better data that can be collected, stored, retrieved, and analyzed in a more timely manner. The question is how to get more and better data.

State marine resource management agencies are empowered by their state legislatures with the authority to conduct investigations and collect data for the purpose of managing fisheries under their jurisdictions. Likewise, Congress authorized the National Marine Fisheries Service (NMFS) to conduct the same activities in pursuit of fisheries management within the federal jurisdiction. These authorities make the states and the NMFS unique in this respect. With the exception of at-sea observers and the occasional roving boat creel surveys, most data are collected shoreside, either at the dock or at wholesale fish houses. At that point it does not matter whether a fish is landed in state or federal waters. It makes no sense to have a federal program on the dock collecting only federal data and a state program on the dock collecting only state data. Such an arrangement is duplicative, wasteful, and annoying to the fishermen and dealers. It is clear that the most efficient and effective way to collect fisheries data is through a state-federal cooperative program, combining the expertise, funding, and manpower of those agencies toward a common goal.

Management of anadromous, estuarine and marine fisheries species requires a mechanism to provide for research, data collection, and regulatory strategies that transcend state and federal jurisdictional boundaries. This fact was recognized many years ago, and was manifested in the establishment of the three interstate marine fisheries commissions with the consent of the U.S. Congress. The advent of the Magnuson Fishery Conservation and Management Act of 1976 again acknowledged that regional management bodies are necessary to appropriately address the

problems presented by multi-jurisdictional fisheries stocks. It stands to reason, if interjurisdictional fisheries stocks must be managed on a regional basis, the data required for management must likewise be consistent regionally, and must be available to a wide variety of user groups, including state and federal scientists, councils, interstate commissions, to name a few. This leads us to the first, and perhaps the most important, factor in the process.

There must be a unified agreement within the fisheries management community that there is a need for a state-federal cooperative program.

If this need is not embraced by all parties with a legitimate management interest, there will be divisiveness at worst, and a gap in the program at best. There are a number of good examples of state-federal cooperative data programs, including the Pacific Fisheries Information Network (PacFIN), the Southeast Area Monitoring and Assessment Program (SEAMAP), the Recreational Fisheries Information Network (RecFIN, Pacific and Southeast), and the Commercial Fisheries Information Network (ComFIN), which is currently in the formative stages. These programs did not just happen. A great deal of effort and planning went into their development and implementation.

There are a number of formats that can be used to conduct the program development process. In the case of the RecFIN and the ComFIN, the concept arose from the Data Management Subcommittee of the Gulf States Marine Fisheries Commission (GSMFC) for a Gulf of Mexico program, and was later expanded to include the South Atlantic and Caribbean. The following is a sequence of events that will result in a cooperative program:

(1) identification of the problem;

(2) identification of agencies and organizations that should be involved in solving the problem;

(3) obtain agreement from the participating agencies and organizations that the identified problem is real;

(4) conduct brainstorming session(s) to identify specific problems and issues related to the subject area;

(5) sort identified problems and issues into broad categories;

(6) obtain agreement that the participating agencies should be organized into a formal, multi-agency group to address the subject area for the long-term;

(7) adopt the categorized problems and issues as a set of goals and objectives for the newly organized group;

(8) formulate tasks that address the goals and objectives;

(9) assign tasks to subcommittees and work groups for resolution of identified problems and issues; and

(10) apply results to operational activities of data collection, management, and dissemination.

(11) The formalized group then becomes an oversight body for regular review and evaluation of ongoing data collection, management, and dissemination activities, and for recommending change.

The process will usually require several workshop and meeting sessions to reach agreement on the direction of the group, and to get formal endorsement by the cooperating agencies for continued participation in the program. During the development of the RecFIN, the group itself conducted the brainstorming and review steps. During the development of the ComFIN, we used a facilitator to assist the group in identifying problems and issues. It was generally agreed that the use of a facilitator was more efficient and thorough. As you can imagine, this is a lengthy process.

One thing that all state-federal, cooperative data programs have in common is a second important factor.

For a state-federal cooperative data program to be successful, it must have director level support and understanding.

In the early stages of program development, director level support is vital to gain cooperation of the agency for participation in the program development process. Following conceptual agreement, there is a need to involve technical level personnel who can contribute to formulation of program details and still adequately represent the agency throughout the decision-making process. Funding to support travel and other expenses typically must be carved out of existing budgets until such a time as the program becomes established and receives funding. Participants on committees and work groups must spend time in and out of the office working on issues directly related to the program. All these needs require approval of the director to allocate such time and expense.

One good way to demonstrate director level support and agency commitment to a program is the development of a Memorandum of Understanding (MOU) to be signed by all participants. Such a document represents the individual agencies' commitment long after the people involved have moved on to other opportunities. The MOU should outline broad goals and objectives and the contribution that each signatory agency is willing to make to the cooperative effort. The MOU will also represent the signatory agencies' long-term commitment to the cooperative effort.

Having gone through the development of RecFIN, and still being in the process of establishing the ComFIN, it is evident that the development of a cooperative program and the first several years of operation are slow and cumbersome. There are a few shortcuts that can be gleaned from other similar programs (eg. we used SEAMAP and PacFIN as models for developing RecFIN and ComFIN); however, in the overall process, each participant must experience the stages of development in order to have a full understanding of and agreement with the guiding principles and the direction of the program. There is no shortcut for the investment of time and personal ownership that take place during program development.

Development of a multi-state, state-federal program requires a lot of up front work before the program ever gets started. For example, the GSMFC conducted planning meetings and workshops for approximately two years prior to the establishment of SEAMAP. Prior to the

establishment of RecFIN, meetings and workshops on marine recreational fisheries data were conducted for three years. Likewise, we formally introduced the concept of ComFIN in late 1992, and the program has still not been established, although we are quite close. Part of the reason for this extended time frame for program establishment is the next factor in this process.

Development and establishment of a multi-state, state-federal cooperative program requires an initial period of great change, after which there will be periodic changes to accommodate the evolution of technology and fishing activities.

While state and federal agencies do change, such change is usually slow and can be relatively painful. This fact is reflected in the protracted period for program development and establishment. Once the program has been established, the first few years represent a period of change to reflect efforts to achieve the common goals and objectives that have been established. After this formative period, program activities typically become more routine; however, the program must remain open to change to accommodate the changing needs of fisheries management and the development of new technology. This brings us to the next factor.

To insure long-term program stability, there must be a formally established organizational structure of committees and work groups that regularly reviews the program and its activities. As part of this organizational structure, there must be a staff whose purpose is to coordinate the various state and federal participants to achieve the mutually agreed upon goals and objectives.

Agency participants typically have operational responsibilities related to a cooperative data program, such as data collection, data entry, editing, and other duties. It is difficult for any single agency to also have responsibility for the day to day coordination of all the participants toward mutual goals and objectives. We believe that such cooperative programs are the very reason that the interstate marine fisheries commissions were formed. Consequently, we contend that interstate, state-federal data programs should be staffed within the appropriate interstate commission office. Successful examples of this arrangement include PacFIN and SEAMAP. Only time will tell if RecFIN and ComFIN are equally successful.

Finally, marine fisheries data needs are long-term. It should then follow that programs to collect and manage marine fisheries data are long-term. As with any long-term effort, there is an important factor that is required for success.

There must be a long-term commitment for sufficient, dedicated funding for any state-federal cooperative data program, including provisions for operational and administrative costs.

Historically, funding for PacFIN and SEAMAP has been appropriated by Congress and administered through the NMFS budget. It is our hope that RecFIN and ComFIN will receive a similar commitment from Congress and NMFS to assure that we continue to have long-term fishery dependent data for recreational and commercial fisheries.

Development of a Multi-Participant Database Management Program for Marine Resources Research and Management

by

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Introduction

Multi-participant, long-term environmental monitoring is both a scientific and management imperative for effective marine resources research and management. The establishment of long-term monitoring programs provide for baseline studies, trend analyses and impact assessment of both natural and anthropomorphic phenomenon (Clark, in press). Advances in information technology are rapidly changing the way research and resource management agencies can assimilate, manage, disseminate, and share the data and information pertinent to effective resource management (National Research Council, 1993). The technology revolution is providing organizations the opportunity to collect and integrate digital data independently, while providing cost-effective mechanisms for the exchange of data and information among various state and federal resource agencies, scientific disciplines, industry and jurisdictional areas.

The Belle W. Baruch Institute for Marine Biology and Coastal Research has and is participating in several multi-participant, long-term environmental monitoring programs each having an emphasis on data and information exchange. These programs include the National Science Foundation (NSF) funded Long-Term Ecological Research (LTER) program, and the National Oceanic and Atmospheric Administration (NOAA) funded Urbanization and Southeastern Estuarine Systems (USES) and National Estuarine Research Reserve System (NERRS) programs (see Table 12). Building on these experiences, this paper addresses issues important for consideration in the development and implementation of an inter-agency, -departmental, -disciplinary, -jurisdictional, -site, -state (or all the aforementioned) database management program.

Table 12. Multi-Participant Database Management Activities

Program	Participants	Types of data collected
LTER	LTER sites	biological, chemical, meteorological, physical
USES	Federal and state resource managers and researchers	biological, chemical, land use/land cover, physical, socio-economic
NERRS	NERRS reserves and state coastal zone management agencies	biological, chemical, meterological, physical

Why Develop a Multi-Participant Database Management Program?

Acknowledging that it is difficult enough to develop and maintain a single participant (e.g., intra-agency, intra-site) database management program, potential participants of a multi-participant program must first come to grips with why they should participate. Two compelling reasons are as follows.

(1) Recent federal directives will require federally funded organizations to make their data and information available to the public, and to coordinate database development. By Executive Order, the National Spatial Data Infrastructure (NSDI) program calls for heads of agencies to submit to the Office of Management and Budget (OMB) a schedule and coordinated funding plan to ensure a coordinated and coherent federal effort in database development. OMB Circular A-130 states in summary, as policy, that agencies shall *"...distribute information at the agency's initiative, rather than merely responding when the public requests"* (Anderson, 1994).

(2) It makes sound financial and resource management sense. Marine resource data such as trawl survey data are very valuable. Data collection efforts are expensive to implement and maintain. On average, the more expansive the geographic area covered, the more expensive the data collection efforts. By implementing a program fostering the exchange of good data and information between inter-jurisdictional groups, spatial overlap in data collection efforts can be eliminated potentially lowering data collection costs. By providing managers with the best available marine resource data regardless of jurisdictional boundaries, more informed resource management decisions can be made and appropriate plans implemented. This is especially true when dealing with issues related to fisheries management. Fish species do not adhere to jurisdictional boundaries, therefore management plans that may have both resources related and economic impacts within and across jurisdictions should be based on the most comprehensive data available.

Components of a Multi-Participant Database Management Program

A properly implemented database management program consists of several items including hardware and software, personnel and data. More important to the overall success of maintaining a usable database is the implementation of a database management strategy. In addition to obtaining inter-administrative support, there are at least five key components for a successful implementation of a multi-participant database management strategy:

(1) a user needs assessment (UNA);
(2) data collection protocol;
(3) quality assurance/quality control (QA/QC) procedures;
(4) program documentation and metadata; and
(5) an information hub.

Within a multi-participant database management program, there will exist a variety of hardware platforms, software preferences, data management practices and expectations. The identification of existing and proposed database management programs, technology facilities and support personnel, and system requirements and expectations comprise the first step in the development and implementation of a multi-participant database management program. This is accomplished through the administration of a UNA to all potential participants in the program. The UNA addresses, at a minimum, five issues:

(1) perceived mission, goals and objectives;
(2) type of data being collected;
(3) amount of data collected and information generated;
(4) sophistication; and
(5) infrastructure (Michener and Haddad, 1992).

By analyzing the results of the UNA, the development of the database management program begins by identifying what is being done by whom, who has what, and what is expected. From a synthesis of the obtained information, it is determined what is necessary and what can be accomplished.

From the UNA comes an identification of what data are being collected and what data are necessary for effective resource management. This forms the basis of the development of the data collection protocol. Data collection protocol is the documented identification of what parameters are to be measured; when they are to be measured; and how they are to be measured. These constitute your data standards. The data collection protocol combined with proper documentation provides for consistency and ensures data collection procedures can be assessed at a later date (e.g., years later after data collection personnel and data collection techniques may have changed).

It is unreasonable to expect every participating group in a multi-participant database management program will require the same data. An expectation that every group will or can conform to consistent data collection techniques is most likely unrealistic. If the results of the UNA indicate that one or more environmental parameters are consistently identified as important, it may be possible to implement a data protocol that ensures consistency for key data variables. For example, the 22 current NERRS reserves collect disparate amounts of data often dependent on facilities, personnel and current research projects. As part of a system-wide water quality monitoring program, NERRS reserves will be working together to develop a nation-wide database of baseline environmental conditions in NERRS estuaries. A one week workshop held in February 1994 identified eight indicators of estuarine water quality to be collected at fixed 15-30 minute intervals at every reserve (Table 13). Using a consistent data collection protocol, these data will provide for an inter-site comparison of water quality parameters.

Table 13. Selected Indicators of Estuarine Water Quality

(1) temperature (+/- 0.1 ^{o}C)
(2) conductivity/salinity (+/- 0.05 mS/cm,+/-0.2 ppt)
(3) turbidity/total dissolved solids (+/-10% NTU)
(4) dissolved oxygen (+/- 2% saturation or +/-0.2 mg/L)
(5) ammonia (+/- 0.1 mg/L)
(6) ammonium (+/- 0.1 mg/L)
(7) pH (+/- 0.01 pH units)
(8) water depth(+/- 0.1 ft.)

Data required for effective resource management may be collected using a variety of techniques. These include remote sensing, *in situ* sampling, and the use of automated data loggers. Data entry may involve manual entry of data from handwritten field sheets, downloading data directly from a data logger to a computer, or the use of sophisticated digital image processing and Geographic Information System (GIS) techniques. Collected data are of no use to researchers and resource managers if the data do not accurately reflect measured conditions. The development, implementation and consistent application of quality assurance/quality control (QA/QC) procedures facilitate the detection of data corrupted by errors caused by automated or human data collection and data entry techniques (Michener and Haddad, 1992). QA/QC procedures often entail multiple levels of data checking. With some automated data collection equipment, the potential for human-introduced errors is reduced by downloading directly from data loggers to computers. For non-automated field data collection efforts, standardized data entry forms can help reduce the potential for human-introduced errors. Visual verification performed during and after data collection and entry as well as automated procedures for data entry verification help provide for higher quality data.

Data archival and protection are additional components of QA/QC procedures. When dealing with the potential for loss of data (e.g., natural disaster, hard disk crashing, fire), plan for the worst. Implement and adhere to a data backup plan. Maintain multiple copies of all data sets. If an off-site storage facility for data archival is not feasible, a secure, fire-proof cabinet is a small investment. In addition to data backup and archival, a database management strategy must provide for data integrity and security. This is to ensure that data sets are not altered or accessed improperly. Implemented QA/QC procedures, no matter how rigorous, are of no value if not fully implemented and adhered to. As with all components of a multi-participant database management program, documentation of the QA/QC process is a requirement.

The importance of system and data documentation cannot be overemphasized. Often times, documentation procedures are disregarded for reasons such as:

- documentation takes extra time;
- no reason to write it down, it is all stored in my head;
- if anyone has questions, they can ask me; and
- it is my system and/or data, so I do not have to document it.

Proper documentation does take time and often the importance of documentation is not recognized. As personnel changes occur, data collection procedures are altered, and data are exchanged among groups, documentation is the key component linking everything together. Procedures for system and data documentation must be budgeted for when designing the multi-participant database management program.

Data documentation, currently referred to as *metadata*, are "data about data." Metadata provide information as to the characteristics of a data set, lineage of a data set, and contacts for accessing or acquiring a data set. Standardized metadata procedures provide a means to document data sets within organizations, to contribute to and facilitate multi-participant data exchange programs, and facilitate locating, understanding and utilizing existing data sets. The choice of a database structure should not matter as long as the content and structure of the metadata standard are adhered to by those responsible for data collection and management (Federal Geographic Data Committee, 1994). The federal government, through the Federal Geographic Data Committee, as well as state governments, are working to develop standardized metadata procedures that are expected to enhance the use of data, reduce redundancy in data collection activities, and provide a means for determining the usefulness of specific data sets. Based in part on emerging federal guidelines for metadata content, Table 14 lists the contents of the metadata standard in use for several years by the Baruch Institute.

Table 14. Contents of a Metadata Documentation Form

I. Data (general descriptors)
1. Title
2. Code
3. Index terms
4. Entry verification
5. Data set status
6. Last update
7. Documentation status

II. Research origin descriptors
8. Principal investigator
9. Study purpose
10. Experimental design
11. Research methods
12. Site collection and character
13. Data collection period
14. Associated researchers & projects

III. Access descriptors
15. Security restrictions
16. Storage location and medium
17. Contact persons

IV. Physical structure descriptors
18. File names and contents
19. Data type
20. Variable number, code, name, columns, format
21. Relational key indicator
22. Sorting hierarchy
23. Units of measurement
24. Rounding standards
25. Coded variable indicator and code definitions
26. Data anomalies
27. Missing data

V. Source Data
28. Data source
29. Date of acquisition
30. Scale of acquisition
31. Projection information
32. Processing
33. Accuracy -- positional
34. Accuracy -- thematic
35. Copyright status
36. Custodial liability

In addition to the development of data protocol and procedures for QA/QC, a multi-participant database management program can only be successful if participants have access to the data being collected and information being generated. This is the issue of connectivity and communication. Connectivity is the ability to access data and information regardless of where the data are stored and on what type of machine. Advances in hardware, software and telecommunications have eliminated the past bottleneck of communicating across different hardware platforms. Communication is the process of utilizing the connectivity to identify, provide, obtain and exchange data, ideas and information pertinent to effective resource management.

The development of an information hub is one technique used for connectivity and communication. The concept of an information hub should not be confused with the concept of centralized computing. Centralized computing implies a single computer acting as a server to one or more terminals, each of which is dependent upon the server. The role of an information hub is to facilitate coordination and communication within a site and across any number of sites. Although the information hub will be at one location interacting with numerous other groups, the information hub does not take the place of or supersede the existing database management programs of organizations involved in the multi-participant program. At a minimum, the information center coordinates the exchange of data, develops and disseminates standard products and provides documentation.

Data exchange or data dissemination should not be confused with information dissemination. The federal and state governments are working to define the public's right to access data and information under the Freedom of Information Act (FOIA). It is important to be cognizant of FOIA and their potential impact on a multi-participant database management program. The issue of data disclaimers covering custodial liability must also be addressed. There are documented cases of litigation resulting from decisions made by one party based in part or in whole on data or information provided by another party. While the information hub may be set up as a central repository for all collected data, it is not a requirement. Individual participating groups may be inclined to not provide the information hub their data sets. Instead links are implemented so that when a data request is made to the information hub, the transfer of requested data is transparent. No matter what the distribution medium (e.g., CD-ROM, diskette, on-line transfer), always provide associated metadata with data sets.

An information hub can facilitate the exchange of ideas and foster interaction by developing a series of standard products providing for some level of inter-site comparison. The availability and dissemination of standard products can provide an effective tool for facilitating inter-site interaction and communication. The standard products may be as simple as a chart comparing total catch from a two-seam shrimp net tow by geographical region to the development of an on-line atlas providing inter-site comparisons of estuarine water quality. Standard products, regardless of complexity, should provide information important to the overall goal of effective marine resource management. Documentation, as mentioned previously, is the important link that ties everything together. The information hub should be responsible for acquiring, maintaining and disseminating metadata with all data request.

One effective tool for the development of an information hub is a Mosaic-based server. The National Center for Supercomputing Applications' Mosaic is an Internet based global hypermedia browser. Mosaic is available free of charge to academic and research institutions. It provides a hypermedia interface to the various protocols, data formats and information archives used on the Internet. It provides powerful new methods for visualizing, exchanging, and using data and information. Mosaic is capable of accessing data via FTP, Gopher, NNTP and WWW and other data services such as Archie, Veronica and WAIS through gateways. A strength of Mosaic for the development of multi-participant data programs is that it can be run from a variety of platforms including Macintoshes, Windows and Unix-based systems.

Conclusions

The ability to exchange data and information is critical to resource managers and the private sector for effective management of marine resources. A multi-participant database management program can enhance the efforts of resource managers responsible regulating the use of marine resources. By making available data and information not feasible to collect by individual groups, resource managers will have an increased knowledge base for use in their decision making process. The successful development and implementation of a multi-participant database management program must be supported at the appropriate administrative level of participating organizations. A UNA is a first step to identify existing capabilities, infrastructure, needs and expectations of participants. From an assessment of the results of the UNA, program implementation begins with the development of data protocol, procedures for QA/QC, and the design of an information hub that facilitates connectivity and communication through the exchange of data and information. Most important, standardized procedures for system and data documentation must be implemented and adhered to.

Acknowledgments

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SESSION III: DATA ANALYSIS AND ASSESSMENT

A Brief Overview of the Use of Trawl Survey Data for Stock Assessment With Emphasis on the ADAPT VPA Tuning Model

by
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Trawl survey data are an important source of information for stock assessments of fishery resources off the Northeastern United States. In this context, they provide essential information for the development of scientific advice for fisheries management. Trawl survey data can be used to estimate biological parameters such as stock size, age composition, growth rates, mortality rates, maturation rates, and stock distribution. In particular, trawl survey data provide information on relative population size and recruitment that can be used in analytical stock assessments, where a time series of stock sizes is estimated, or in non–analytical, index–level assessments, where stock status is inferred from available information including relative abundance indices.

In the context of analytical assessments, relative abundance data from trawl surveys are often used as tuning indices for virtual population analysis (VPA) with the ADAPT model (Gavaris 1988; Conser and Powers 1990) or as auxiliary information for other age–structured assessment models such as CAGEAN (Deriso et al. 1985) or STOCK SYNTHESIS (Methot 1990). Relative abundance data from trawl surveys can also be used to estimate parameters of surplus production models (cf. Prager 1994) and modified DeLury models (Collie and Sissenwine 1983; Conser 1994). For brevity, the focus in this paper will be on the use of trawl survey data in the ADAPT model.

The ADAPT model is a method to calibrate or "tune" a VPA. The principle basis for a VPA is the relationship between the number of fish alive at the beginning of one year and the number of fish alive at the beginning of the next year for every cohort in the stock. In particular, the number of fish of age A+1 in year Y+1 is equal to the number of fish of age A in year Y that survived fishing and natural mortality. VPA uses this basic relationship to calculate stock numbers at age for each year in the past based on a time series of catch at age information.

The ADAPT model is an age–structured, adaptive framework for estimating historical stock sizes. It was developed in conjunction with stock assessment working groups of the International Commission for the Conservation of Atlantic Tunas and the Canadian Atlantic Fisheries Scientific Advisory Committee. As a result, many scientists have contributed to its conceptual development. The ADAPT model uses VPA calculations of stock numbers at age to predict observed indices of relative abundance at age based upon estimated catchability coefficients and to estimate instantaneous fishing mortality rates (F) in the terminal year of the VPA. Here, minimization of a least squares objective function determines the best estimates of catchability coefficients and terminal Fs. These indices can be developed from trawl survey or fishery–dependent measures of relative abundance. The model does not require an assumption of separability, but does require that the errors in the time series of catch–at–age data are negligible.

A key feature of the ADAPT model is its flexibility. The least squares objective function used for parameter estimation is easy to modify and can include various abundance indices. The software implementation of the ADAPT model can provide numerous diagnostics of the quality of model fit. Residual plots of estimated indices and correlation among parameter estimates are among the diagnostics often used to determine whether a given model configuration is adequate. Thus, in the ADAPT model, the emphasis is on iterative model construction and parameter estimation.

Multiple indices of relative abundance can be used in the ADAPT model. Indices of relative abundance can be derived from recreational and commercial fisheries, or research surveys including larval and trawl surveys. For estimation purposes, each index adds a component to the objective function to be minimized. When indices differ in the quality of the information they provide on relative abundance, a weighting factor can be applied to each index to reduce or to increase its importance in the calculation of the value of the objective function. At present, the weighting of indices in the objective function can be accomplished in a number of ways including inverse variance weights (Gavaris 1988; Conser and Powers 1990) and inverse variance weights with iterative re-weighting (Collie 1988; Conser and Powers 1990). Overall, the determination of weighting factors for tuning indices is an area of ongoing research.

Regardless of the assessment model used to estimate stock size through time, the indices of relative abundance must provide a consistent time series. In the context of trawl surveys, it is essential that a standard survey methodology be maintained through time. If changes in survey procedure are made, the utility of the measurements of relative abundance taken from the survey may be seriously comprised. This could lead to biased estimates of stock size through time. Thus, if a change in survey methodology does occur, it is very important to measure the effects of the change and to adjust the survey time series to a standardized measure of relative stock abundance.

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Application Of Trawl Survey Information In Massachusetts

by
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Introduction

The Massachusetts Division of Marine (MDMF) has conducted annual spring and fall bottom trawl surveys of marine waters within the Commonwealth's jurisdiction since 1978. The survey's objectives include: (1) estimating relative abundance and size composition of finfish and certain crustaceans and mollusks; (2) describing species composition and distribution relative to locality, season, and depth; and (3) collecting information on an ad hoc basis to meet a wide variety of agency management needs. Our survey design and sampling procedures have been described in detail by Howe (1989) and Currier and Depres-Patanjo (1989) at a previous Atlantic States Marine Fisheries Commission (ASMFC) Trawl Survey Workshop (1989). In this paper, I briefly describe our survey design, and report several examples of data use by our fishery managers.

The primary goal of this monitoring program has been to meet agency management needs for concise, timely assessment information, e.g., fisheries-independent trends of abundance of pre-exploitable and exploitable stages of fish. The survey's database has been invaluable for state fisheries management decision-making. Many of the commercially and recreationally important species caught within state waters are a part of stocks with broad geographic distributions. With this perspective, MDMF data has supplemented Northeast Fisheries Science Center (NEFSC) and ASMFC stock assessments in various ways by providing simple index-based assessments (winter flounder, spiny dogfish), recruit and pre-recruit indices for DeLury assessment (American lobster) (Conser and Idoine 1992), and tuning indices for virtual population analyses (summer flounder, Gulf of Maine cod). These results have been used by the ASMFC and the regional management councils in managing interjurisdictional fisheries resources.

Survey Design and Sampling Procedures

Bottom trawl surveys are conducted in daylight during May and September according to a stratified random sampling design. State territorial and internal waters are divided into six depth zones and five geographic sampling regions. The overall number of sampling stations within stratum is proportionately allocated by each stratum's area. Tow locations are pre-selected but alternate locations are chosen if concentrations of fixed gear, or untowable bottom precludes trawling. Fishing gear consists of a 3/4 North Atlantic type two seam trawl (39-ft. headrope/51-ft footrope) equipped with a fine mesh (0.5-in. stretch) codend liner, rubber disc (3.5-in.) chain sweep, wooden doors (6 ft. by 40 in., 325 lbs) and 10 fathom legs. Tow time is 20 minutes at 2.5 knots. Total weight, total number, and length frequency are recorded for most species. Commercially and recreationally important species are sampled for scales and/or otoliths, sex, state of maturity, and presence of gross external pathology.

Survey data are entered on the Woods Hole Oceanographic Institute's VAX computer. Hard parts sampled from selected species are either archived or aged by the NEFSC. Age data are also entered on the VAX. Stratified mean number and weight per tow, stratified number per tow at length, and stratified mean number at age are calculated for various combinations of strata sets using NEFSC SURVAN ANALYSIS program. These data are used to construct various abundance indices for use in assessments.

Caveats

Although trawl survey data can be extremely useful for managers, experience has shown that several caveats are in order. Trawl survey data often contain large amounts of inter-annual variability from various sources. These sources include sampling error, alterations in trawl efficiency, and changes in catchability due to spatial and temporal differences in fish distributions. As a result, single point estimates of relative abundance may be highly uncertain. Time-series techniques exist for smoothing survey data by removing some of this inter-annual variability, but long time-series (>20 points) are generally needed (Box and Jenkins 1976).

Examination of underlying catch distributions (normal, lognormal, etc) before constructing abundance indices (e.g., using log or delta transformation) is also useful for increasing precision (Pennington 1985). Use of the most appropriate measure of central tendency for a given data distribution (e.g., using geometric mean rather than the arithmetic mean for lognormally distributed data) can substantially reduce variance (McConnaughey and Conquest 1993). Catchability and availability of fish to the gear vary by species, resulting in abundance indices that are better for some species than others. Knowledge of the biology, distribution, stock structure, and the fishery along with sampling intensity, and the geographic and temporal scope of the survey increases interpretability of survey abundance indices.

Applications

The MDMF emphasis has been on sampling the state's most important finfish resources: winter flounder (Gulf of Maine and southern New England stocks), summer flounder, Atlantic cod (Gulf of Maine stock), yellowtail flounder (Cape Cod ground group), scup, black sea bass, American plaice, ocean pout and long-finned squid. Indices of abundance for most of these species have shown a decline since time-series highs in the early eighties. Truncation of length frequencies and/or ages in the survey catch at age matrices were also evident for winter flounder, summer flounder, black sea bass, and yellowtail flounder. These declines were also noticeable in commercial landings, and commercial catch per unit effort (CPUE) indices.

The decline of the northern winter flounder stock was of particular concern to state managers because of winter flounder's economic importance to the inshore small vessel fleet, and because most of the stock occurs within state waters during much of the year. A growing market demand for "peewees" (< 10 in.) during the early 1980s and survey results showing that up to 74 percent of the resource was less than 11 in. in some state regions, led to the first size limit. In 1985, a seasonal closure was enacted to remove fishing effort from aggregations of spawning flounders. Observations of winter flounder gonads during the spring survey were used to set the ending date

of the closure. Later, distributions of survey catches of winter flounder were used to delineate a 5-in. large mesh area for flounders and groundfish from a small mesh area for underutilized species.

In 1990, survey data played a major role in an in-house assessment of both stocks of winter flounder. In addition to the construction of overall and age-disaggregated indices of abundances, length-weight equations, discard mortality, maturity ogives, and Von Bertalanffy parameters were estimated from routine and special survey sampling (Witherell and Burnett 1993). An increasing trend in fishing mortality, declines in spawning stock biomass, exploitable biomass, and recruitment were causes for concern (Witherell et al. 1990). Because commercial catch at age data were unavailable at the time, Thompson and Bell yield per recruit and spawning stock biomass per recruit were calculated using length frequencies, maturity ogives and trawl discard mortality rates derived from the survey along with mesh selectivity ogives, estimates of hooking mortality and the BIOREF program (Correia 1991). These analyses were incorporated into the ASMFC Winter Flounder Management Plan (ASMFC 1992). Thereupon, MDMF and the Marine Fishery Advisory Commission enacted several additional regulations including a ban on night-time dragging, adoption of 5-in. diamond mesh codend, 100 lbs. bycatch limit (total weight for all flounder species combined) for all vessels using less than 5-in. mesh, and a seasonal closure with bag limits for recreational fishermen.

Other information such as discard mortality rates of winter flounder, yellowtail flounder and lobster caught during the survey have also proved useful to managers. Although extrapolating survey results to commercial operations is risky, blindly accepting status quo hypotheses because lack of data (e.g., assuming 0 percent discard mortality) can also be risky.

Survey data can also be useful in interpreting fisheries dependent data: inter-annual variation in commercial discard rates can often be interpreted as year-class effects (i.e., discard rates are correlated with abundance of sublegal recruits as measured by the survey). For example, the MDMF sea sampling program recently concluded that discarding of sublegal winter flounder in the small mesh squid fishery was not significant in 1993. This conclusion was challenged by some anglers on the grounds that the discard rate was artificially low because flounder abundance was at an all time low. Survey data indicated that although adult abundance was at an all time low, abundance of sublegal fish was a time series high, therefore the low discard rate of sublegal winter flounder could not be attributed to low abundance.

Another example of our trawl survey's use in fisheries management involved evaluating the conservation benefits of proposed inshore mobile gear closures. Supporters of a 1993 petition, consisting mostly of recreational fishermen, claimed that the intense small mesh squid fishery that occurs in May is the cause of decreased abundance of certain sportfish species. Proposed mechanisms included harvest/discard of finfish, disruption of food chain by removal of "bait" species, and destruction of eel grass beds. Our research trawl indices, landings of squid and other bycatch species, and effort data were integrated in a study to evaluate the proposed closure. The abundance of bycatch species as measured by survey catches in the areas open to trawling were compared with survey catches in existing closed areas using ANOVA and Wilcoxon tests. Several bycatch species were more abundant in the existing closed areas; others were more abundant in the open area, suggesting that habitat differences were more important in determining local abundance.

Regressions of either local squid effort or landings on our local indices of abundance were not significant, but significant negative relationships existed between our local survey indices and trawl effort on Georges Bank and southern New England. Inferences of causal relationships between the squid fishery and decreased finfish abundance were not supported (Cadrin et al. In Prep). These conclusions resulted in a decision to enact a much smaller areal closure to protect eelgrass beds rather than increase population abundance of various finfish.

Parameters of growth, size and age of maturity, partial recruitment vector, and fishing mortality estimated from the survey were used in an egg per recruit analysis to assess how changes in fishing mortality and age-0 survival impact egg production of winter flounder (Boreman et al. 1993). The analysis compared the change in potential egg production of an age-1 female resulting from changes in age-zero survival, presumably due to habitat alterations, versus changes in fishing mortality. The authors concluded that either restoring habitat or preventing further habitat degradation may result in longer term benefits to this species' reproductive success and provide a firmer basis for increasing fishery yield.

Since the early 1980s, the survey program has also been instrumental in facilitating research on habitat matters such as determining and commenting on fish abundance and distribution at existing and proposed dredging and spoil sites (Howe et al. 1982); researching incidence of fish disease (Ziskowski et al. 1987) and hepatic neoplasia resulting from chronic contaminant exposure (Sass and Murchelano 1986); and, providing samples to monitor various contaminant levels in edible fish and lobster tissues (Schwartz et al. 1991, 1993). Other departmental sampling requests are also fulfilled by the survey. For example, water samples are collected for bacteriological analysis as part of MDMF Shellfish sanitation and management efforts. The survey has also served as a source of specimens requested by researchers from other state and federal agencies, and academia.

In summary, the Massachusetts trawl surveys provide information on relative abundance, recruitment, population age/size composition, growth, maturity, and mortality for species inhabiting or transiting state waters. This information, used alone or in conjunction with other survey and commercial data, has proved invaluable for fishery managers.

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Uses of Trawl Survey Data Beyond Traditional Stock Assessment Applications

by
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ABSTRACT

The objective of this presentation is to demonstrate imaginative and creative applications of trawl survey data, in addition to those techniques that have been associated historically with stock assessment efforts. Four recent case studies, all conducted by the National Marine Fisheries Service's James J. Howard Marine Science Laboratory -- will be used to demonstrate various applications of trawl survey data. Brief descriptions of the case studies follow:

- **12-Mile Dumpsite Recovery Study (1986-1989)**: This 39-month study was conducted cooperatively among the National Marine Fisheries Service (NMFS), the Environmental Protection Agency (EPA) and academia. The study was designed to ascertain changes in the flora and fauna of the New York Bight Apex after the cessation of sewage sludge dumping at the site. Emphasis is placed on the results of the finfish and megainvertebrate portion of the study.

- **106-Mile Deepwater Dumpsite Study (1989-1991)**: This two-year study, conducted by the National Oceanic and Atmospheric Administration and EPA, was designed to detect the effects of sewage sludge dumping site located beyond the continental shelf 106-miles off the coasts of New Jersey and New York. Specific emphasis is placed on the megafauna and lobster disease segments of the study.

- **Hudson-Raritan Estuary Study (1991-present)**: This NMFS multi-year study is designed to define functional value and life history linkages between various habitats. The findings of this study are compared to those of similar studies conducted in the estuary from 1974 to 1976, and in the adjacent nearshore waters from 1989 to 1991. Emphasis is placed on the study's progress to date in defining the function and linkage of nearshore, open estuarine, and riverine-estuarine habitats.

- **Newark Bay Ecosystem Study (1993-present)**: This two and a half year U.S. Army Corps of Engineers study, funded through a grant of the Passaic River Flood Control Project, is designed to biologically and hydrographically characterize the riverine-estuarine Newark Bay ecosystem. Emphasis is placed on a discussion of the study's objectives, sample design and preliminary results. The study area is considered to be one of the most highly degraded and industrialized areas in the world.

SESSION IV: SURVEY TECHNIQUES AND NEW TECHNOLOGIES

Effective Sample Size and Precision of Marine Surveys

by
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Introduction

The Northeast Fisheries Science Center conducts intensive bottom trawl and dredge surveys of the Atlantic shelf from the Gulf of Maine to Cape Hatteras, North Carolina, an area of nearly 75,000 square miles. The survey region is subdivided into sampling strata whose geographic and depth boundaries are broadly related to fish distribution. Within a stratum, stations are chosen randomly and at each station selected the trawl is towed for thirty minutes or, for shellfish surveys, a dredge for fifteen minutes. The size of the sampling unit, i.e. the area swept by the trawl, for a standard trawl haul is approximately 34,350m^2 and 3,954m^2 for a dredge station. Survey procedures and equipment are kept as uniform as possible over time. For further details on the design of the surveys see Grosslein (1969), Azarovitz (1981) and Serchuk and Wigley (1986).

The purpose of these multispecies surveys is to generate indices of stock abundance and to estimate population characteristics such as length and age distributions, dietary patterns and growth rates. This fishery-independent information is essential for managing the commercially important species (Clark 1981) and for understanding the entire ecosystem. For example, the surveys provide estimates of recruitment for stock assessments and inputs needed for mathematical models of the ecosystem.

Though useful, survey estimates of population parameters are not particularly precise given the high cost of these surveys. For example, the average catch per tow is used as a measure of relative abundance. It generally tracks trends in abundance, but the standard error of the yearly estimates ranges from 25 to 50 percent of the mean (see, e.g., Pennington 1985, 1986; Pennington and Godø, 1994). In general, the variance of survey estimates is a function of the effective sample size for estimating the parameter of interest.

Effective Sample Size

The precision of abundance indices are inversely related to the square root of the number of stations sampled. Thus the effective sample size for indices, such as estimates of the average catch per tow, is simply the number of tows. That is, the tow is the primary sampling unit and the number of fish caught is the random variable. The precision of the survey indices will increase if the number of tows taken is increased. But this may not be a particularly efficient way to improve survey precision since for many species, survey catchability appears to change from year to year. If catchability does vary through time then increasing the number of stations will only reduce the

variability caused by within survey differences in catches, but not that caused by changes in catchability, which may be the source of 50 percent of the variability of survey indices (Pennington and Godø, 1994).

Determining the effective sample size for estimates of populations characteristics, such as age or length frequencies or average stomach contents, is not as straight forward as that for estimates of mean catch per tow. This is because we are trying to estimate attributes of a population made up of individuals, e.g., mean weight per fish, but the individual fish are not selected at random, they are caught in groups or clusters at each station. That is, the sample consists of a number of clusters of fish each collected at one of the stations in the sample. Fish caught together at a location tend to have similar characteristics. For example, the fish may have been eating the prey available at that station (see Bogstad et al. 1994). The tendency for fish to be more alike in a particular spot than those in the general population means that the effective sample size will be less than the actual total number of fish collected. But for cluster sampling, what then is the effective sample size?

The easiest way to define effective sample size is to say it is the number of fish that would be needed to obtain the same precision if the fish were sampled randomly. For example, suppose we are estimating the length frequency distribution of a fish population using survey data. Then since the fish were caught in clusters, the appropriate estimate of the population's mean length is the ratio estimator

$$\overline{x_r} = \Sigma\Sigma x_{ij} / \Sigma m_i, \quad (1)$$

where m_i is the number of fish caught at the ith station and x_{ij} is the length of the jth fish at station i. The expected variance of equation (1) is given approximately by (Pennington and Vølstad 1994)

$$\sigma_x^2\{1+(\overline{M}-1+\sigma_m^2/\overline{M})\rho\}/\overline{M}n, \quad (2)$$

where $\overline{M}$ and σ_m^2 are the mean and the variance of m_i, ρ is the intra-haul correlation coefficient (i.e. a measure of how similar in length fish caught together are), σ_x^2 is the population variance of fish length and $\overline{m}n$ is the number of stations in the survey. Now if n fish could be sampled at random from the population then the variance of the estimate of mean length would be just the usual estimator, the variance divided by the sample size or

$$\sigma_x^2/\overline{m}n. \quad (3)$$

From equation (2) it can be seen that if ρ is zero (that is in terms of length the population is well mixed) then random sampling of individuals and cluster sampling would have the same

sampling variance. If $\rho > 0$, then the variance from cluster sampling [equation (2)] will be greater than that from sampling the same number of fish randomly.

The effective sample size is defined to be the number of fish that it would be necessary to sample randomly to get the same sampling variance as that obtained by the cluster estimate of mean length [equation (1)]. To estimate the effective sample size, the variance of (1) is first estimated and then equation (3) is used to estimate how many fish would be needed if sampled randomly from the population to get the same variance. This number is the estimate of the effective sample size (see Pennington and Vølstad 1994 for details).

As an example, in Table 15 are estimates of the effective sample sizes for estimating the length frequency distribution of Georges Bank haddock (last column). As can be seen, these survey based estimates of mean length also appear to be quite imprecise. That is, even though thousands of fish may be measured during a survey, the effective sample size for estimating length frequencies distributions is often as few as twenty individuals, which is less than the number of stations at which haddock were caught (Table 15 is from Pennington and Vølstad 1994). This low precision is caused by the highly variable density of the stock over the Bank and by the tendency of fish that are caught together to have similar length (i.e. the problem of intra-cluster correlation, see Pennington and Vølstad 1994).

It should be stressed that it is not only the mean length which is imprecisely estimated but the entire length distribution. That is the effective sample size is a measure of how well the length distribution is known. To see this, consider Figure 48. The stations sampled in 1967 were randomly split into two groups. The two splits are from the same distribution and therefore are NOT statistically different even though they appear to be quite dissimilar.The same was done for 1978. In 1978, 175 stations were sampled, which is more than twice the number of stations that is usual in a standard survey. Therefore, splitting the data (the stations) in half gives an example of the variability of estimates produced by a standard survey. Examining Figure 49, it is quite clear that the two surveys would have produced much different estimates of the relation between the two modes. But again, the two random splits are not statistically different. It is just an example of what it means to have a sample of 4353 fish that is equivalent to an effective sample size of only 16 fish (Table 15).

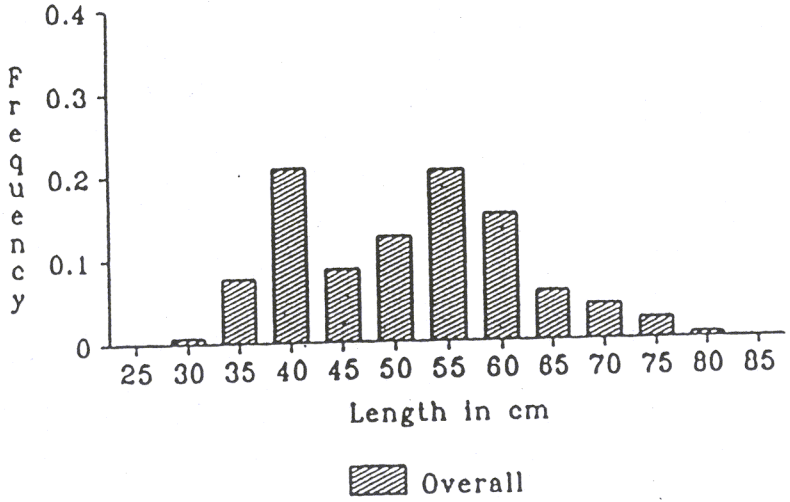
Discussion

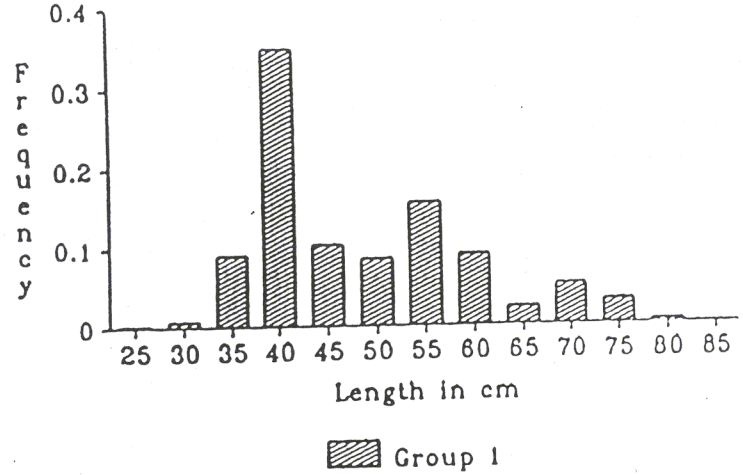
What is often done in practice to compare length frequencies distributions from data collected in clusters is to use the Kolmogorov-Smirnov test to compare the two distributions. If, for example, this test is used to compare the random splits in the previous examples, the K-S test would indicate that the two distributions are highly significantly different even though they are obviously NOT statistically different. The problem is that the critical assumption for the K-S test to be appropriate, which is often ignored, is that the fish have to be a RANDOM sample from the population. But again, the fish were collected in clusters, not selected randomly.

Table 15. Summary statistics for estimating the mean length of haddock on Georges Bank.

Year	n	Num. of non-zero tows	$\bar{x}_r$	Estimated S.E. Approx.	Jack	Eq.(2)	Total num. of fish	Random sample
63	73	62	25.3	2.4	2.6	3.2	7083	38
64	73	60	33.7	1.1	1.1	1.4	8411	83
65	76	67	38.9	0.6	0.6	1.0	4725	152
66	74	53	40.0	2.8	3.1	2.4	1505	20
67	78	59	49.2	2.8	3.4	2.4	893	10
68	80	36	57.0	1.0	1.0	1.9	414	97
69	84	36	52.8	3.2	3.4	3.9	157	29
70	81	40	50.7	3.1	4.8	4.7	450	9
71	84	40	34.8	6.4	7.3	6.1	279	13
72	85	49	28.6	3.5	4.0	4.5	639	24
73	84	31	34.8	2.5	2.7	4.0	796	33
74	85	32	38.8	3.2	3.6	4.0	247	21
75	84	58	24.6	4.7	5.3	4.6	1955	12
76	78	36	34.6	0.8	1.0	2.8	3727	56
77	112	56	45.2	0.7	1.2	2.1	4688	28
78	175	124	33.1	4.2	4.7	4.3	4353	16
79	171	100	35.4	0.5	1.3	3.8	12208	28
80	102	62	29.3	5.0	6.5	5.1	3927	7
81	82	43	43.9	1.9	2.1	2.2	930	33
82	79	40	45.8	4.3	4.8	4.7	381	16
83	81	52	32.5	3.4	3.7	4.2	772	25
84	80	30	37.0	2.0	2.9	3.7	576	12
85	77	41	25.6	2.3	2.9	3.9	1136	21
86	79	22	39.9	2.8	3.6	3.8	679	9
87	77	25	31.2	7.1	10.7	7.3	419	3
88	77	25	43.1	3.3	3.8	3.5	592	12
			Avg.	2.92	3.54	3.62		

Figure 48. Length-frequency distributions of haddock (group 1, 2 and overall) for 1967.





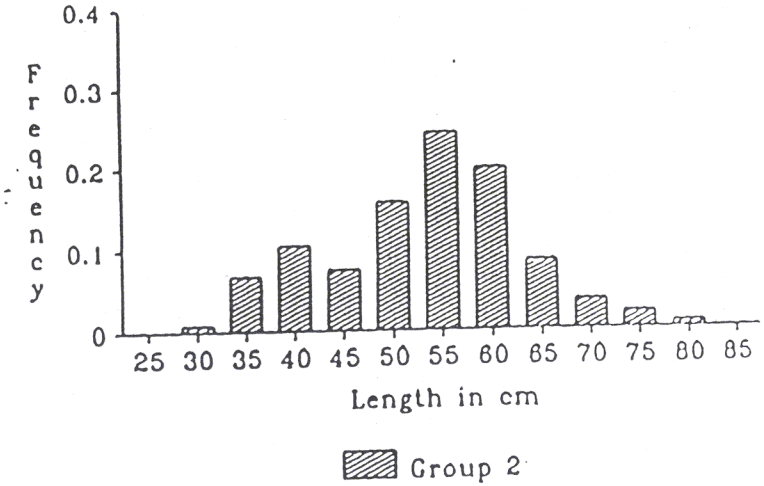
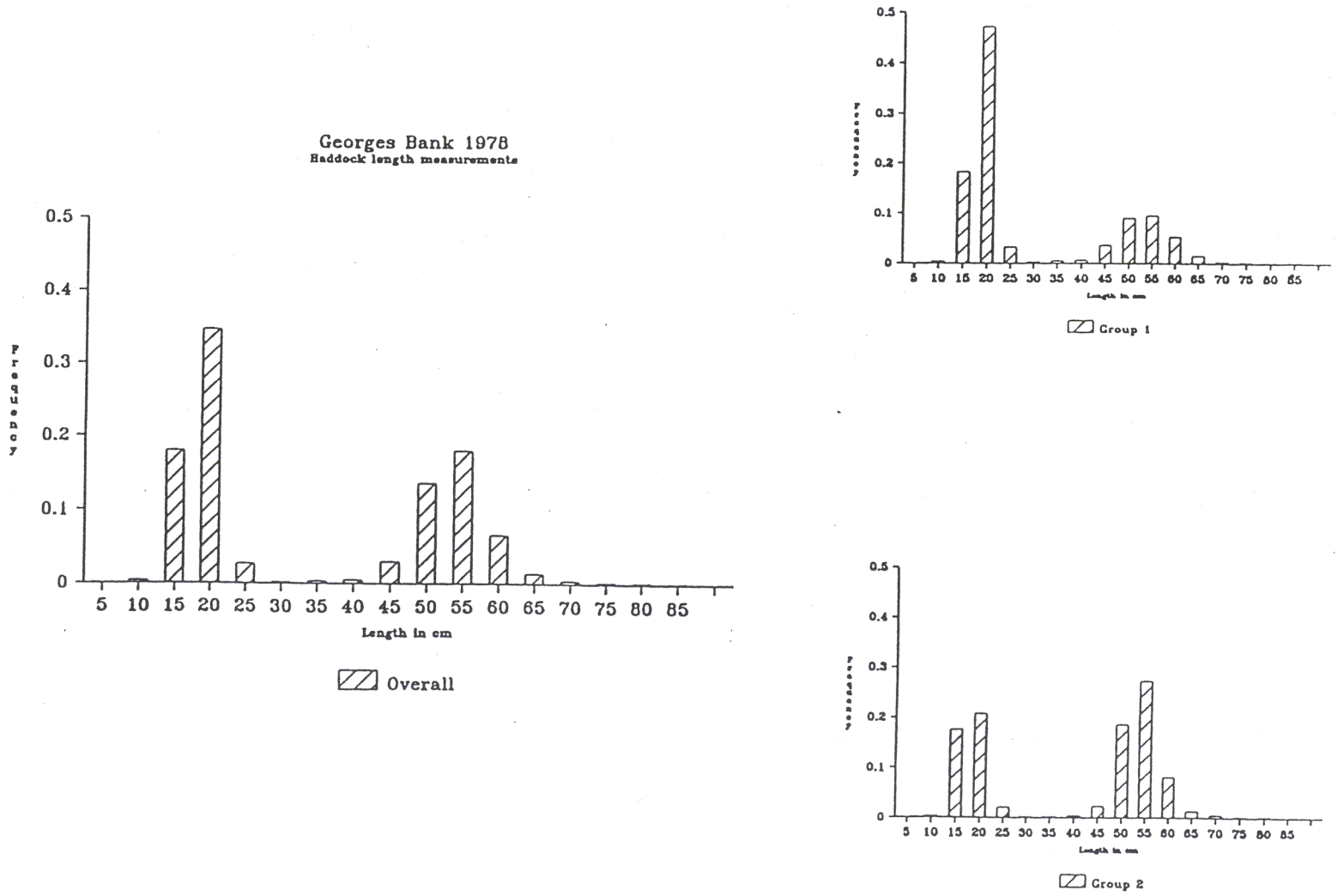


Figure 49. Length-frequency distributions of haddock (group 1, 2 and overall) for 1978.



One way to increase the effective sample sizes and hence improve survey precision would be to reduce tow duration, say to five minutes for dredging and ten minutes for trawling, and use the time saved to sample at more stations (Pennington and Vølstad 1991, 1994). In light of the present variability of most survey estimates, there is little risk that the consistency of an historical survey time series would be significantly compromised. There are at least two ways to implement the changes. Tow duration could be reduced at all stations or at a random subset of the stations. For the latter strategy, the proportion of shorter tows, if they are effective, would be increased over time, i.e. the effect of reduced tow duration on survey reliability and efficiency could be monitored while evolving the survey toward an optimal design (see Box and Draper 1969).

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Northeast Fisheries Science Center Survey Vessel and Gear Research

by
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Introduction

The Woods Hole Laboratory of the National Marine Fisheries Service has conducted standardized bottom trawl surveys since 1963. The methods and history of the time series are documented earlier in this report (see SESSION I: Review and Comparison of Atlantic Coastal Trawl Surveys). Since the beginning of the time series, considerable effort has been directed towards maintaining standardized survey design and operational protocols. The maintenance of standards has been complicated by many operational changes, which were unavoidable during a time series lasting more than three decades. Effects of these changes were in most cases insignificant, but a few were judged important enough to warrant detailed study and evaluation.

The following paper summarizes Northeast Fisheries Science Center (NEFSC) efforts to assure integrity of the survey time series by monitoring trawl performance, and by evaluating the effects of two changes with the potential to significantly affect survey catch rates, these being: (1) the use of two different research vessels, and (2) the use of two different trawl door types.

Monitoring/Standardizing Trawl Performance

To support standardization objectives, commensurate with the beginning of the fall bottom trawl survey series in 1963, a third wire acoustic mensuration system was developed to test and evaluate trawl performance. One objective was to constantly monitor performance during survey operations, but the system proved to be too cumbersome and lacked the necessary ruggedness to achieve that goal. Instead, during the 1970s special cruises were conducted using the third wire system to certify the performance of each trawl prior to survey use. Once a trawl was tested, it was bundled and stored for future use. This procedure later was discontinued since trawls were never found to perform outside of established criteria. In retrospect constant trawl performance should not have been unexpected, since all were (and continue to be) constructed according to rigid specifications by experienced NEFSC gear specialists.

Almost ten years later, a ruggedly constructed wireless performance monitoring system (SCANMAR) became available. Once again, monitoring of gear performance in real time seemed achievable. The first units were deployed in October 1984. Although accurate headrope and wingspread measurements were obtained, the equipment did not prove sufficiently reliable for routine survey use. Therefore use of SCANMAR gear was not required in standard sampling protocols. Currently, this system is used to test and verify trawl performance during special gear testing cruises and periodically during routine survey operations. However, real time monitoring of trawl performance would be highly desirable and remains a program objective.

Relative Fishing Power - Research Vessels

The use of a single vessel is a desirable (but difficult to achieve) goal for any long-term standardized time series. The *NOAA R/V ALBATROSS IV* has been the primary NEFSC survey vessel although the *NOAA R/V DELAWARE II* has also been used.

The *ALBATROSS IV* is 57 meters (m) long and displaces 988 metric tons (MT); the *DELAWARE II* is 47.2-m long and 688 MT. The vessels are of comparable horsepower but the size differential and rigging differences indicated the possibility of significant fishing power differences. When it became necessary to substitute the *DELAWARE II* for *ALBATROSS IV* due to breakdowns or other survey commitments and it was determined that such substitutions would likely continue, a study of the relative fishing power of the two vessels was initiated.

Research vessel fishing power work began in 1980. The initial experimental protocol was a totally random design. Both vessels fished independently at randomly pre-selected stations within a 10 X 10 nautical mile (nmi.) study area. It was found, however, that an important basic assumption was violated; this being that several important target species were not randomly distributed throughout the study area. Consequently, variability in trawl catches was too great to detect vessel differences, and accordingly, it was determined that a paired tow approach would be more effective. Subsequently, *DELAWARE II* accompanied the *ALBATROSS IV* during bottom trawl surveys. Using this protocol, 510 useable pairs of tows were completed during five seasonal surveys. Analyses of the resulting data revealed significant differences in terms of total weight and numbers for all species combined; and individual species differences were also found, which were expressed as vessel fishing power coefficients. Since the *ALBATROSS IV* continues to be the primary bottom trawl survey vessel, survey results are now standardized to the *ALBATROSS IV* (i.e. multiply *DELAWARE II* catch per tow by the appropriate vessel fishing power coefficient to yield the corresponding *ALBATROSS IV* catch). For more information, see Byrne and Forrester (1991), Table 1.

Relative Fishing Power - Trawl Doors

BMV trawl doors were used from 1963 through 1984. These were flat, oval shaped, trawl doors constructed of wood and steel. After it became apparent that the manufacturer could not continue to provide trawl doors built to the required specifications, a search was initiated in 1982 to find a replacement door. Several door types were evaluated and steel polyvalent doors were selected. These doors are rectangular in design with a rounded front end and a cambered surface. This design was selected for the following reasons: (1) they were simpler to construct, and could be built locally in the event that the manufacturer implemented design changes design over time; (2) the design was easier to use than other designs, therefore reducing chances for increased variability in performance; (3) they were easy to store due to folding brackets; (4) they were relatively inexpensive; and, (5) during field trials they produced a more similar trawl geometry (mouth width and height) to that yielded by the BMV doors than other door types tested. Another important consideration was their wide use and acceptance by east coast fisherman.

Testing began in 1983; and it quickly became apparent that the new doors fished differently and the difference would have to be quantified. Cruises designed to study this problem continued until 1993.

To evaluate differences between the two door types a series of randomized block experiments were conducted. Tows were selected randomly in a series of 5 x 5 nmi study areas. Trawl door types were changed every 6 hours. Four tows were made within each 6 hour period. After four, six-hour periods were completed, the random tows were repeated with the opposite trawl door type in the same time slots occupied the day before. After spending 48 hours in a study area, a new study area was selected. This design yielded pairs of tows that were equal with respect to species availability, bottom type, direction of tow relative to tidal currents and time of day.

Significant differences in the relative fishing power of the two types of trawl doors in terms of both total weight and numbers for all species combined were detected. In addition, species specific differences in weight and/or number were detected for several species, which were expressed as door fishing power coefficients. Since polyvalent doors will be used for the foreseeable future, results of these analyses are standardized to polyvalent doors (i.e. multiply BMV results by the corresponding door fishing power coefficient to yield the standardized catches using polyvalent trawl doors). For more information, see Byrne and Forrester (1991), Table 2.

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Comparison of Relative Fishing Powers of Two Research Vessels

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ABSTRACT

Simple linear regression in arithmetic and natural logarithmic scales was used to analyze catch rates of twenty-two taxa which comprised 91.2 percent of all organisms caught by research vessels *Tommy Munro* and *A. E. Verrill* in 40-ft shrimp trawls. Analyses resulted in significant regressions for all taxa with squid, large-scale lizardfish, lesser blue crab, Gulf butterfish, striped anchovy, and Atlantic bumper showing significant differences between vessels. Although analyses indicated significant differences for squid, Gulf butterfish, striped anchovy, and Atlantic bumper which are considered to be pelagic in habit, no significant differences were found for three other pelagic taxa. Similarly, significant differences between vessels were found for two benthic taxa, largescale lizardfish and lesser blue crab, but no significant differences were found for 13 additional benthic taxa. Neither vessel consistently outfished the other among the six taxa whose analyses showed significant differences between vessels. In another experiment in which similar nets were towed from one vessel thereby removing vessel effects, a similar percentage of analyzed taxa showed significant differences between nets.

Analytical results led to the conclusion that there was no appreciable difference in overall fishing powers of *R/Vs Tommy Munro* and *A. E. Verrill*. This conclusion was based on the following observations; (1) the relatively few number of taxa for which significant differences were found between vessels, (2) for two taxa significant differences were found in one mathematical scale but not the other, (3) the inconsistent results with respect to taxa occupying pelagic and benthic habitats, (4) and neither vessel consistently outfished the other.

Hydroacoustic Techniques Can Complement Trawl Surveys

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Historically, many bottom trawl surveys were initiated to develop indices of relative abundance that would minimize the possible fish size and effort distribution biases of fishery-dependent samples. To such ends, biologists standardized nets and trawling procedures of fishery-independent surveys often using smaller mesh to catch juveniles; some even hoped that a more efficient method would be developed. The early development of hydroacoustic fish counts and biomass estimates suggested that science was on the verge of an accurate, real-time and remote method for assessing fish populations that might replace trawling. Although the advantages of acoustic methods seemed endless (rapid, large scale coverage in continuous data sets), the technique's inability to positively identify fish to the species level limited it's widespread acceptance. Since then, significant progress has been made in the application of acoustics to stock assessment by many dedicated scientists. Therefore, I believe that hydroacoustic techniques should be reconsidered as one of many possible methods to complement fishery-independent trawl surveys to produce more comprehensive estimates of population status.

Prior to designing a trawl survey, hydroacoustics could be used to determine fish distributions and movement patterns related to habitat types or environmental factors. Environmentally related distribution information might, then, allow the development of a sampling design which incorporates population level responses to bathymetry, rocky outcrops, water temperatures, etc. For example, the detailed movements of cod from cold, deep, spawning grounds across the Newfoundland shelf to shallow feeding grounds was determined by acoustic surveys (Rose 1993). Beside the valuable knowledge that fish crossed the shelf, primarily in several deep channels, Rose (1993) provided details on cod spawning aggregations, size/migration hierarchy and school response to prey species which added to the biological story. Each detail of life history or behavior could contribute greatly to the design or rational interpretation of results from a trawl survey. After fish distribution and movement patterns are understood, then trawl surveys could contribute to the confirmation of fish densities to be combined with acoustic distribution information or selectively sample for size and age composition.

Trawl surveys should be designed to sample strata of similar characteristics, such as depth and habitat type. Knowledge of habitat and environmental variables increases the possibility of correlating fish catch with those variables. In many cases, the marine environment is quite variable in time and space, thereby increasing a biologists need to understand species habitat preferences. Habitats that differ in relief or texture can be mapped with side scan sonar systems which are capable of identifying detailed bottom properties that may greatly influence fish distributions. In fact, many bottom types and some large fish or fish schools can be easily detected with high resolution side scan sonars (Fish and Carr 1992). Direct relationships between fish distributions and bottom configurations will require more experience differentiating a fish echo within echo

returns from complex bottom structure prior to allowing routine application of high resolution sonars in a fisheries survey mode.

Often, species of interest are located in high relief habitats that are difficult or dangerous to trawl. In these cases, near-bottom species, such as some snapper and grouper, might have to be assessed with alternative techniques. An alternative being developed by biologists at the National Marine Fisheries Service's Pascagoula Laboratory combines the wide coverage advantages of hydroacoustic methods with the species recognition advantages of visual counts from underwater television (UWTV) (Gledhill et al. Unpublished manuscript). By using UWTV, adequate estimates of species composition can be determined and fish behavior can be observed. Simultaneous acoustic transects should allow extrapolation of visual data to a larger area around and above the UWTV. Each gear adds valuable quantitative and/or qualitative information to an assessment, which is not completely obtained by the alternate gear. As with any new application of techniques, problems must to be identified and addressed while field sampling and analyses need be standardized. Solutions to the problems presently identified for integrating UWTV and acoustic assessments do exist and will be systematically found as application of the complementary techniques evolve.

Assessments of fish populations from high relief habitats with acoustics and/or UWTV might be even more comprehensive by inclusion of information from off-bottom trawls, which could sample those species that remain a distance above the rocky outcrops and associated interstitial spaces. Off-bottom trawls elude some bottom fouling by supporting the net above the footrope via vertical spacers (bobbins) while truly mid-water trawls have some degree of depth control. To sample near high relief, the cod ends of off-bottom or mid-water trawls might require funnel structures or "flappers" (Cummins et al. 1962) to contain or "trap" more rapid swimming reef species. In this example, a reef fish community might be more fully assessed by combining results from three techniques. Interrelating quantitative data from acoustic, UWTV and trawl catches into a single index or estimate would require some standardization of techniques and software development, but it seems feasible in this age of complex problem solving by computers. Other possibilities with application of present acoustic techniques prior to or in combination with trawl surveys to enhance the final population assessment are limited only by the imagination (and budgets) of the trawl assessment research staff.

In some cases, when specific conditions exist, hydroacoustic methods can produce high quality fish counts and biomass estimates that are more cost effective than trawl assessments. Mid-water species are common targets of echo integration surveys that produce estimates of total stock biomass for fishery managers. Conditions that contribute to successful application of acoustics include a widely distributed species which are: (1) acoustically identifiable by size and/or distribution/behavior characteristics; and (2) of known proportional species composition. Hydroacoustic assessments have been successfully conducted on walleye pollock populations in the Northern Pacific by NMFS Alaska Fisheries Center for many years (Karp and Traynor 1989, Traynor, et al. 1990). Even under conditions ideal for hydroacoustic surveys, trawls may be used throughout a survey to confirm necessary information on species composition, population size and age structure, etc.

To accomplish stock assessments which include information from both trawl and acoustic surveys, a more traditional fisheries biologist may have to communicate with biophysics "wizards." As surprising as it may seem, these two groups of scientists have been known to successfully collaborate on fisheries assessment problems. The end result is often a survey design and/or results superior to those possible with either expert working independently. Many large scale biological field questions would benefit from innovative integration of several approaches to obtaining the best answers.

Although bottom trawls may remain the most effective means of assessing the population status of some multi-species groundfish communities, they may have some negative aspects which should inspire consideration of alternative techniques. Any form of removal gear used in research both reduces the often already small population size and competes with fishermen. Fishery biologists directing trawl surveys and concerned with resource conservation should investigate ways of reducing any negative effects of their trawl surveys including excessive mortality of target and bycatch species. In addition to the application of improved techniques to complement trawl surveys, new methods should be explored, as they become available, to address some of the time series questions in a fishery independent mode.

Ultimately, population assessments, resulting from trawl and/or acoustic methods, can contribute more than periodic sources of information for use by fishery managers to regulate specific fisheries. Properly designed assessments can be incorporated into predictive models of fishery production reflecting environmental (density independent and dependent) factors. The estimates of fish abundance, densities and biovolume from hydroacoustic data can often be combined with other forms of information and expanded to address complex questions. Luo and Brandt (1993) related fish abundance determined by dual-beam echosounder transects in the Chesapeake Bay with a detailed growth model to estimate both production and consumption of the bay anchovy.

In conclusion, I suggest that administrators and/or biologists responsible for fishery-independent population assessments, especially trawl surveys, consider some complementary application of hydroacoustic techniques. The selection of the specific technique would require careful consideration of the system capabilities presently available and the population questions being addressed. Acoustic data might be used primarily to assist biologists in understanding movement patterns, and thereby provide data for trawl survey design. Acoustic data could be used to improve the cost effectiveness of trawling by directing samples to important areas. Continuous acoustic data might address fish distributions at spatial and temporal scales far greater than that possible with intermittent trawl samples. I am enthusiastic about new efforts to combine results from hydroacoustic data sets and UWTV counts. In the future, some fish populations may be monitored during their movements past a critical location where a remote combination of sensors send the continuous indices of abundance to a computer on the shore. This temporal acoustic technique is already being applied to estuarine and offshore plankton populations with multi-frequency systems similar to that described by Mitson and Holliday (1990). I encourage population biologists not to pass up any opportunity to improve abundance estimates because of a familiarity with traditional techniques.

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SESSION V: WORK GROUP DISCUSSIONS & DEVELOPMENT OF WORKSHOP RECOMMENDATIONS

Summary of Work Group Discussions and Recommendations

by
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In order to synthesize all the information that was presented over the first two days of the workshop and develop recommendations for future actions, workshop participants met for a half a day in work groups to discuss issues associated with data utilization, data management, trawl survey logistics and regional coordination. Specific issues addressed under these topics included: survey coordination, data accessibility, data collection and documentation protocols, quality assurance and quality control (QA/QC) measures, common data elements, and communication among data collectors, users and managers. The focus of the discussion session was to determine the current status of trawl survey utilization, data management, logistics and regional coordination and identify future goals. The outcome of the session was the development of actions that need to be taken in order to achieve the identified future goals.

Establish Oversight Committee

The most significant recommendation that arose from the discussion session called for the establishment of a "committee," composed of state, federal and regional interests, to improve coordination and communication among data collectors, users and managers along the Atlantic coast. The first recommended action for the committee to undertake was to conduct a user needs assessment, surveying all possible data collectors, users and managers to identify : (1) data uses (i.e., stock assessment, management programs, research); (2) data management systems (hardware, software, networks and operating systems); (3) how data requests are handled and in what format?; (4) extent and type of documentation (changes in survey methodologies, data codes); (5) error checking mechanisms (i.e., data validation, QA/QC); (6) sampling strategies; and (7) user expectations/needs of the data management system for both primary and secondary users.

From the findings of the survey, the committee could then develop a data exchange protocol that would allow for the transference and conversion of different data formats to a common format. It was also recommended that the committee serve as an information nexus -- linking data collectors, users and managers and providing regional coordination. Other suggested committee responsibilities included oversight of survey documentation procedures and fishery-independent data needs for stock assessments and other fishery management techniques, which includes ensuring timely data dissemination to assessment groups and other data users.

Three other major workshop recommendations which might well fall under the purview of the committee, were to: (1) develop a "Guide to Fishery-Independent Surveys; " (2) continue a workshop type forum for the exchange of information on trawl survey and other fishery-independent data programs; and (3) coordinate efforts among the data collectors, managers and users to seek long-term funding for survey programs. There was a general consensus among workshop participants that there is no one source (i..e., contact, publication) where researchers or

managers can turn to access and assess the current state of information available from fishery-independent surveys (including, but not limited to, trawl surveys). A "Guide to Fishery-Independent Surveys," which provides a list of all the fishery-independent surveys that are being conducted along the Atlantic coast would go a long way towards filling this information void. The Guide, much like this proceedings, would contain information on the type of survey being conducted (survey purpose, design and methodology, area of study, time series, routinely collected data), documentation parameters and procedures (including QA/QC methods), and the use of data in fisheries management (analysis and assessment methodologies). Most importantly, the Guide would provide a contact person for each survey.

Workshop participants agreed that a workshop type forum for the exchange of information on trawl survey and other fishery-independent data programs should be conducted at least every four years. The workshop format was found to be an excellent way for all interested parties to come together to exchange information and technology advancements, and identify current data management and use needs.

Workshop participants were also in agreement that in order to be successful for fishery management purposes, fishery-independent surveys require the long-term commitment of data collectors, managers and users to seek long-term, dedicated funding for survey programs (including provisions for operational and administrative costs). It was suggested that the best way to coordinate such efforts is through the interstate commissions.

General Recommendations

The remaining workshop recommendations were geared toward researchers who are either currently conducting, or planning to conduct, trawl surveys:

- Time series should be standardized as much as practical and all changes in time series should be documented, including any changes in QA/QC measures.

- Gear changes should be avoided as much as possible. When changes are necessary determine the appropriate calibrations prior to incorporating the new gear.

- Common data elements that should to be collected at each trawl station, include: location, hydrographic and atmospheric conditions, and catch (total catch, total biomass, length) . Additionally important information to collect, include: individual species weights, age data, gonadal development. Subsampling should be performed following accepted guidelines.

- Although standardized gear among all surveys is neither necessary nor probable, states with shared borders, common concerns and similar species compositions should try to coordinate efforts and use similar gears and methodology.

- In general, random stratified surveys give more flexibility to answer questions which may come up in the future.

- Obtain consistent funding in order to build and maintain effective programs with state of the art equipment.

All of the above recommendations will be presented to the Atlantic States Marine Fisheries Commission's Management and Science Committee for consideration at its next meeting, during the summer of 1995.

APPENDIX A

LIST OF WORKSHOP PARTICIPANTS

Appendix A

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Appendix B

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APPENDIX C

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Appendix C

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