Chesapeake Bay Stock Assessment Committee

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NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION

Chesapeake Bay Stock Assessment Committee Annual Report 1989

June 1990

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

in association with members of the
Chesapeake Bay Stock Assessment Committee

Since 1985, NOAA has received approximately $1,600,000 per year for Chesapeake Bay fisheries stock assessment, environmental effects research, remote sensing, and data management. NOAA's Chesapeake Bay Study is administered by the Northeast Region of the NOAA National Marine Fisheries Service, with support from the NOAA Coastal Ocean Program Office. These efforts are guided by the Chesapeake Bay Stock Assessment Committee, the Chesapeake Bay Environmental Effects Committee, and the Chesapeake Bay Coast Watch Committee. NOAA works closely with the Chesapeake Bay Program to ensure this effort is directly related to and in support of the research, monitoring, and assessment commitments in the 1987 Chesapeake Bay Agreement.

This publication was produced by the Maryland Sea Grant College Program, under the direction of Patmarie S. Maher of the NOAA Coastal Ocean Program Office, on behalf of CBSAC. Related reports include the *Annual Status of Stocks and Fisheries Statistics Report*, a Special Report Series for periodic assessments, and a Technical Report Series designed for distributing full reports of CBSAC projects.

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Foreword

The Chesapeake Bay Stock Assessment Committee was established in 1985 by the NOAA National Marine Fisheries Service, with the support of the NOAA Estuarine Programs Office, to develop a Bay-wide, cooperative program for assessment of fishery resources in the Chesapeake Bay. The Committee has funded Bay area fisheries research every year to improve regional information required for stock assessments. Summaries of recently completed research and ongoing projects are included in this report, along with a full list of all funded projects.

The Committee's main focus was formalized in the Chesapeake Bay Stock Assessment Plan, signed in July, 1988, by the Governors of Virginia, Maryland and Pennsylvania, the Mayor of the District of Columbia, the Administrator of the U.S. Environmental Protection Agency, and the Chairman of the Chesapeake Bay Commission. The Stock Assessment Plan was written in response to a commitment in the Chesapeake Bay Agreement of 1987:

> By July 1988, to develop, adopt, and begin to implement a Bay-wide plan for the assessment of commercially, recreationally, and selected ecologically valuable species.

The Stock Assessment Plan recommends immediate actions for improving the knowledge base upon which stock assessments depend. In general terms, these actions include:

- Improved, cooperative Bay-wide surveys of fish populations.
- Mandatory reporting of commercial catch data through a trip-ticket or similar system.
- Routine, expanded Bay-wide recreational fishing surveys.
- Research to investigate effects of human activities on fish populations.
- Annual reporting of fisheries statistics and the status of the stocks.

The Committee, charged with implementing the Stock Assessment Plan, established a Work Plan in October, 1988, and designated work groups. In the fall of 1989, the Committee added a Policy Board to oversee progress in implementing the Stock Assessment Plan and to provide increased accountability and policy direction.

This document contains the first report of achievements under the Stock Assessment Plan. A summary of Chesapeake Bay stock status is also included in this report. More detailed information on Bay fisheries will be available in the *1989 Chesapeake Bay Status of Stocks and Fisheries Statistics* report, available in July 1990. Extended abstracts of each of the completed FY 87 and 88 projects funded through CBSAC are presented as well.

Membership

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*October 1989 - present,

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Achievements Under the 1988 Stock Assessment Plan

Introduction

The Chesapeake Bay Stock Assessment Plan (CBSAP) was prepared in response to a 1987 Chesapeake Bay Agreement commitment to develop, adopt and begin to implement a Bay-wide plan for the assessment of commercially, recreationally and selected ecologically valuable species. The major goals of the Chesapeake Bay Stock Assessment Plan are embodied in recommendations to design and implement long-term fishery-dependent and fishery-independent sampling programs. The Stock Assessment Plan recommendations are listed below along with summaries of the CBSAC funds, totalling approximately $900,000 per year, have been used to support research and management projects in response to these recommendations. Summaries of CBSAC projects funded in 1987 and 1988 are included in this report. The accomplishments described below would not have been possible without the strong support of other state and federal initiatives in addition to those funded by CBSAC.

Recommendations on Fishery-Dependent Data Needs and Achievements

- Initiate a Bay-wide fishery statistics program to provide improved estimates of catch and fishing effort for each type of fishing gear and area of the Bay.
- Outline procedures for collecting such data, to include the implementation of a trip-ticket system for commercial fishermen and more extensive recreational fisheries surveys.
- Institute a program for obtaining species and age composition, as well as other biological characteristics of commercial and recreational catch.

Commercial Harvest Reporting

The Virginia Marine Resources Commission (VMRC) and the Maryland Department of Natural Resources (MDNR) are actively working to improve their respective commercial harvest reporting systems. In Maryland, work has continued to automate entry of catch data onto computers through use of an Optical Character Recognition System (OCRS). Using FY87 CBSAC funds, MDNR purchased an OCRS in late 1988. MDNR expects to begin operational use of the system for recreational licenses and shellfish data in 1990. It is hoped that the development of this technology will provide an efficient data entry system capable of dealing with the massive amounts of data that would be produced by a fish ticket system.

In Virginia, a VMRC state budget proposal to provide the staff necessary to implement a mandatory reporting system was not funded. Alternate funding is still a possibility; however, activity will undoubtedly be delayed. Existing VMRC staff, with the assistance of a CBSAC intern, will continue to plan improved reporting systems. In particular, VMRC is hoping to institute reporting by soft crab shedders and truck dealers.

In January, 1989, Virginia and Maryland began submitting commercial harvest data through the Northeast Marine Fisheries Information System (NEMFIS). NEMFIS was developed by the National Marine Fisheries Service and Northeast coastal states to provide access to consistent regional harvest data. The system has standardized data management procedures for data submittal to NMFS.

Management of historical harvest data (prior to 1989) has also improved as a result of the production of reports on the status of stocks and fisheries statistics in 1988 and 1989, designed to document the status and relative importance of Chesapeake Bay fishery species (see Status of Stocks section). CBSAC has funded students at VIMS and staff at VMRC to produce a consistent Bay-wide set of historical commercial catch data; review of this 1929-1988 catch data set will be completed in 1990. The CBSAC Annual Status of Stocks and Fisheries Statistics Report — 1990, will be completely updated in the coming year using historical and NEMFIS data.

The process to develop a comprehensive, consistent report system will continue in 1990 with the long-term goal of establishing a fish ticket system, as recommended in the Stock Assessment Plan. The scheduled reopening of the striped bass fishery in the Bay in the summer of 1990 will offer the states the opportunity to develop and test fish ticket reporting systems. It is expected by the Fall of 1990 that all Bay jurisdictions will have in place regulations allowing a restricted fishery for striped bass. A key element of these regulations will be the institution of commercial harvest quotas to prevent overharvest during the designated seasons. This will be the first use of quota management in the Chesapeake Bay and will come under close scrutiny. Present plans call for weekly reporting of daily harvest by harvesters and dealers by mail, as well as a daily phone survey of dealers to gauge daily harvest.

Commercial Harvest Biological Sampling

Biological data (length, weight, age, sex, and maturity) are primary data needs of stock assessment models, along with catch and effort statistics. They help describe what portion of a given fish population is being harvested. During the spring of 1988, in anticipation of the plan recommendations, a VMRC request for state funds was granted to add personnel to form a stock assessment program, with special emphasis on the biological sampling program. In the fall of 1988 the program began work with a staff of four. In addition to sampling work during the winter, the stock assessment program also developed a descriptive document for program procedures in 1989. To date over 25,000 pounds of finfish have been sampled; a detailed report of the first year of the VMRC program was produced in March, 1990. In addition to the work of VMRC, the Virginia Institute of Marine Science has had a long term program to collect biological data for shad, river herring, and striped bass caught by Virginia watermen (see project summary by Barth, p. 75).

At present, biological sampling programs are being carried out in Maryland for yellow perch, river herring and blue crabs. MDNR is currently designing a biological sampling program for striped bass, which will be in place when the commercial and recreational fisheries reopen. As an extension of the striped bass program, biological data will be collected for other commercial species that are harvested in the fall and winter months. Another by-product of the commercial striped bass sampling program is that it will serve as the template for conducting dealer-based biological sampling programs for other important commercial species, such as white perch, catfish, weakfish and eels.

Commercial Effort Statistics

Virginia collects basic fishing effort data through several programs and will be attempting to compile and document consistent and usable statistics during 1990 (see project summary by Barth, p. 37). Sources of data and anticipated activity are as follows:

1. *VMRC commercial license data.* License data will be documented in the 1990 Fisheries Statistics Report.
2. *VIMS effort survey.* VIMS has conducted an effort survey for anadromous fish since the early 1970's and for all species since 1986; there are survey problems in terms of geographic scope and estimated fishing time, particularly for gill net fisheries, that must be rectified.
3. *VMRC harvest reports.* The proposed mandatory reporting system will request data on time fished by gear which may be usable for calculation of catch-per-unit-effort (CPUE) and total effort.
4. *VMRC will also begin collecting "trip data" through dockside interviews in July 1989.* This would include such data as catch and fishing time.

In Maryland, effort data is currently collected from license sale information and from their monthly harvest and effort reporting system. MDNR plans to improve the reliability of effort statistics by moving to a trip ticket system that would attempt to record daily fishing effort (see project summary by Lewis, p. 65).

Recreational Catch and Effort Statistics

Currently all recreational catch, effort and biological composition data for the Chesapeake Bay are derived from the NMFS Marine Recreational Fishery Statistics Survey, a national survey of anglers that estimates recreational catch and effort by state. There are three ongoing recreational statistics projects being undertaken at Old Dominion University that will assist in the development of improved survey design: (1) a CBSAC project to review existing programs and develop recreational fishery statistics recommendations for Chesapeake Bay stock assessment (see project summary by Jones, p. 71); (2) a VMRC project to estimate recreational harvest of black drum and other species in the lower Bay during the spring; and (3) a Virginia Sea Grant project to investigate recreational blue crab harvest estimation methods.

MDNR and VMRC plan to design and conduct recreational surveys, based in part on these studies, once the striped bass fishery is reopened. In Maryland, the survey will be designed to provide real-time estimates of the number of striped bass harvested each week. Although the data needs in this survey will be extensive, the survey is a prerequisite to successfully implementing a quota-based management system for striped bass in Maryland. In Virginia, a survey which accurately assesses harvest, effort and biological characteristics of harvest without the quota management time constraints is anticipated. The design phase of this survey, which is underway, will include participation of the principal investigators of the CBSAC recreational fishery statistics project.

Recommendations on Fishery-Independent Data Needs and Achievements

- Complete final design for a Bay-wide trawl survey to obtain fishery-independent estimates of abundance and distribution.
- Augment trawl survey with other sampling methodologies to obtain abundance indices for species and life stages not captured by the trawl survey, such as the ongoing beach seine surveys in Maryland and Virginia.
- Develop research program to investigate the effects of the environment on juvenile fish and shellfish populations.
- Coordinate these surveys and studies with the Chesapeake Bay Program Bay-wide Monitoring Program.

Trawl Survey

During the summer of 1987, in anticipation of the recommendations of the stock assessment plan, VMRC requested state funds to augment ongoing trawl survey work at VIMS. Funds became available in July, 1988, and have been used to run the trawl survey, designed through a 1987 CBSAC project, for Virginia's portion of the Bay (see project summary by Chittenden, p. 29). VIMS is also in the process of re-designing their river trawl survey to be consistent with the mainstem Bay trawling; parallel comparison cruises are planned for the fall of 1989, with institution of the full Virginia survey (river and bay) by 1990. The trawl survey may also be augmented by a shallow water trawl survey along the seaside of the Eastern Shore.

In 1988, the University of Maryland's Chesapeake Biological Laboratory (CBL) initiated a five-year trawl study. In year one, the study was divided into an experimental design project, a trawl calibration project, and a project to develop a foundation for stock assessment analysis. The major objectives of the CBL trawl study in 1989 were to provide a framework for identifying optimal sampling methodologies and to implement a stratified random sampling program. The survey program currently being tested by CBL is based on the historical distribution of species such as white perch, striped bass, weakfish, spot, and croaker. Approximately 70 tows are made in the mainstem Bay each month - 35 are taken above the William Preston Lane Memorial Bridge and 35 are taken below. Samples are also collected within the first five river miles in the Elk, Choptank, and Patuxent rivers every other month. Biological data collected includes length, weight, age, sex and total biomass of each species. Further description of the CBL work can be found in the FISHMAP project abstract in this document (see DiNardo and Rothschild project summary, p. 93).

Design of a Bay-wide trawl survey with consistent sampling protocols has been discussed at workshops at the NOAA Northeast Fisheries Center (NEFC) and CBL during the last year and will serve as the basis for discussion concerning the implementation of a Bay-wide trawl survey (see project summary by Bolgiano et al., p. 33).

Other Surveys

In addition to the trawl survey implementation, the states of Maryland and Virginia have improved a number of key fisheries-independent surveys. When examined in the context of the primary objectives of fishery-independent studies as defined in the Chesapeake Bay Stock Assessment Plan, each of these projects should provide the following, depending on the habitat requirements of a given species: (1) data necessary to derive species specific estimates of relative or absolute, age-specific abundance for either the tributaries, the mainstem Bay or both areas; and (2) other data useful in stock assessments to determine age specific patterns of distribution, growth, mortality, fecundity, sex and maturity.

To achieve the first objective, tributary specific surveys will be needed for anadromous, semi-anadromous and some resident species. Given what is known about the life history of species such as alewife, blueback herring, American shad, channel catfish, white catfish and yellow perch, abundance estimates for a particular river system for these species cannot be derived from studies carried out in some other region of Chesapeake Bay. If, for example, fisheries and water quality management actions are to be taken in the Patuxent River based on the status of stocks as determined from fishery-independent studies, then the status of species found in the

Patuxent River needs to be determined in that system. In most instances, it cannot be inferred from studies conducted in the Nanticoke River or the Upper Chesapeake Bay.

River specific surveys will probably not be necessary for marine spawners such as spot, croaker, spotted sea trout, weakfish, and blue crabs because Chesapeake Bay landings of each of these species are composed of one stock. However, it may be necessary to sample low salinity waters of some of the major tributaries because juveniles of some species of marine spawners occur in tidal freshwater habitat. With this in mind, the CBSAC Fishery-independent Work-group is in the process of designing a Bay-wide fishery-independent program that will integrate ongoing Maryland and Virginia fishery-independent projects (and, if necessary, modify existing studies and add new projects) into an assessment program that is consistent with the objectives described in the Chesapeake Bay Stock Assessment Plan. The states have already begun to ex-pand some of their existing surveys to meet these objectives.

VIMS has expanded its striped bass seine survey from eighteen sites to approximately forty. The expanded geographic scope will be used to assess more accurately the geographic and temporal distribution of striped bass juveniles. A VIMS proposal to reinstate a juvenile sur-vey for alosids is expected to be prepared for submission to CBSAC in FY 90. Other VIMS sur-vey projects involve collections of stock assessment data for blue crabs, summer flounder, At-lantic croaker, black drum and sharks.

MDNR is currently funding or conducting fishery-independent studies of adult and ju-venile stocks of American shad, river herring, striped bass, yellow perch, blue crabs, and oysters. Species specific young-of-the-year abundance surveys are being carried out for river herring, American shad, yellow perch, blue crabs, oysters and striped bass. Specific projects funded by CBSAC in FY87 and FY88 include studies to evaluate fisheries-independent samp-ling methods for three species: (1) blue crabs (see project summaries by McConaugha, p. 99; Stagg and Rothschild, p. 81), (2) oysters (see project summaries by Tsai and Rothschild, p. 53; Barber and Mann, p. 79) and (3) white perch (see project summaries by Buckley and Nammack, p. 43; Brandt, p. 17). Also funded was an assessment of aging errors in fishery yield models (see project summary by Prager and MacCall, p. 61).

Environmental Effects Studies for Fishery Species

CBSAC has several projects in FY87 and FY88 to evaluate patterns and trends of histori-cal fisheries and environmental data in the Choptank, York and Rappahannock rivers (see pro-ject summaries by Norcross and Wyanski, p. 23; Stroup, p. 97; and Bolgiano et al., p. 33). The Chesapeake Biological Laboratory is currently undertaking an environmental effects project, and although it is not funded by CBSAC, it is patterned after the approach suggested for recruitment process studies in the Stock Assessment Plan. The study deals with egg produc-tion, spawning biomass, and factors influencing recruitment of striped bass in Chesapeake Bay. The Committee plans to work closely with the NOAA Chesapeake Bay Environmental Effects Committee to improve Bay-wide research on this topic.

Recommendations on Stock Assessment Implementation and Achievements

- Chesapeake Bay Stock Assessment Committee (CBSAC) will have oversight responsibilities for Bay-wide Stock Assessment.

- Maintain CBSAC working group roles for reporting on status of Bay stocks, investigating analytical techniques, and data management.

- Establish new stock assessment working groups on finfish, oysters, and blue crabs to begin immediately with the evaluation of available data and proposed sampling programs.

- Produce annual reports on the status of stocks, fishery statistics, and periodic Bay-wide stock assessment reports.

Organizational Activity

CBSAC has been restructured to improve its function to oversee Bay-wide stock assessment. It now has a Policy Board which will provide oversight and direct priorities and will ensure that the Stock Assessment Plan is implemented in a timely fashion. The Policy Board is composed of upper level resource management officials who are in positions to influence state and regional stock assessment policies and budgets, and therefore bring stronger leadership to address fisheries assessment issues which have long been identified but not implemented.

Fisheries Statistics and Status of Stocks Reports

In 1988, Virginia and Maryland cooperatively produced a document entitled Chesapeake Bay Fisheries: Status, Trends, Priorities and Data Needs. The Stock Assessment Plan requires that this information be produced annually. CBSAC has produced a condensed update to be published in July 1990, which combines status of stocks information and commercial fishery statistics. An excerpt of this update is contained in Section III. Also included in this report is a summary of the CBSAC effort to produce a status of knowledge regarding Chesapeake Bay fish and shellfish populations (see project summary by Austin, p. 101). In subsequent years, CBSAC will produce a complete Status of the Stocks and Fisheries Statistics Report.

Status of the Stocks Summary

The status of key commercial and recreational fishery species are summarized below. Excerpted from the report, *Chesapeake Bay Fisheries: Status, Trends, Priorities, and Data Needs* (September 1988), they were compiled jointly by the Maryland Department of Natural Resources and the Virginia Marine Resources Commission. The second annual CBSAC *Fisheries Statistics Report* will contain a complete update of these summaries and data analysis (approximate release, winter 1990).

Alewife and Blueback Herring (River Herring)

Commercial landings data indicate a large decline in river herring abundance from the 1930s to the present time. Causes of the long-term decline in Chesapeake Bay are not known with certainty but apparently relate to habitat loss and the effects of overfishing. Strong circumstantial evidence exists that the precipitous decline in landings that occurred in Chesapeake Bay in the 1970s was attributable to large river herring harvests by offshore fleets operating along the East Coast of the United States from 1967-1972. (With the exception of incidental catches in the mackerel fishery, the offshore fishery for river herring no longer exists). Alewife abundance may be more depressed than that of blueback herring; however, this relationship cannot be quantified at the present time.

American and Hickory Shad

At present, both the American and the hickory shad spawning stock are at low levels of abundance in all spawning tributaries in the Maryland portion of Chesapeake Bay. However, restoration efforts and the moratorium on American shad have contributed to an increase in the population in the Upper Bay. Recent trends in abundance in this region suggest that the stock may be recovering from a prolonged period of very low abundance. Adult population estimates by the Maryland Department of Natural Resources indicate that the upper Bay American shad spawning stock increased from roughly 2,600 fish in 1980 to 75,000 fish in 1989; however, given that the recovery continues, it will still take several years for the stock to recover to former levels of abundance. (Estimates of the upper Bay spawning stock approached 1.4 million fish in 1965.)

In Virginia, the precipitous decline in landings over the last 15 years is, in part, related to changes in fishing effort. Virginia shad stocks appear to be stable at low levels of abundance relative to earlier years.

Striped Bass

Spawning success as measured by the 1989 MDNR striped bass juvenile index strongly indicates that the Chesapeake Bay striped bass stock is recovering from a prolonged period of low abundance. The 1989 juvenile index value of 25.2 was the second highest since the juvenile abundance survey began in 1954.

Striped bass spawning stock surveys carried out from the period 1982-1989 on the spawning reaches of the Choptank River, Upper Bay, Chesapeake and Delaware Canal and Potomac River suggest that the recent recovery of the female spawning stock from several years of very low abundance is the dominant cause of the large 1989 year class. The lack of females in the spawning population was so severe from 1982 through 1986 that the oldest year classes in the population (the 1969-1971 age classes) were contributing a significant portion of the eggs produced on the spawning grounds. There has been a significant increase in the contribution of 1982 year class and younger females to the total number of eggs produced in 1989.

A trend of steadily increasing values in the Virginia juvenile index since 1981 has also been observed. The 1987 index of 15.8 was the highest ever recorded for striped bass spawning populations in the Lower Chesapeake Bay. Indices of 7.8 and 11.2 for 1988 and 1989, respectively, produce a three year running average (1987-89) of 11.6, almost three times the historical average, for the Virginia portion of Chesapeake Bay. Comparing this with the index of 25.2 for the Upper Bay, the 1989 year class may turn out to be one of the strongest ever produced in the Chesapeake.

White Perch

Young-of-the-year data obtained as part of the annual estuarine juvenile fish survey indicates that white perch are now less abundant in Maryland then they were in the 1960s. Reproductive success appears to have declined in the Potomac and Nanticoke rivers. In the upper Bay, current juvenile abundance levels appear to be in the range of those reported in the 1960s and 1970s (with the exception of 1966, 1969, and 1970 which were unusually high). Although white perch juvenile abundance has declined in recent years, it appears unlikely that stocks are currently severely depressed in Maryland.

Juvenile and adult abundance information for VIMS seine and trawl surveys do not indicate declining abundance of white perch in Virginia rivers. However, commercial harvest data shows a sharp drop in reported harvest since the 1960s. The decline in harvest may be attributed to declining fishing effort for white perch.

Yellow Perch

In 1988, the Secretary of the MDNR determined that yellow perch were in need of conservation and imposed a number of harvest restrictions. This determination was based on the results of studies which show that spawning runs are virtually non-existent in many small tributaries which supported substantial fisheries prior to the mid-1970s. Declines in yellow perch abundance have been evident in streams which have been closed to fishing, as well as in streams which are still open. The age composition of fish taken from severely depressed spawning runs in some areas is composed primarily of older fish, which is an indication of several consecutive years of poor reproductive success. The low levels of brood stock in many streams are apparently adversely affecting reproduction, and remnant stocks could be eliminated in some areas unless fishing mortality is controlled and habitat is improved.

Catfish

MDNR juvenile survey data show that channel catfish abundance has increased significantly in the upper Chesapeake and the Potomac River since the early 1970s. There has been no corresponding increase in white catfish and brown bullhead abundance in these areas. Sport fishing surveys carried out in the Susquehanna River in 1970 and 1985 also indicate the trend for increasing abundance of channel catfish, but not of white catfish. In 1970, channel catfish and white catfish made up 6.4% and 1.8%, respectively, of the total number of fish sampled in the survey, while in 1985, channel and white catfish made up 20.1% and 2.0% respectively, of the fish sampled.

Commercial fisheries data indicate that catfish landings have increased in nearly all areas in Maryland in recent years. Unfortunately, because of a lack of species-specific information on catch and effort, it is not known whether exploitation rates are too low, optimal or too high.

American Eel

At present, there is insufficient data to assess the status of eel stocks in Chesapeake Bay. Anecdotal comments, however, indicate that eels are now less abundant than they were some years ago and that the average size of eels in the catch has decreased. If correct, this is a cause for concern because continuously declining catches composed of progressively smaller fish indicate that the stock may be suffering from the effects of over-exploitation.

Bluefish

Data collected from 1974 through 1986 indicate that the bluefish spawning stock biomass peaked in 1979. Spawning stock biomass has apparently declined by about 55% since 1979, and recruitment has been below average in the last three years. Although bluefish appear to be at or above historical levels at the present time, primarily as a result of the strong 1981 and 1984 year classes, stock abundance will decrease in the next few years because of below average recruitment from 1987-1989. The most recently completed bluefish stock assessment indicates that bluefish are being harvested at or near full exploitation and that an increase in fishing mortality could result in stock collapse.

Summer Flounder

Estimates of current fishing pressure for summer flounder are 2-3 times the rate at which fishing mortalities reduces landings (i.e., twice or three times the point of diminishing returns). Based on these estimates of fishing pressure, it is likely that the Atlantic Coast summer flounder population is overexploited and stock biomass will continue to decrease in the near future.

Atlantic Menhaden

Because of social and economic constraints on the fish meal and fish oil industry, menhaden landings are currently less than potential yield (as determined for current levels of recruitment). In general, the fleet is fishing on younger and smaller fish than it did in past years, partly because of the proportional shift of operating plants from northern to southern waters. Apparently, the reduction in total catch has compensated for fishing activities directed towards smaller and younger menhaden, because recruitment has been good in recent years. However, the overall East Coast fishery for menhaden is experiencing a trend in increased landings. Recent improvements in market regulations and development of joint venture fisheries with foreign governments are factors responsible for the current trend. Anticipated changes to regulations which would allow menhaden oil to be sold for human consumption, as well as new technologies which may improve the marketability of menhaden products, can be expected to further increase effort on the species in future years.

Spot

The importance of spot to the commercial and recreational fisheries of Chesapeake Bay has varied over the years and is related to its abundance. High year-to-year fluctuations in landings occur because the catch in most years is composed primarily of a single year class. Much like croaker, environmental variation on the spawning grounds is most likely responsible for the fluctuations in spot abundance. Increasing fishing effort and habitat degradation and loss could lead to declining spot abundance.

Atlantic Croaker

The importance of this species has varied over the years and is related to its abundance. Stock recruitment models suggest that croaker abundance in Chesapeake Bay is governed by climatic factors. Low abundance is coincident with low winter temperature during juvenile recruitment into Chesapeake Bay; winds also influence the fate of post-larval distribution. Abundance in Chesapeake Bay is affected as well by the North Carolina fishery which harvests a large proportion of potential recruits. Recent croaker landings are only about half of the historical landings, suggesting a recent decline in abundance.

Red Drum

Data collected in the middle Atlantic region (New York to Virginia) and in Chesapeake Bay indicate that red drum are less abundant than they once were. The estimated recreational red drum catch in the middle Atlantic region declined from 11.4 million pounds in 1960 to 1.3 million pounds in 1965 and 84,000 pounds in 1970. In 1986, a NMFS Recreational Survey estimated 183,000 pounds of red drum were caught by anglers. In Chesapeake Bay, catches of citation size fish (over 40 pounds) have declined sharply in number since the mid-1970s.

Black Drum

Many questions surround the status of the black drum stocks. Years of apparent low abundance are followed by years of above average landings. The average age of the fish encountered in the Virginia fishery is age 10+, which may point to sources other than fishing pressure as the major cause of the observed short term declines in landings. The average fish entering the Virginia fishery has been mature for a minimum of 6 years before being caught.

Weakfish

Historically, weakfish landings have fluctuated greatly. However, the National Marine Fisheries Service has recorded a recent drop in juvenile abundance. Similarly, qualitative reports from individual states suggest a decline in abundance based on reduced harvests in some northern sport fisheries.

Spotted Seatrout

The present condition of the Atlantic coast spotted seatrout population is unknown. Catches have fluctuated since 1950 with Florida and North Carolina accounting for the majority of Atlantic coast landings. Declines have been attributed to winter cold kills, environmental degradation and fishing pressure.

Blue Crab

Commercial catch statistics and fishery-independent data reveal that the blue crab stock fluctuates considerably. Fishery-independent studies carried out by MDNR since 1977 indicate that blue crab abundance was relatively high in 1977, was low from 1978-1980, and has been relatively high through 1985, with a downturn thereafter. VIMS trawl data collected from 1972-1988 indicate that abundance was low from 1974-1977 and from 1985-1988, and was high in 1972-1973 and 1978-1984. Landings data suggest that abundance has been relatively stable since 1981. However, it is important to note that commercial fisheries data indicate a long-term trend of increasing effort with probable concurrent declines in catch-per-unit effort.

American Oyster

At present, the Bay-wide oyster stock can be characterized as severely depleted. Recent expansions of the range of oyster diseases, MSX (*Haplosporidium nelsoni*) and Dermo (*Parkinsus marinus*), low dissolved oxygen episodes and past harvesting practices are primarily responsible for the population's current decline. Average levels of spatfall have dropped in the past decade, and the number of natural beds receiving spatfall adequate for replenishment have been reduced from historic levels. In Maryland, the 1983 and 1984 spat sets were virtually non-existent. Although the 1985 spatfall was exceptionally high and well distributed, the year class was essentially wiped out in those areas infected by disease. Maryland's 1986 spatfall was considered average and of limited distribution. Many 1986 year class oysters have been infected by MSX and Dermo and may be killed in areas of high salinity. Continued low levels and poor geographic distribution of spatfall levels occurred during 1987 and 1988.

Since 1985, the James River has become the center for the oyster market in Virginia. The low number of surviving spat since the spring of 1986, as determined from the VIMS oyster shoal surveys, however, indicates that the James River is failing to match the harvest of oysters with an equal recruitment of spat. Bushel counts (spat, small and market) for spring 1988 were below 199 oysters per bushel downriver from Wreck Shoal and Dry Shoal in the James. Upriver of these same bars, the bushel count has dropped from an average of 504 oysters per bushel in the spring of 1986 to 274 oysters per bushel in the spring of 1988. In the Great Wicomico River, in contrast, spat per bushel averaged 887 spat on all bars, but the number of small oysters decreased 56% in one year.

Softshell Clam

Commercial harvest data appear to be a good indicator of the status of the clam resource. Based on these data and reports from the scientific community, it appears that the Maryland clam stock is in good condition at the present time. However, given the susceptibility of Chesapeake Bay clams to high summer temperatures, it is not unreasonable to assume that massive die-offs will have a significant, but not necessarily long-term, effect on stock abundance in the future.

Project Summaries

Hydroacoustics as a Stock Assessment Technique in the Potomac River

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Introduction

The Potomac River, one of the largest tributaries to the Chesapeake Bay, is a major spawning ground for striped bass (*Morone saxatilis*) and white perch (*Morone americana*). These fish are ecologically and economically valuable to the Chesapeake Bay. The dramatic decline in the abundance of striped bass over the past decade has raised questions about our understanding of its population dynamics and our ability to effectively monitor stock size. Moreover, due to increased regulatory restrictions on the striped bass fishery in the Potomac River, the white perch is now the primary spring-early summer recreational fishery in the District of Columbia's portion of the Potomac River. White perch were thus selected as one of the species for the Chesapeake Bay Stock Assessment Committee's trial stock assessment.

Management agencies need to know the absolute abundance of fish stocks so that harvest levels of economically valuable species can be set and relationships among the ecologically important species can be quantified. Accurate measures of changes in stock size are also needed to evaluate the ecosystem's response to management decisions. Different types of gears have been used to measure the abundance of fish, but all are limited as to the specific types and sizes of species that can be caught by the gear and the type of habitats that can be sampled. Sampling is particularly difficult for fish that live in midwater in physically complex environments such as the Potomac River.

One promising alternative to traditional sampling for midwater fishes is the use of hydroacoustics. Sound travels efficiently in water and will reflect from targets that have a density different from that of water. This property has been used for over forty years to search for aggregations of fish but recent advances in technology have allowed these echoes to be used to measure fish abundance and fish size directly, provided that the species of interest is well-behaved and that appropriate data analyses procedures are used. Acoustic sensing of fish depends upon the fraction of the acoustical energy reflected by the target species and upon the variation of that energy due to changes in fish behavior. Thus, acoustic pilot studies must be done on the movements and behavior of the target fish species to evaluate the usefulness of this technology to any particular species and to devise statistically valid sampling protocols for long-term monitoring programs.

Objectives

Our primary objective was to evaluate the feasibility of using hydroacoustic technology to estimate the abundance and distribution of adult white perch and striped bass in the tidal freshwater portion of the upper Potomac and Anacostia rivers and to assess its potential and its limitations. This study was a cooperative program with the District of Columbia, Department of Consumer and Regulatory Affairs, Fisheries Management. Specifically, our intent was to:

- Examine the spatial distribution of white perch in the upper Potomac River during day and night, from early March through late May, 1988.
- Compare acoustic measures of fish size to trawl-caught measures of fish size.
- Recommend a general sampling protocol for long-term monitoring of white perch abundances in the upper Potomac River using underwater acoustics.
- Make a preliminary evaluation of the effectiveness of assessing adult striped bass abundance in the same region using underwater acoustics.

Methods

This study encompassed the tidal freshwater portion of the Potomac River estuary between nautical river mile 68 (Quantico Marine Base) and nautical river mile 98 (Three Sisters). The average cross-river depths of this portion of the Potomac River estuary ranged from 1.4 to 7.0 meters and the maximum depth along any cross-river transect ranged from 6.5 to 23.0 meters.

Five surveys, each four to five days in duration, were conducted (1-4 March, 22-25 March, 11-15 April, 2-6 May, and 23-27 May, 1988). During each survey, thirty acoustic transects that spanned the Potomac River study area were run across the channel towards shore to depths of (usually) less than 2 meters during day and night. Also, an acoustic transect was taken along the entire 30 mile section of the river centered in the deepest part of the river during day and night. Four sites were selected for biological sampling to cover different areas of the river. At each site during each survey, a combination of bottom trawling, midwater trawling, and gillnetting was done to identify species and collect size and life history information. At each trawling/gillnetting site, a record was made of gear type, time of day, length of set or tow, water temperature, dissolved oxygen, pH and conductivity. All data were collected using the University of Maryland's 26' *R/V PISCES*.

The principal acoustic sampling system consisted of two scientific echo sounders with dual receivers operating at frequencies of 38 kHz and 120 kHz. On occasion, additional portable echo sounders operating at frequencies of 420 kHz and 70 kHz with single beam transducers were used. The two to four transducers were mounted on a stable aluminum towbody and towed near the surface alongside the research vessel. The echoes were digitized and recorded. Subsequently, echo-squared integration was used to measure the relative fish abundances throughout the water column at 0.5 m depth intervals for each two minutes along a transect. Target strengths and size of fish were measured using dual-beam analysis of the 120 kHz (early March) and 38 kHz systems. The acoustic size frequency distribution was compared to the length frequency distribution of fish collected with nets. A detailed description of the methods and results can be found in Brandt (1989).

Results

The Potomac River was generally well-mixed throughout the study. Temperature, dissolved oxygen and pH values were nearly constant from surface to bottom. Mean surface temperature increased steadily from 5.7°C on 1-4 March to 19.9°C on 23-27 May. Surface dissolved oxygen showed a decreasing trend from a mean of 11.5 ppm on 1-4 March to 9.9 ppm on 23-27 May. Physical and chemical conditions across the 30 miles of the upper Potomac River showed little variation within seasonal trends.

A total of 7,953 fish representing 22 identified species were sampled. White perch were, by far, the most common species comprising over three quarters of all species caught and 96% of all fish that typically live in midwaters. Striped bass comprised less than 1% of the total number of fish caught in all gear types combined and were taken only by gillnets. Bottom trawling was the most effective method of catching fish in the relatively shallow waters of the Potomac River. Since most acoustic scattering patterns showed a continuous distribution of fish from the pelagic zone to near bottom, we concluded that bottom trawling would be effective at catching fish observed by the acoustics. Mean densities of white perch estimated from bottom trawls ranged from .001 to .400 fish/m^2 during day and from .003 to .409 fish/m^2 at night. Numbers of white perch in the central channels increased to the third week in March, then slowly declined by the third week in May.

In general, highest densities of fish were generally located in the deeper parts of the river channel and few acoustic targets were detected in water that was less than 5 m deep. Mean densities of fish, measured acoustically, in the central channel of the Potomac River were two to four times higher in April and early May than in early March or late May. The length frequency distribution of white perch was bimodal with one mode centered at 65-75 mm total length (juveniles) and a second mode broadly centered at 105-135 mm (adults). Acoustic measures of fish size corresponded well with length-frequency distributions of trawl-caught white perch. A group of smaller-sized targets (5-10 mm) was also apparent in the acoustic data during mid-April and May.

Although few striped bass were captured, there was a correlation in peak catch of striped bass and occurrence of large acoustic targets. The size distribution of large (>300 mm) acoustic targets matched the combined length-frequency distribution of sampled striped bass, blueback herring (*Alosa aestivalis*) and gizzard shad (*Dorosoma cepedianum*). Most striped bass were likely concentrated down river from our sampling region.

Summary and Recommendations

This study, although limited in breadth and scope, showed that acoustic techniques have good potential for assessing the distribution, abundance and sizes of white perch in the upper Potomac River during late winter-early spring. The white perch proved to be an ideal candidate for acoustic assessment because the species lives in midwater, is concentrated offshore in the deeper channels of the river, and dominates the midwater component of the fish species composition. Acoustic assessment of striped bass may be possible but further studies are needed in areas with higher concentrations of this species.

The final report (Brandt 1989) makes specific recommendations on a general sampling protocol for an acoustic stock assessment of white perch in the upper Potomac River and on specific areas requiring further research. The ideal survey design would combine an acoustic assessment for abundance estimation with a netting program to collect data on species composition, size, growth and maturity, and physical sampling to help interpret the distributions of fishes. The patchiness and rapid day-to-day changes in fish distributions require that acoustic data be taken continuously. We recommend a zig-zag survey design similar to the one that was used in our pilot study or a series of parallel shore-to-shore transects that span the region of the river of interest. These survey patterns have the advantage of maximizing coverage in an area and crossing all depth strata.

Within the time frame of our study, white perch are most suitable for acoustic assessment during late March through mid-April when water temperatures were warming from approximately 6.5 to 15.0°C. This time corresponds to the peak abundances of white perch and acoustic scatterers in the central portions of the river. By May 1988, white perch had apparently begun their shoreward migration to spawn. The exact timing of an acoustic assessment would probably vary from year to year depending on the physical conditions of the river. Ideally, both day and night samples should be taken for abundance estimates. A good data management scheme, data quality control and data assurance guidelines should be developed.

Given the complexities of this technology, it is critical that an expert in fisheries acoustics be involved in the assessment at the program manager level. The decision to use acoustics for fishery management requires at least a commitment by the agency for in-house or contracted expertise in fisheries acoustics at the project manager level. Such an expert is needed for survey design, data quality control and data interpretation. Automated signal processing systems are not yet trouble-free and require an understanding of basic fisheries acoustics to ensure that proper calibration and system parameters are used.

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Climate/Fisheries Resources Interactions

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Introduction

Little is known about the recruitment of larval summer flounder to Virginia estuaries and the habitat requirements of the juveniles during the first year subsequent to recruitment. This is a noteworthy lack of information because there are large commercial and recreational fisheries for summer flounder between Massachusetts and North Carolina. This lack of information may be attributable to three factors: (1) inadequate locations of study sites, (2) season of study, and (3) choice of sampling gear.

Summer flounder spawn in the fall and winter as they migrate from estuarine and coastal waters to outer continental shelf wintering grounds (Morse 1981). An examination of egg abundance indicates that the spawning season is characterized by a north to south progression: eggs were collected in greater abundance north of Chesapeake Bay from September through December, and south of Chesapeake Bay from November through February (Smith 1973). Seasonal trends in a maturity index (ovary weight/body weight) concur with trends in egg abundance. The maturity index for specimens collected on the continental shelf between Cape Cod (Massachusetts) and Cape Lookout (North Carolina) indicates that most spawning occurs between October and February (Morse 1981).

The principal investigator hypothesizes that surface currents generated by NW to NE winds transport larvae originating north of Chesapeake Bay to estuarine nursery habitats. Larvae settle in the mesohaline and polyhaline areas of estuaries (Bozeman and Dean 1980; Weinstein et al. 1980), though they may occur in areas with salinities as low as 0.0 ppt (parts per thousand) (McGovern 1986). Poole (1966) speculated that North Carolina sounds, Chesapeake Bay and seaside bays of Virginia's Eastern Shore are the primary nursery grounds for summer flounder. The juveniles remain in estuarine and coastal areas until maturity at age two to three, after which they migrate to and from spawning and wintering grounds on the continental shelf.

The results of other studies suggest that larval summer flounder may settle in shallow habitats with mud substrate (Bozeman and Dean 1980; Weinstein and Brooks 1983) and that they later utilize seagrass beds (Orth and Heck 1980; Weinstein and Brooks 1983) and unvegetated sand substrates (Powell and Schwartz 1977). In these studies, sampling was conducted in a limited range of depths and the substrate was not quantitatively described. Simultaneous sampling of shallow and deep areas over fine (very fine sand, silt and clay) and sand substrates is needed in order to describe the depth and substrate characteristics of their habitat. In the present study, we examined the depth and substrate characteristics of age 0 (< 1 year old) summer flounder habitat by sampling in two depth ranges and over two substrate types. The seaside of Virginia's Eastern Shore served as one of the study areas in order to examine the speculation by Poole (1966) that this area is a primary nursery ground for summer flounder. Very few age 0 summer flounder were captured during previous studies in this area (Richards and Castagna 1970; Cowan and Birdsong 1985).

Objectives

- To determine the water depth and substrate characteristics of summer flounder, *Paralichthys dentatus*, nursery habitat.
- To describe the timing of summer flounder recruitment in 1986-1987 to five estuarine areas in Virginia.

Methods

A 4.9 m semi-balloon trawl was used to sample four habitats, each different in terms of depth and substrate. The habitats and their corresponding numbers were: (1) sand substrate in 5-12 m of water, (2) sand substrate in 1-2 m of water, (4) fine substrate in 1-2 m of water, and (5) fine substrate in 5-12 m of water. These habitats were sampled at each of five sites (Figure 1) every other week between September 1986 and July 1987. During each sampling period, two 5-minute tows were made in each habitat, one with the current and one against the current.

To quantify the composition of the substrate at each habitat, six to ten sediment samples were collected with a small Peterson grab. Upon retrieval, the grab was carefully opened and the top 2 cm of sediment was removed for analysis. Only 2 cm of sediment was collected because age 0 summer flounder probably don't burrow to greater depths. Percentage weights of gravel (> 2.00 mm), sand (0.063-2.00 mm), silt (0.003-0.063 mm), and clay (<0.003 mm) fractions were determined for each habitat. The habitats could be divided into two groups based on the combined percentages of very fine sand (0.063-0.125 mm), silt and clay. The substrate was labeled "sand" for habitats in which this combined percentage was > 50%, whereas it was labeled "fine" when this percentage was < 50%.

Results

Eighty-eight newly recruited summer flounder (13-20 mm) were captured during the study period. Most (77.3%) of the specimens were captured in habitat 4 (shallow, fine substrate). New recruits were first captured in November on the seaside of the Eastern Shore (sites S and W, Figure 1) and December on the bayside of the Eastern Shore (site O). They were not captured in the lower York River (sites G and T) until February. Peak recruitment occurred in November and December on the seaside of the Eastern Shore, in contrast to early March to early April in the lower York River. Recruitment occurred for 5-6 months on the Eastern Shore compared to 2-3 months in the lower York River. These differences warrant further investigation to determine if summer flounder recruiting to all sites are the same age. If they are not the same age, it could mean that there are two or more spawning populations of summer flounder in the mid-Atlantic region. A total of 618 age 0 summer flounder (13-160 mm TL) were captured in trawl collections at the five sites. They were most abundant and most frequently captured in the shallow, fine-substrate habitats at all sites except Occohannock Creek (Table 1). At this site, the trawl did not fish properly in the shallow, fine-substrate habitat in the spring and fall because an unidentified gelatinous material clogged the liner. These shallow, fine-substrate habitats were < 15 m from salt-marsh vegetation.

Table 1. Catch-per-unit-effort (No. age 0 summer flounder per minute) in trawl collections.

	Habitat			
Site	1	2	4	5
Guinea Marshes	.055	.071	.540	-
Occohannock Creek	.066	.053	.051	-
Sand Shoal Channel	.005	.029	.572	-
Wachapreague Channel	.025	.165	.905	.081
Tue Marshes	-	.014	.327	.005
Mean	.038	.066	.479	.043

Summary

This study presents evidence that juvenile summer flounder require shallow, fine-substrate habitats during their first year of life. These nursery areas are found adjacent to salt-marshes and probably within saltmarshes. This is further evidence that estuarine areas need to be protected from extensive municipal and residential development.

Evidence is also presented to support the speculation by Poole (1966) that the shallow bays and salt-marshes on the seaside of Virginia's Eastern Shore are one of the major nursery areas for summer flounder. Prior to the present study, very few age 0 summer flounder had been captured in this area.

Recommendations

Future research should focus on determining the factors that cause the distribution of age 0 summer flounder reported in the present study. Some factors to be investigated are temperature, water depth, composition of the substrate and food availability. It is also possible that mortality rates are higher in other habitats.

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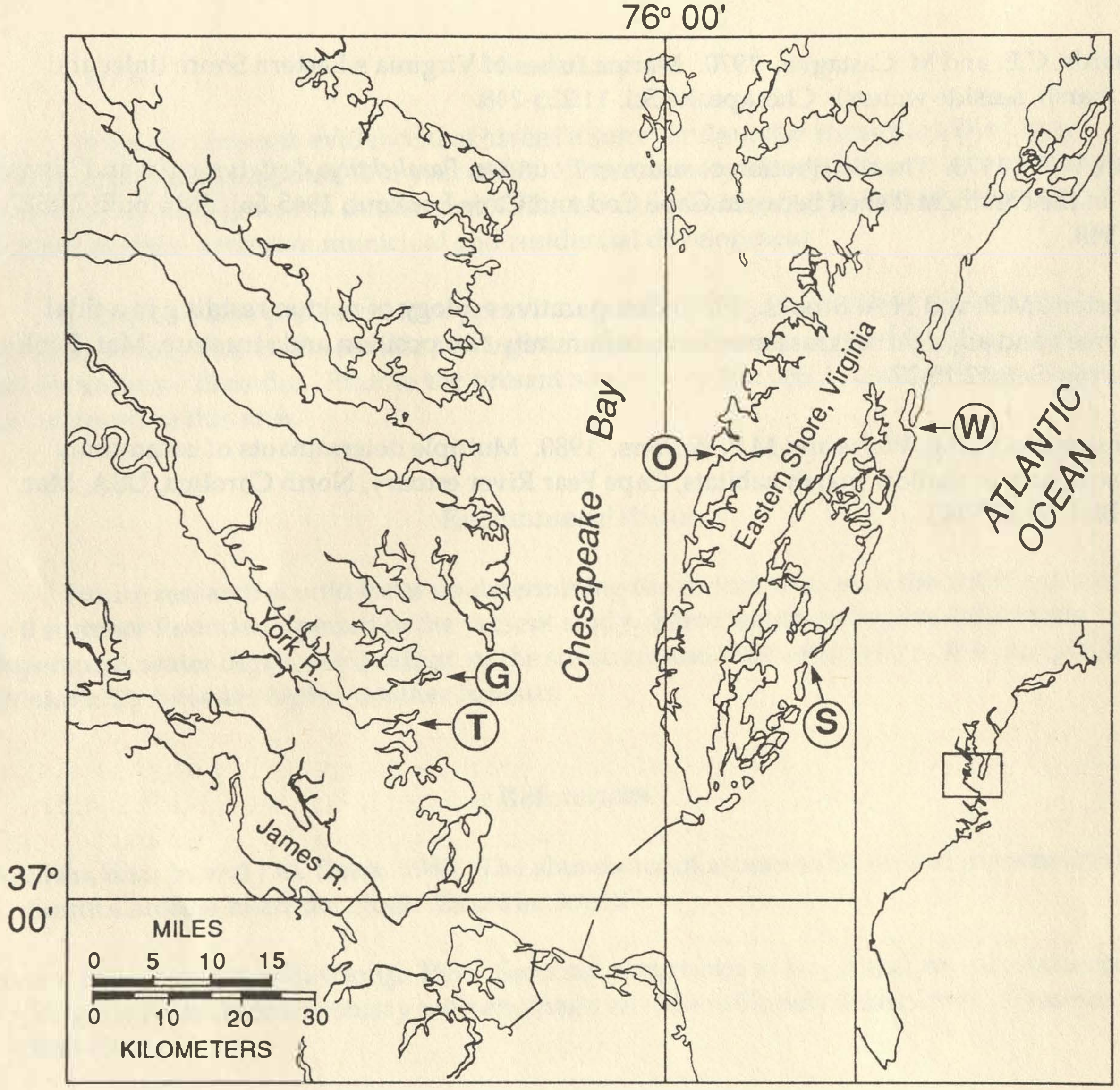

Figure 1. Sampling sites for nursery habitats of summer flounder, *Paralichthys dentatus*: (G) Guinea marshes; (O) Occohannock Creek; (T) Tue marshes; (S) Sand Shoal Channel; and (W) Wachapreague Channel.

Initiation of Trawl Surveys for a Cooperative Research/Assessment Program in Chesapeake Bay

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Introduction

This project aimed to initiate via trawling a cooperative bay-wide fishery-independent monitoring program to eventually provide a broad spectrum of presently unknown life history-population dynamics data required for wise management of Chesapeake Bay resources. In particular, the goal was to determine whether trawls should be stratified, that is, made at different levels in the water column. The project was to provide data and analyses on fish and blue crab locations in Virginia waters to help plan future survey sampling designs. It was not clear if stratified trawling would be useful since no published work describes the spatial distributions of fishes in the Chesapeake Bay other than in general terms.

Objectives

The essential objectives of this project were to describe spatial and temporal sources of variation in trawl catches of fishes and blue crabs from which to define strata to design future trawling programs. Envisioned as a two-year project, the first year's goals were to design and initiate a trawling program, make collections over an initial half-year period, and provide some simple descriptive statistics of the data collected; the second year's goals were to extend the collection base over a one-year period, and then to evaluate spatial/temporal sources of variation in catch and the efficacy of the initial sampling design.

Methods and Results

An initial stratified random sampling design was established using general features of the bathymetry of the Chesapeake Bay. Briefly, twelve geographic (spatial) strata were set up for sampling each month of the year: an upper, a middle and a lower portion of the Virginia waters of the main-stem Chesapeake Bay, each being subdivided into an Eastern Shore littoral (3.5-9m), a Western Shore littoral (3.5-9m), a Central Plain (9-13m), and deep (13m). The sampling frame, therefore, consisted of some 16,000 possible stations located in waters 3.5m or more deep, the minimum depth our gear could fish. Ignoring the depth restriction, the sampling frame included the entire main-stem Chesapeake Bay in Virginia.

To support the field program, a station randomization and plotting program was developed that is capable of plotting an outline of the Bay with locations of randomly selected stations at which to trawl. Additional tables provide latitudes and longitudes of the randomly selected stations along with first and second alternate stations in case trawl hangups occurred at the desired station. The program permits a choice of completely random or stratified random sampling from the sampling frame. The sampling frame was also extended to include, and permit randomized sampling from, major extensions of the mainstem Chesapeake — the James, York and Rappahannock rivers, Mobjack Bay, and Pocomoke Sound. Electronic weighing and measuring systems were developed and acquired to permit efficient data capture and processing of trawl catches.

Field collections were made each month in the period January-December, 1988 inclusive. A total of 48 stations were occupied each month using VIMS 30-foot Marinovich trawls. Four randomly-selected stations were occupied in each stratum each month. A complete set of the planned collections was successfully made each month over the entire year — 48 stations per month for a total of 576 stations in the year. Bottom hydrographic data — temperature, salinity and dissolved oxygen — were collected at all but three of these stations.

Collections were sorted to species in the field and generally returned to the lab for further processing. All fish were weighed as a species lot, counted and measured for length at each station. Abundant species were processed for length data using an adaptation of Lahiri's method of systematic sampling intended to give roughly 500 specimen lots each tow.

Some 507,000 specimens were identified and processed during the course of the field programs. Data are now being analyzed in a simple descriptive fashion. Two species — the bay anchovy and the spot — greatly predominated and made up nearly 92% of the total catch by numbers. Bay anchovy alone made up nearly 65% of the catch; spot made up 27%. All other species individually made up less than 1.5% of the total catch; some 16 of these species were each represented by 500 to 7,000 specimens. Catches and their compositions varied greatly from month to month.

Anticipated Benefits

Anticipated benefits of this project, when the data are more fully analyzed, will include published descriptions of the spatial and temporal sources of variations of the faunal compositions and abundance in the mainstem Chesapeake Bay and an evaluation of the efficacy of the stratified sampling design used. This second year of work has been funded as a Chesapeake Bay Stock Assessment Committee project for the 1989 fiscal year.

Observed benefits already include the establishment of computer-based programs for randomized station selection throughout Virginia's waters of the Chesapeake and the acquisition of electronic weighing and measuring systems to provide a sound system for data capture. The project has also led to the establishment of the survey under State funding in 1989; expansion of the survey design to the larger Virginia tributaries is anticipated in 1991.

Analysis of White Perch Abundance Trends in the Choptank and York Rivers

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Year-to-year differences in fishery abundance may be the result of numerous environmental and anthropogenic factors. In an attempt to partition the contribution of these factors to a particular species, white perch, *Morone americana,* was selected for several reasons. To begin with, because white perch are thought to be largely restricted to river systems within Chesapeake Bay, they may be a better barometer of pollution effects of river systems on fish stocks than species which move out of river systems. In addition, there appeared to be extensive measurements in the Choptank and York rivers of white perch populations, environmental variables and water quality.

Data collection on white perch in the Choptank River goes back to 1929 when the Chesapeake Biological Laboratory (CBL) first began recording catch statistics. CBL gathered data between 1929-1941 and 1944-1956; the Maryland Department of Natural Resources (MDNR) has recorded data since 1957. Prior to 1944, data were gathered from interviews with state and federal personnel, fishermen and dealers. Since 1944, data have been collected from interviews with fishermen, who are required to keep daily records. Also beginning in 1944, catch has been recorded by river region, year, month and gear type.

CBL recorded Choptank River commercial nominal fishing effort data from 1964-1974; MDNR has recorded that data since 1975. There were apparent inconsistencies in the coding for gill net classifications and for gill net effort units between the original sources. Since gill nets were the consistently dominant gear in terms of catch during the years in which effort data were collected, this gear was of interest for assessing trends in effort and construction of a catch-per-unit-effort index of abundance.

In addition to catch statistics, the MDNR has sampled white perch young of the year in Maryland rivers since 1958, while performing seine net surveys for prediction of striped bass year-class strength. Two seine net sweeps are made at each of four sites on the Choptank River, in each of the months of July, August and September, although one or two months have been missed in some years. A summary of the Choptank River analysis is given here, as it is more extensive than the York River analysis.

The original goal of this research was to partition white perch mortality with respect to environmental and anthropogenic factors and to then rank the importance of environmental and anthropogenic factors.

The Choptank River white perch juvenile indices and catch and effort records were examined for a determination of data validity, and a determination of trends. There do not appear to be glaring inconsistencies in much of the data that would invalidate their use, and knowing that these data were collected by dedicated fisheries scientists lends some credence to the numbers. However, inferences from these data for stock assessment are limited by data incompleteness and uncertainty.

Because the Maryland seine survey is aimed at striped bass young of the year, the accuracy of white perch young of the year counts may be lower than desired. A fairly large sampling error — the possible influence of month effects, the small sample size, the differential and dynamic station rankings, and the loss of stations through time — suggests that a different sampling procedure could produce more accurate young of the year counts for an assessment of Choptank River white perch. More intensive sampling within a shorter time span may increase precision without being highly dependent upon individual stations. The accuracy of the fishery-dependent survey is unknown. Lack of data documentation and the occurrence of data inconsistencies diminished the reliability of the fishery-dependent data. There is little information available to assess whether the past surveys accurately measured the variables of interest. The problem of survey accuracy is compounded in a multispecies fishery such as the Choptank River commercial fishery. It is unclear if the measure of nominal effort for finfish is accurate, but almost assuredly, since striped bass was the target species of many fishermen for the years of interest, the nominal effort figures are not accurate representations of nominal effort aimed at white perch. In using these data, one must assume that the survey bias is relatively constant.

In assessing Choptank River white perch, the lack of age-structured catch data prohibits the use of powerful analytical tools, such as virtual population analysis, which can provide estimation of fishing mortality from knowledge of the size of various age classes. The lack of knowledge of how real fishing effort varies with stock size and with nominal effort hindered calculation of reliable catch/effort statistics. Some hypothesized forms of this relationship were assumed for the Choptank River white perch analysis. However, for reliable stock assessment, the age structure of the catch and a good estimate of fishing effort is needed. Without accurate catch and effort data, the degree of confidence in any conclusion on stock status is unknown.

Despite uncertainty of the white perch data, however, a summary of past data may be useful. Some degree of relationship was observed between certain statistics, and observations about abundance trends were noted.

There appear to be trends in the white perch young of the year counts from the seine survey. Three yearly white perch young of the year indices were computed, with indices differing by the computation method; data were categorized in two ways to detect trends. The series was divided into approximate halves, and index values were also classified as being below or above the index median. A chi-square test indicated a significant relationship between the time variable and the index variable for two methods of juvenile index calculation. For these two indices, odds ratios indicated that the odds of a low index value occurring in 1958-1970 was 1/10 to 1/4 of the odds of a low index value in 1971-1984. Although these tests were influenced by the relatively small sample sizes, the observed trend was of higher probabilities of low young of the year catch during 1971-1984 than in 1958-1970.

The commercial white perch landings data exhibit a distinct temporal pattern. The landings peaked four times between 1940-1970, with peaks 8 to 12 years apart. The 1950, 1961 and 1970 peaks ranged from 280 to 545 thousand pounds, and the three troughs between the 1940-1970 peaks ranged from 128 to 152 thousand pounds. The recorded landings declined in 1974-1986 from earlier levels. The 1981 peak of 121 thousand pounds was the lowest observed peak in the data, after the lowest catch in 40 years occurred in 1976. The autocorrelation of 1944-1973 commercial landings indicated positive autocorrelations at lags 9 to 12. These autocorrelations were not significant, but with the omission of the large 1961-1962 data values, the lag 9 and lag 10 autocorrelations were significant at the .05 level.

Adjustment of the gill net nominal effort to a standard unit became necessary for using the full 1964-1986 effort data set. Apparently, the units of effort for CBL and MDNR data were the maximum monthly amount of square yards of net used and the average amount of linear yards of net used, respectively. A conversion factor of 6.10 CBL effort units/MDNR effort units was calculated to give a similar rate of change of net use from 1974 to 1975 as was observed in 1971-1974 and 1975-1976. Using this correction factor, nominal effort, in units of thousands of square yards of net used in a fishing season (a fishing season was defined as the January-June of the present year and July-December of the previous year), ranged from 1988 to 2242 square yards during 1964-1968, increased to 3045 square yards in 1971, fell sharply through 1971-1977 to 700 square yards, rose slightly in 1981-1982, then declined to 271 and 142 square yards in 1985 and 1986, respectively.

White perch commercial landings appear to be related to fishing effort, and landings are probably not a valid surrogate of stock size. Gill net catch per effort statistics were used as a measure of stock size instead. A nonlinear relationship between effective fishing effort and nominal fishing effort probably exists. A model of the form, fishing effort = c (nominal effort) raised to the power a, where c is a constant and a = 1/3, 1/2, or 2/3, was conjectured for this relationship. Two juvenile indices appeared to be related to catch per effort with a lag of 0 and with lags 9-10. This may impart some weak validation to these juvenile indices.

An 8-inch minimum size limit on white perch has been imposed by MDNR since at least the early 1950s. Age-length data collected by MDNR from the Choptank River indicates that the average length of females surpassed 8 inches at age seven, while the average length of males was less than 8 inches for ages 1 to 16. Individuals of ages two or older were observed to be larger than 8 inches for both sexes. A documented age of sexual maturity of two to four years of age would allow reproduction by most Choptank River white perch before reaching legal catchable size, so it is possible that the observed landings pattern is due to a natural cycling. The cycling in landings and the possible relationship between the juvenile indices and catch/effort data may point to a positive stock size-recruitment relationship, though this conclusion needs corroboration.

High fishing mortality in the late 1960s and early 1970s, partly in response to the large 1970 striped bass year class, could explain the low 1974-1976 catch per effort values and the tendency for low juvenile indices in 1973-1977. However, there is no reliable way to calculate fishing mortality in past years without knowledge of the age structure of the catch. If the assumed fishing effort-nominal effort relationships are reasonable, then the juvenile index data and the catch per effort data indicate that white perch populations may have partially recovered from the 1974-1976 low. If white perch abundance occurs in cycles, data on further cycles may be necessary before judgment could be made on whether Choptank River white perch have returned to levels they apparently reached before the mid-1970s. Intrinsic factors, such as cycling and a positive spawning stock size-recruitment relationship, need understanding before effects from extrinsic factors can be fully determined.

Sources of mortality to examine for stock assessments include fishing mortality and pollution-induced mortality. However, measures of stock size and fishing mortality for Choptank River white perch are uncertain or nonexistent. Measures of pollution, as collected by Versar, Inc., were not made on the water quality variables needed for the assessment of pollution effects upon white perch mortality.

For Chesapeake Bay stock assessment, an understanding of stock dynamics will require the appropriate fishery-dependent and fishery-independent data. The anthropogenic variables must be measured at the appropriate temporal and spatial scales at which fish populations are affected. If mortality factors are to be assessed with confidence, that data will need to be more detailed than the data examined here.

Acknowledgements

The work reported here was performed in consultation with the Data Identification and Interpretation Working Group of the Chesapeake Bay Stock Assessment Committee.

Improvement of Virginia Fisheries Statistics: Development of VMRC Data Management Capabilities

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Introduction

When the Chesapeake Bay Stock Assessment Committee was established in 1985 one of the designated areas of attention was improvement of fisheries statistics for the Bay. Consequently, CBSAC has allocated a portion of its available funds to projects designed to improve aspects of fisheries data management and collection. In 1987, the Virginia Marine Resources Commission requested and was granted CBSAC funds to upgrade existing computer capabilities in order to better deal with future demands for data management and analysis. Where the bulk of the project costs were devoted to hardware and software purchases, a number of data management tasks were identified as objectives for the project.

Objectives

- Compile historical commercial harvest and revenue data base on microcomputer.
- Develop audit programs. Describe specificity of historical data base.
- Develop interactive programs to ease access to historical data.
- Document commercial fishing effort data.
- Provide programs to extract habitat permit data from VMRC Permitting data base.

Accomplishments

The primary goal of increasing the amount and capability of existing computer equipment has been accomplished. The Fisheries Division now has a twelve PC network running under Novell Netware (up from three independent PCs). Although equipment linked by the network has been purchased by both state and federal funds, the CBSAC project provided for the creation of the network, and in doing so set a precedent within the agency for use of state-of-the-art PC equipment for computing. Some features of the system are: PC 386 fileserver (20 MgHz), 11 PC 286 workstations, 500 MB combined hard disk storage, 60 MB tape backup units, Bernoulli 20 + 20 removable storage backup, HP Draftpro "D" size plotter/HP 7475 A flatbed plotter, RBASE System V, Wordstar, Harvard Graphics, Quickbasic, and a variety of other DOS compatible softwares.

In addition to system improvements, the data management tasks have been completed. Maryland and Virginia harvest and revenue data for 1929-1986 were received from the Maryland Department of Natural Resources, Tidal Fisheries Division. The data (approximately 10 MB) was downloaded to PC for manipulation. The source files for the downloaded data are the NMFS/NOAA cooperative data base, as edited by Chris Bonzek (formerly MDNR), and the MDNR data set used to generate *An Atlas of Commercial Fishery Statistics in Chesapeake Bay, 1929-1980.* The data has been reorganized to use the latter data set for 1929-1961 and the National Marine Fisheries Service data for 1962-1986. Only Virginia data have been worked with to date, although similar manipulation of Maryland data should be relatively easy.

Documentation of data specificity will be provided in the final project report. There are approximately 75,000 records in the combined Virginia file with fields for year, month, state landed, area, gear, species, pounds landed and dockside value. For the most part data prior to 1962 does not include gear, area, month or value. Data from 1962 to 1972 often lack area and month. Data for 1973 and forward usually have all fields. RBASE audit routines to recognize out-of-range or incorrect values have been developed to error check active data entry of harvest data.

To ease access to the harvest data a set of menu-driven Quickbasic (Microsoft Ver. 4) programs which produce standard formatted reports have been written. The programs use menus to simplify selection of subsets of data. For example, a user will be presented with lists of codes for area, gear and species; selection is then made by highlighting desired code combinations. Results are delivered in the form of three reports which show seasonal distribution of harvest or revenue, distribution of harvest by different gear types, and distribution of harvest by statistical region. Report examples are attached (see Tables 1 and 2). Individual program runs take from a low of 10 seconds for a single species to about 2 minutes for aggregates of species codes. Screen and file output from the program can be easily captured by graphics software to create charts of the data.

The remaining data management tasks for the project concerned fishing effort data and habitat permit data. Although these tasks were minimal, because of the scarcity of data, they represent an attempt to make historical Virginia commercial fishery license data more available and to initiate an index of permit activity (habitat alteration).

Benefits

The most tangible benefits have been to VMRC in that data management capacity and capability have been increased. It is also hoped that the project will eventually contribute to the development of a consistent harvest and revenue data set between cooperating resource agencies. Finally, the programs that have been developed will provide stock assessment researchers with PC ATs an opportunity to work with available harvest data quickly and easily.

Table 1. Catch by area.

YR	Atlantic Ocean	Eastern Shore	Chesapk Bay	James River	York River	Rapahnk River	Potomac River	TOTAL
82	0	1,262	22,112	2,884	3,274	3,238	3,806	36,575
83	0	4,538	21,599	4,059	4,826	2,328	2,950	40,302
84	0	4,769	22,460	2,586	3,544	3,314	2,817	39,491
85	0	2,074	19,501	1,525	2,967	3,586	4,461	34,237
86	1	3,188	16,971	1,722	4,885	44	3,336	30,145
AVG	0	3,166	20,528	2,555	3,899	2,502	3,474	36,150
PCT	.0000	.0876	.5679	.0707	.1079	.0692	.0961	

** Note — All values are in thousands of pounds.

Table 2. Catch by month for all types of gear.

Yr	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Total
82	291	60	927	698	15	15	103	161	85	106	562	461	4,085
83	950	747	998	1,029	179	44	205	228	205	137	1,795	1,224	7,743
84	1,168	1,060	712	519	89	52	31	139	426	950	2,276	1,696	9,118
85	583	790	586	457	199	76	96	110	117	198	680	727	4,620
86	633	780	549	185	129	69	2	16	156	98	443	358	3,419
%	.1251	.1393	.1302	.0997	.0211	.0088	.0151	.0226	.0341	.0514	.1986	.1541	
AVG:	725	807	755	578	122	51	87	131	198	298	1,151	893	5,797

** Note – All values are in thousands of pounds.

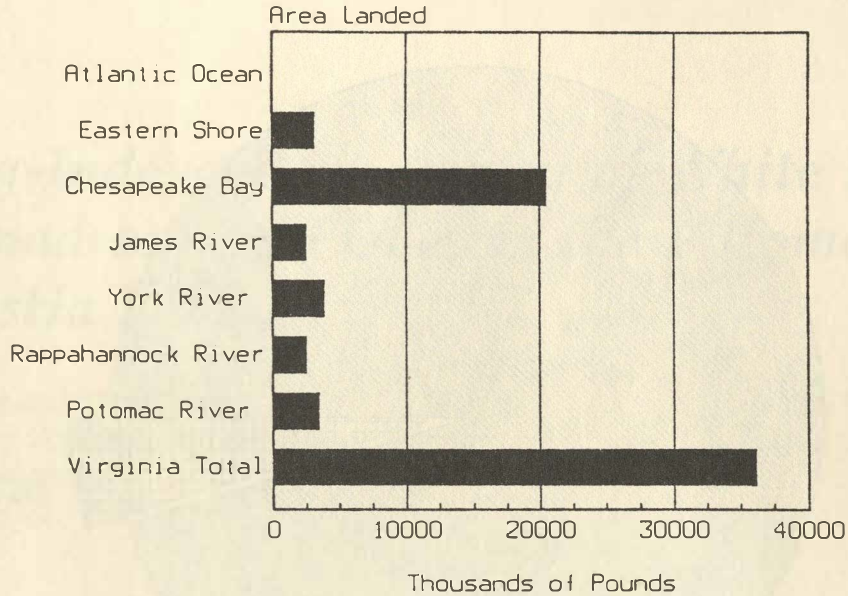

Figure 1. Virginia blue crab landings average for 1982 through 1986.

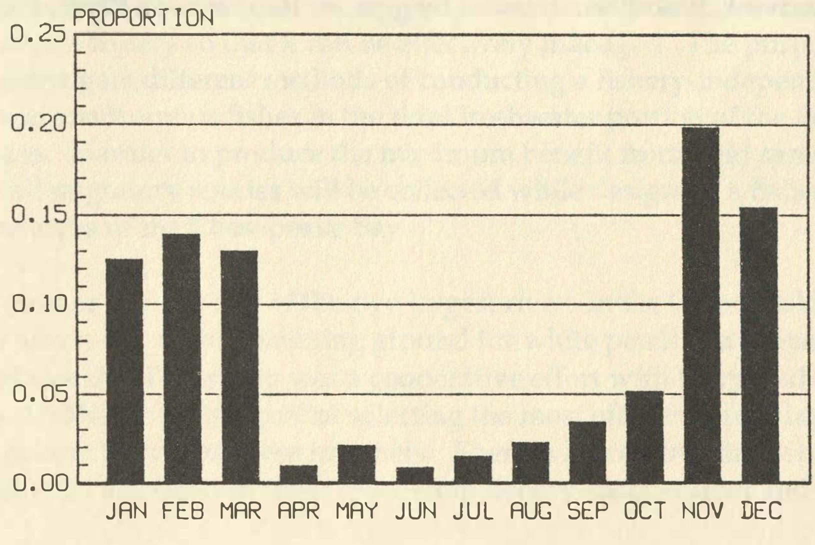

Figure 2. Virginia territorial sea trawl landings. Proportion of harvest by month, 1982-86; average harvest 5,797,000 lbs.

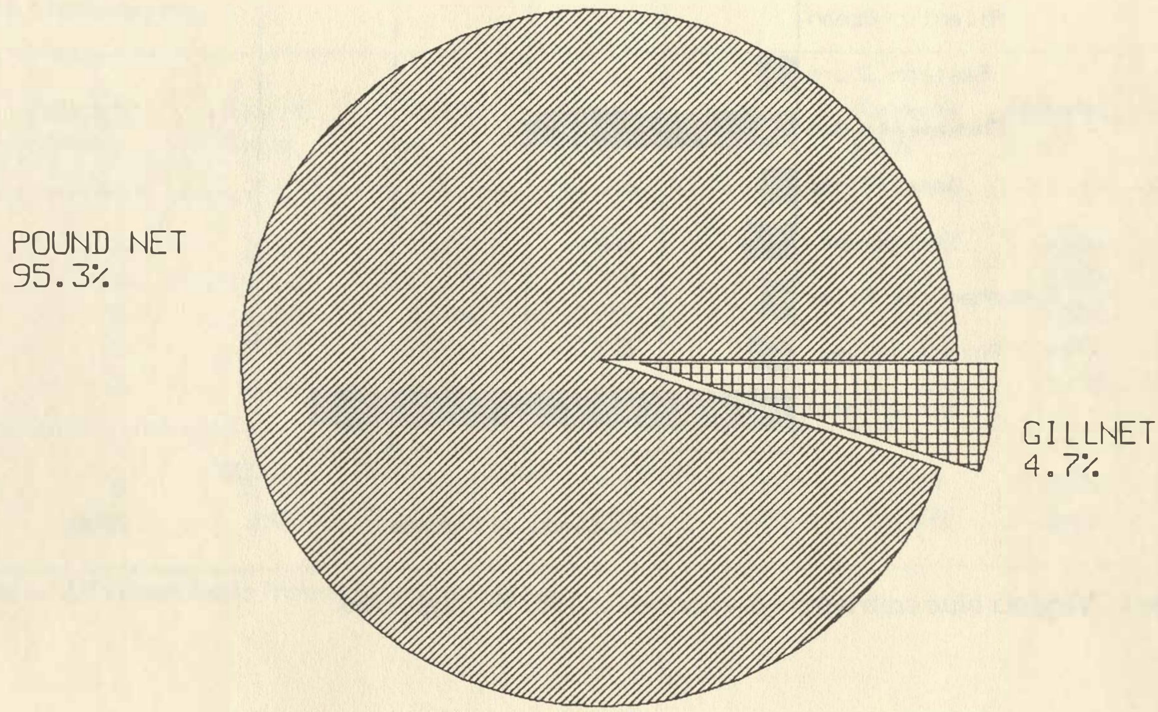

Figure 3. Gray trout harvest, 1982-1986. Harvest by gear for Rappannock River; average harvest 69,000 lbs.

Fishery-Independent Survey of White Perch and Anadromous Fishes in the Potomac and Anacostia Rivers

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Introduction

In recent years, with increasing regulatory restrictions on the striped bass fishery in the Potomac River, the white perch has become the primary spring-early summer recreational fishery in the District of Columbia; consequently, there is an immediate need to develop an understanding of this fishery so that it can be effectively managed. The purpose of the proposed project is to investigate different methods of conducting a fishery-independent survey of adult white perch and anadromous fishes in the tidal freshwater portion of the Potomac and Anacostia rivers. In order to produce the maximum benefit from field sampling, biological information on all migratory species will be collected while designing a fishery-independent survey in riverine areas of the Chesapeake Bay.

The Potomac River is one of the two largest rivers in the Chesapeake Bay drainage, the upper part of which is a major spawning ground for white perch and striped bass, as well as four species of alosids. This study was a cooperative effort with Maryland Department of Natural Resources (MDNR) with the goal of selecting the most efficient sampling technique for assessing the stocks in the riverine environment. There is no commercial fishery in the District portion; all fisheries information must come from fishery-independent and recreational fishery sampling.

Many different gears have been used in fishery-independent surveys; all have certain limitations. The District currently samples anadromous fish with gill nets, electrofishing equipment and fyke nets. The trawl survey is a classical method of fishery-independent sampling. We proposed to use a trawl of the same specifications as the trawl Maryland and Virginia will use to determine anadromous fish spawning area and estimate relative spawning stock size. However, due to the physiography (rocks, debris) of the river bottom in the upper Potomac River, bottom trawl sampling is limited to areas with little debris on the bottom. Alternative sampling methods need to be explored along with trawling. An alternate method to traditional sampling is hydroacoustics.

Hydroacoustics is a relatively new technique which is being successfully employed in stock assessments. A hydroacoustic survey of striped bass spawning stock showed promise in the Potomac River in 1974, despite some problems (Zankel et al. 1975). Hydroacoustic technology has improved greatly since then. Dual-beam techniques can convert relative densities computed by the echo integrator into absolute estimates of fish densities and total biomass because average backscattering cross section of the fish can now be accurately estimated. This new technology provides a more efficient and accurate method of estimating population abundance and should be helpful in making management decisions. We cooperated with MDNR in determining the feasibility of hydroacoustics in assessing white perch and anadromous fish abundances in the Potomac River.

We will use data collected during the trawling to study age and growth of white perch in more detail. Some problems have arisen that need attention before any confidence can be placed on aging methods. Research currently in progress in the Choptank River indicates that white perch otolith readings result in greater ages than scale readings from the same fish; also, scales are more difficult to read (Minkkinen 1986, pers. comm.). White perch scales collected in the District's waters during spring, 1986, are not as difficult to read as those collected in the Choptank River. The disagreement between scale and otolith readings may be a problem particular to the Choptank River population. Oxytetracycline markings is being conducted on white perch held in ponds to solve this problem of disagreement between structures (Minkkinen, 1986, pers. comm.). We will compare otolith and scale readings from Potomac River white perch.

Only two published age and growth studies are available for white perch in the Chesapeake Bay, one in the Patuxent River (Mansueti 1961) and the other in the James and York rivers (St. Pierre and Davis 1972). In these studies, scale circuli were counted as annuli, but only indirect methods of validation (scale-length/body-length relationship, time of "annulus: formation, length frequency analysis) were attempted (Mansueti 1961). Because white perch undergo extensive spring movements and therefore probably encounter more extremes in temperature and food availability in their natural environment than they would in a pond, a mark-recapture study is necessary before annulus formation can be validated. This is beyond the scope of our program. Assuming that circulus formation is annual on otoliths, we will calculate a growth curve for white perch in the Potomac and Anacostia rivers.

We are addressing the fishery-independent module by analyzing white perch landings data collected by the Potomac River Fisheries Commission (PRFC) and the Maryland white perch young-of-the-year index to determine the relationship, if any, between stock and recruitment. PRFC total landings data dates back to 1963, and the data have been separated by area since 1981. They are already stored with the Chesapeake Bay Program. These data will be analyzed to determine the historical trends of the fishery.

A recreational fishery survey will be conducted to determine fishing pressure on white perch in the District of Columbia. We will continue our white perch young of the year beach seine survey to determine if young of the year abundance can predict future adult abundance for this species as well as it does for striped bass. It is important to conduct this survey every year.

This study addresses two terms of reference established by CBSAC — the documentation of the abundance of economically important species and description of spawning patterns of fishery resources in Chesapeake Bay and its tributaries. It is directed at two of CBSAC's research priorities for 1988: (1) relevant to current and anticipated state and interstate FMP stock assessment data and information needs, and field sampling and data management development.

The study will contribute to the understanding of economically important species in the main tributary of the Chesapeake Bay and should lead to the development of successful management plans. The cooperative nature of the study will promote communication among regions of the Chesapeake Bay. The study is relevant to all principal components (distribution, existing data, sampling design) of module I, fishery-independent monitoring plan (post-recruitment), and it addresses modules II and III, fishery-dependent monitoring plan and pre-recruitment dynamics.

If hydroacoustic techniques of estimating absolute abundance prove feasible for the Potomac River, they could be used in the rest of the Chesapeake Bay drainage basin as well. Fisheries managers would no longer need to rely only upon estimates of relative abundances.

This project will incorporate information on anadromous fish collected in the 1985/86 CBSAC funded projects by the District of Columbia. The District is committed to fisheries surveys, and survey work previously funded by CBSAC in the District on anadromous species will be continued by Wallop-Breaux funds.

Objectives

The objectives of this project are to:

1. Conduct a trawl survey of white perch and anadromous fish spawning stock.
2. Investigate hydroacoustics as an alternate method of estimating abundance.
3. Calculate age and growth parameters.
4. Analyze white perch landings data in the Potomac River.
5. Assess recreational fishery for white perch in the District of Columbia.
6. Develop a white perch young-of-the-year index.

Progress

The progress on the six objectives of this study is as follows:

Objective 1. A trawl survey of white perch and anadromous fish was conducted — a total of 49 trawl samples were taken as part of the groundtruthing procedures under the second objective. This data is sufficient to meet the two goals under this objective: (1) to determine species abundance, composition and distribution, and (2) to establish sampling protocols for a long-term monitoring program. Since this is the first such survey conducted in the District of Columbia for white perch, the data analyzed will serve as baseline information concerning the abundance of white perch and other anadromous fishes in the District. The data has been analyzed and the results will be included in the final report.

Objective 2. Thirty-four zig-zag transects were selected along the Potomac River from Quantico to Three Sisters. Four sites were selected for biological groundtruthing based on appearance of dense scatter on the charts recorder's echogram. Five 720-hour surveys were conducted (1-4 March, 22-25 March, 11-15 April, and 23-27 May 1988). During each survey, the first 24 hours consisted of zig-zag acoustic transects, with the night shift going downriver and the day shift going upriver. The next 24 hours consisted of a mixture of trawling and gillnetting at four sites and channel acoustic runs. The last 24 hours consisted of more trawling and gillnetting. There were slight changes in itinerary as circumstances dictated (need for gasoline, equipment failure, weather).

Acoustic data were collected mainly on three frequencies: 38 kHz, 120 kHz, and 420 kHz. A 70 kHz transducer was also used during one survey. This data was digitized and recorded on tape with a VCR. Dual-beam processing and echo integrating of over 200 hours of tape recorded data was begun in June 1988. One transect was processed early during the study, and together with the trawl data, it was determined that acoustics might be a promising technique in the Potomac River, at least for white perch. All fish from trawl and gillnet samples were identified and counted, and total weights were recorded. Individual lengths were recorded for the anadromous and semi-anadromous species. Individual weights and sex were recorded and scales and otoliths were taken from subsamples of white perch in an effort to obtain more data for objective. The hydroacoustics report has been completed and submitted to NOAA. The data and analysis will be included in the District of Columbia's final report.

Objective 3. Over 1,000 scales and otoliths have been collected this spring with gillnets (2-3/4, 3, 3-1/4, 4 inches), beach seine, and the 16-foot bottom trawl used for groundtruthing in the acoustic surveys. The scales and otoliths are presently being analyzed and will be included in the final report.

From the scales and otoliths collected last year, it is apparent that otoliths yield greater ages than scales (Minkkinen pers. comm.). Minkkinen is using OTC tagging in an effort to verify annuli on otoliths.

Objective 4. Data from 1929-1985 have been received from Maryland DNR and Potomac River Fisheries Commission. Landings data have been separated by gear since 1962. The white perch young-of-the-year index dates back to 1958. As a result of the District of Columbia's Fisheries current staffing limitations, the analysis of the white perch landings data will not be completed until January 1990.

Objective 5. Data for this objective were collected during the District's ongoing creel survey. The analysis of data has been completed and will be presented in the final report.

Objective 6. No white perch young of the year have been collected yet during the District's ongoing monthly beach seine. There are five stations in the District of Columbia, and five are being sampled down river to Indian Head.

Products

1. Development of a standard fishery-independent sampling method.
2. An assessment for hydroacoustics and a method of estimating absolute abundance of white perch and anadromous fishes with potential application to other migratory species.
3. Age and growth information for white perch.
4. Element in an integrated fisheries management plan.
5. A comprehensive understanding of the white perch fishery in the upper Potomac River.

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Objective 4: Data from 1929-1985 have been compiled from Maryland DNR and Potomac River Fisheries Commission. Landings data have been separated by gear since 1960. The white perch YOY and the year index dates back to 1955. Because of the Principal Investigator's current staffing limitations, the analysis of the white perch landings data will not be completed until January 1990.

Objective 5: Results for this objective were reflected during the Patuxent's upcoming field season. The analysis of data that has been completed to date will be presented in the final report.

Objective 6: No white perch ecological surveys were conducted [illegible] in the Choptank [illegible] this work was [illegible] to the Patuxent, Choptank, and Potomac [illegible] being sampled down river to [illegible].

Future needs

1. Development of a standard fishery-independent sampling method.
2. An assessment of fishing mortality and survival of white perch [illegible].
3. [illegible]
4. [illegible]
5. A comprehensive understanding of the white perch fishery in the Chesapeake Bay.

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Integrated Sampling Design for the Bay-Wide Trawl Survey

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Implementation of a Bay-wide trawl survey to provide information for abundance estimates, for assessment of spatial and temporal distributions, and for life history characterizations is an objective of the Chesapeake Bay Stock Assessment Plan. To help design the trawl survey in a scientific manner, the Penn State Center for Statistical Ecology examined related issues of which estimation model and which sampling scheme should be utilized for the Chesapeake Bay setting. This work was performed through the spatial modeling of past trawl survey data for determining statistically efficient estimation and sampling and through theoretical consideration of the statistical efficiency of "expert system" sampling and estimation.

Statistical efficiency of estimates can be pursued by accounting for spatial variability in the estimation model. Hypothesized sources of spatial variability include trend, or large-scale variability, and small-scale variability due to a random stochastic process. Estimation when small-scale variability is present in the data can be performed by kriging, a minimum-variance unbiased prediction of a response surface of random autocorrelated observations. We first examined the implications of the kriging model assumptions to fish and shellfish data (Bolgiano et al. 1989a).

Appropriateness of the kriging model for abundance estimation with an accompanying variance estimate assumes data stationarity, implying constancy of the mean and of the variance in space. A data transformation to stabilize the variance, omission from the analysis of regions of zero counts, and the removal of trend were steps of ensuring some confidence in the stationarity assumption. Small-scale variability was apparently detected by autocorrelation in trend model residuals, when sampling provided enough station pairs within the spatial scale of the random stochastic population process. Spatial autocorrelation was a data-determined property. In our analysis of sea scallops, ichthyoplankton, and adult haddock survey data collected by the Northeast Fisheries Center, only the sea scallops data and one of the adult haddock samples exhibited apparent autocorrelation. Abundance estimation from the other samples could proceed from considering trend in the estimation model. Regression modeling might be one approach to this, but stratified random sampling and estimation appeared to be a robust methodology, as indicator variable trend models were generally good approximations to the data; the variance could differ among strata, and the bias of backtransformation could be minimized.

The same model of spatial variability was applied to selected Chesapeake Bay samples from the Virginia Institute of Marine Sciences historical data base (Bolgiano et al. 1989b). Selected data were the largest samples of the most abundantly caught species from both the Bay mainstem and the York River. If autocorrelation is present in any past Virginia trawl survey data, it would probably appear in these samples.

A strong tendency for a trend did not appear in Bay mainstem samples, except for the presence of regions of zero counts. These observations were omitted to assume data stationarity and to assess autocorrelation. Of the Bay mainstem data, bay anchovy counts sometimes appeared autocorrelated, but croaker, hogchoker and spot counts generally did not. A tendency for a trend did appear in York River data, as counts may have been related to a distinct gradient in salinity. Failure to remove this trend induced an apparent autocorrelation pattern in some samples, but post-stratification of observations induced apparent randomness of the data within strata.

There are implications to efficient sampling and estimation from assessing the scales of spatial variability in Chesapeake Bay trawl data. Data autocorrelation may be influenced by the species examined, and for kriging to be useful in predicting a response surface of counts, some station pairs must be sampled within approximately 6-8 km, the observed range of apparent autocorrelation. But generally, kriging probably cannot be relied upon for estimation of Chesapeake Bay finfish sampled by trawl surveys, as most species do not exhibit spatial autocorrelation at the spatial scale it is feasible to sample. Stratified random sampling and estimation appear to be robust statistical methods for the Chesapeake Bay for the same reasons they appeared to be appropriate for the marine organisms of the first study. The optimal choice of Bay strata is not presently clear, and may partially depend upon the resources available and the desired estimate precision.

Random statistical models appear to be robust strategies for present sampling and estimation of Chesapeake Bay finfish. However, if it is possible to identify the sites of highest abundance, then in some cases it may be more efficient statistically and logistically to sample these sites than to sample randomly (Patil and Taillie 1989). This form of sampling and estimation is the theoretical basis behind the "expert system" approach being explored by the Chesapeake Biological Laboratory. The relative performance of this approach compared to random sampling awaits determination, however, and for the near future our research has indicated that stratified random sampling and estimation appear to be a robust, feasible approach to Baywide sampling of finfish.

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Assessment of the Natural and "Repletion" Population of Oysters in the Chesapeake Bay

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Introduction

Historically the American oyster, *Crassostrea virginica*, has been the most valuable fishery in the Chesapeake Bay. At the end of the last century, oyster landings in the Bay were greater than anywhere else in the world. At the beginning of the twentieth century landings declined precipitously, then fluctuated between 200,000 and 400,000 tons a year until the last several years when they have fallen to all-time lows (Figure 1). In contrast, the last ten years have seen the total world oyster production increase by 20% from 859,682 tons in 1977 to 1,011,079 tons in 1986. While production grew in Korea, France and Japan it decreased by 29% in the U.S. beginning in 1982 (Figure 2); until 1986, U.S. landings of oysters ranked first, ahead of Japan, France and the Republic of Korea. These four countries produced nearly 87% of the total world landings. Steadily falling production along the northeast coast, particularly in the Chesapeake Bay, has resulted in the decline of U.S. landings (Figure 3).

Despite considerable research in Chesapeake Bay, there is much uncertainty regarding the specific causes of this decline, whether they are due to overfishing, disease, loss of habitat or other factors. Contributing further to the uncertainty, management attempts to protect the resource and reverse the decline have evidently been unsuccessful.

For a number of years the state of Maryland has had an oyster repletion program that involves shell planting and seed transplanting components. The program has reportedly operated under the influence of political necessity rather than scientific and biological considerations. To evaluate the repletion program and assess the status of stocks, the Maryland Department of Natural Resources has conducted an annual bay-wide oyster survey for the last several decades. While the survey collects information on the relative abundance of oyster spat, juveniles and adults, it lacks consistency in data recording, sampling methods and sampling locations. In its present form, therefore, the survey does not provide quantitative information on oyster abundance, spat settlement, recruitment, growth and mortality. A lack of statistically-based estimation procedures makes it difficult to assess the magnitude of population among time periods and areas — information that is critical to managing recovery of the stock.

Thus, because of (1) uncertain causes of the decline, (2) evident unresponsiveness of oyster populations to management and (3) absence of statistical foundations for estimation of abundance and consequently recruitment, growth and mortality, it is difficult to determine appropriate management and repletion strategies.

Objectives

To begin addressing these issues and questions, the main objective of this work is to develop a system for the assessment of *natural* and *artificial* oyster stocks. Secondary objectives are to (1) use these assessments in management of fishing and (2) determine the causes of the decline.

Stock assessment objectives are twofold and involve (1) determination of the number and size of spat juveniles and adults from which mortality, growth and recruitment can be determined and (2) investigation of the causes of variability in mortality, growth and recruitment. Determination of the number of oysters requires the development of an adaptive management strategy, which involves the choice of sampling gear and the theory of sampling.

Methods

Oyster Gear Evaluation

A survey conducted on three oyster bars in the Chesapeake Bay, Hog Island, Holland Point and Walter White, was designed to determine which gear is most suitable for the assessment purposes. Three collection methods were used: (1) diver harvest, (2) hydraulic patent tongs and (3) oyster dredge (used by the State survey). The primary results indicate that patent tongs are more accurate collection gear than the oyster dredge in estimating oyster abundance. Relative to diver-obtained samples, the patent tong has the best catch efficiency (trend to 100%), while the dredge's catch efficiency ranged from 2 to 25%. Quantity of shell and bottom type appeared to have no effect on patent tong catch efficiency, but may have substantially affected the catch efficiency of the dredge. Both patent tong and oyster dredge samples adequately represented the size class distribution.

This study produced a preliminary stock assessment survey of the Potomac and Patuxent rivers during May 1989. In particular, 45 of the 51 Potomac River mainstream oyster bars were sampled using patent tongs. These samples are used to develop a sampling strategy.

Sampling Design

Different sampling strategies are compared to maximize the precision of the estimators for total number of samples, or inversely to minimize this number according to a precision level. The methods are (1) simple random sampling, (2) cluster sampling and (3) stratified sampling.

Technical constraints which limit the total number of samples, depending on the scale of sampling, are taken into account. The decision among several strategies needs to consider sampling concerning the surface of each strata, or the cluster size determination, and needs to determine the associate variance to the estimator and the optimization (sample/strata). The end products will enable us to: (1) estimate the oyster standing crop, (2) determine the stock structure, (3) assess the effect of abiotic factors and (4) study oyster population dynamics in the two tributaries. Finally, this work will enable us to extend these techniques to the Chesapeake Bay by a larger survey.

Investigation of Courses of Variability in Mortality, Growth and Recruitment

A critical aspect in understanding the decline of the oyster and in developing strategies to reverse that decline is to assess the following: (1) the relative importance of recruitment, growth and mortality in the decline and (2) the factors that affect these population-dynamic variables. To accomplish these goals, a model quantifying the impact of environmental variables that control the growth of the oyster is developed, based on energy fluxes. In particular, the survey may explain the mortalities observed during the global approach on the natural population (stock assessment), and related to the effect of environmental variables.

In July, the survey structures were installed at two sites in the Patuxent River, one near Benedict Bridge and one at the mouth of the river. On each site, a yearly survey will be realized at three densities of oysters (200/m^2, 300/m^2, 600/m^2) at two depths (one meter from the surface and near the bottom).

Artificial Population and the Repletion Program

Two aspects of the repletion program are considered for improvements. The first is its effectiveness, based on biological criteria (intensity of settlement), as well as on costs induced by their operation. The second is the relation between the "artificial" population produced by the repletion program and the natural population.

Spat Success

A large part of the repletion program's effectiveness depends on the efficiency of spat settlement on the transplanted shells. Consequently, the main goal of this study is to determine the optimum shell planting regime. The first part of the study is to determine the optimal time-space location for shells, such that maximum concentrations of spat occur in the vicinity of the shells.

Eight study locations are selected based on historical records of spat settlement. They are in the Patuxent, Potomac and Honga rivers. Beginning in April, 1989, cages with shells were set up at two-week intervals. A minimum of 200 cages will be deployed by the end of the study period, which will be determined by the end of the reproductive period. At the same locations, a substitute for dredge-shell, in this case an artificial plastic spat collector, is being tested. The relationship between the spat densities and shell planting times will be established and related to the effect of environmental variables.

Operations Research

The results of the oyster program, as it is being currently implemented, have not been satisfactory. This problem has two associated components: (1) to determine the "attractiveness" or productivity of the individual oyster bars in terms of spatfall and seed oyster production, and (2) given the attractiveness measures, what is the appropriate allocation schedule for shell plantings? How many shells are to be planted, and on which bars and how? The overall problem can be seen as one of maximizing some measure of over "productivity," subject to a variety of resource constraints. A linear programming model is the first step in the study of quantitative treatment of shell planting program.

The objective function attempts to maximize annual oyster production by allocating dredge shells more effectively. This model takes into account (1) the number of oyster bars available for planting per county, (2) the attractiveness factor in terms of oyster production of bar, (3) the number of tugboat trips made to one bar during one working day and (4) the carrying capacity of each bar. The linear programming model has been tested on realistic data using INDO. This model can be used to perform sensitivity analysis on the input data.

Different cases are being examined with the model. The main differences between cases is the restriction on how many bushels of shells must be allocated to each county. Detailed solutions include the number of tugboat days, number of tugboat trips, and the volume of shells planted. The key point is that the output tells us where to plant the shells and how many shells to plant at each bar.

This model can therefore be used to mathematically represent and solve the oyster shell planting problem in Maryland. Model parameters can be varied to examine the impact of additional tugboats, dredged shells, available working days and other factors. The model encourages the calibration of objective function and other coefficients on a yearly basis. This should provide a major benefit to the State in and of itself.

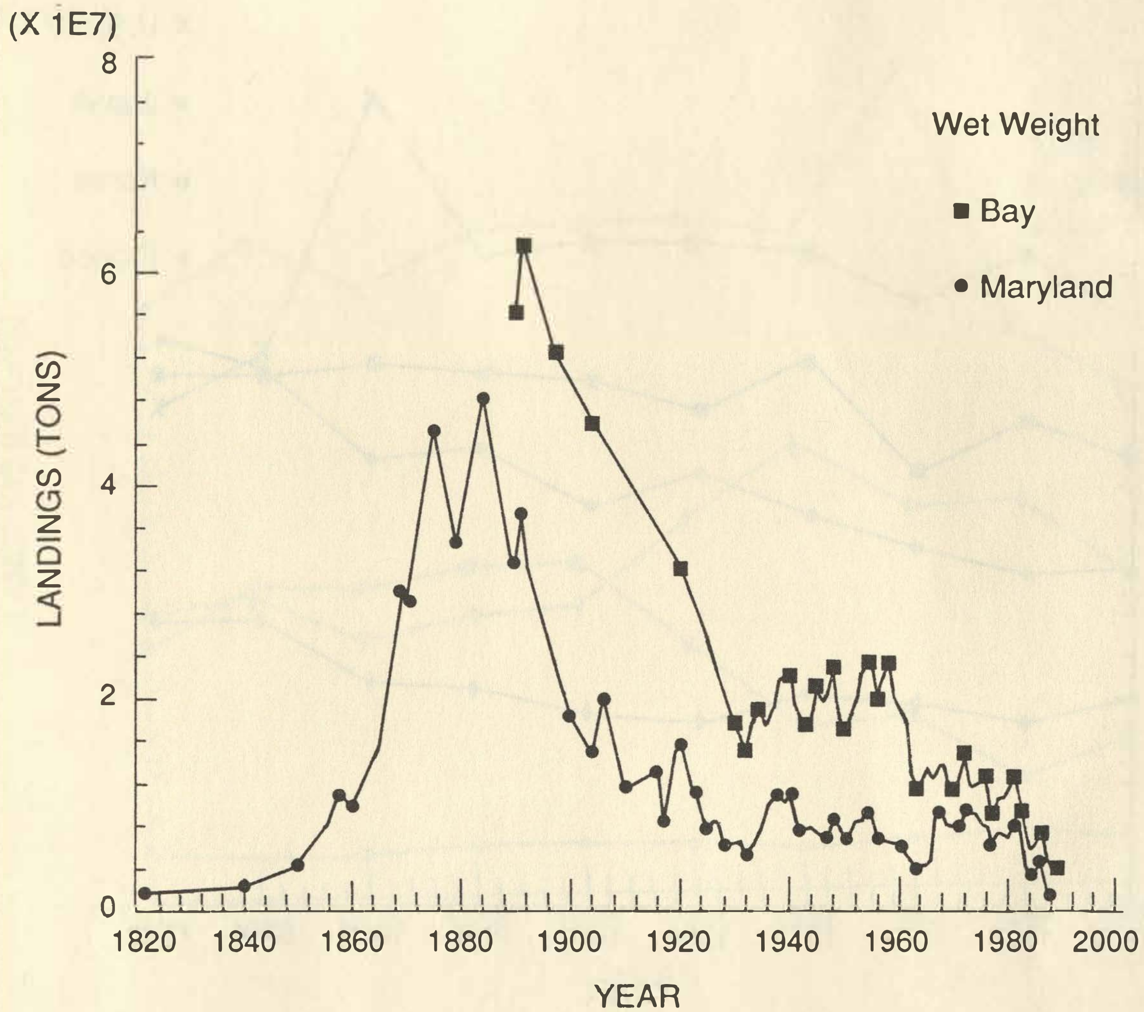

Figure 1. Historical oyster landings in Chesapeake Bay and Maryland. Evolution of oyster production in total weight in tons: Maryland part of the Bay (●) and total Chesapeake Bay (■) (from Heral, et al., 1989).

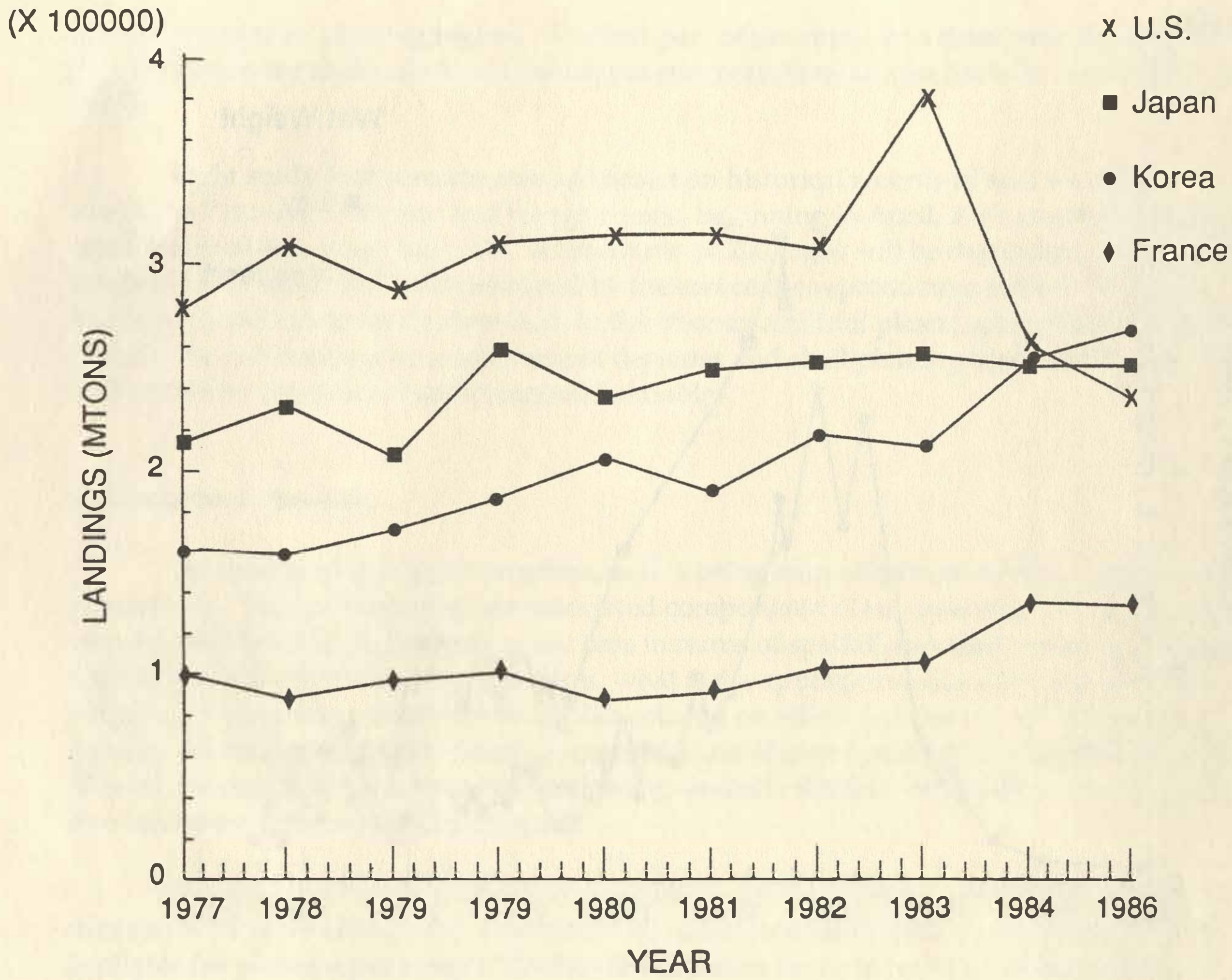

Figure 2. Historical oyster landings. Evolution of oyster production in the U.S. (X), Japan (■), Korea (●) and France (♦).

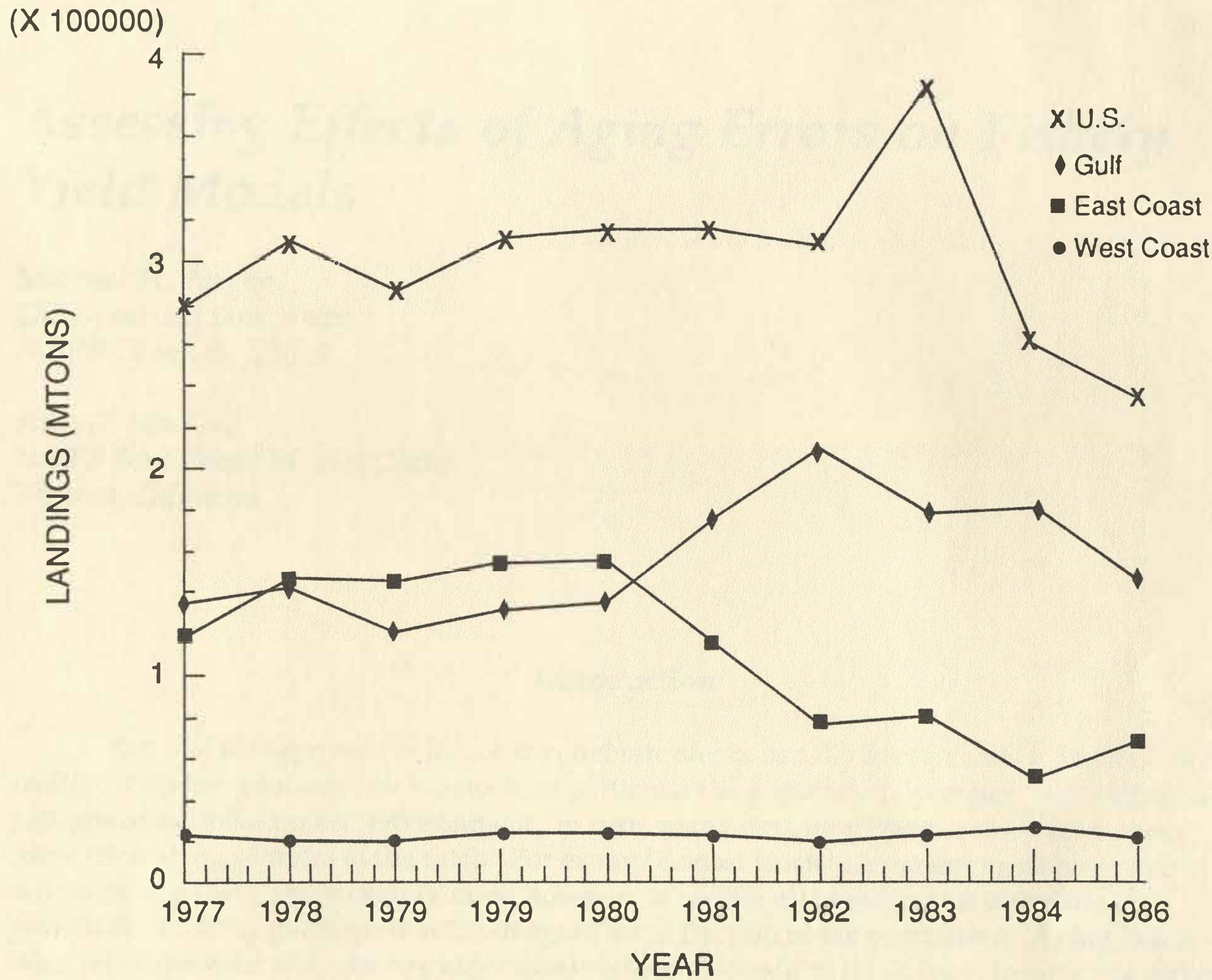

Figure 3. Historical oyster landings in the U.S. Evolution of oyster production in the U.S. (X), Gulf (♦), East Coast (■) and West Coast (●).

Assessing Effects of Aging Errors on Fishery Yield Models

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Introduction

Rational management of fish or invertebrate stocks usually involves stock assessment, in which the biological aspects of the stock, in particular the population dynamics, are related to patterns of exploitation and environment. In turn, many data important to stock assessment come from aging samples of the catch. For example, most stock assessment models require estimates of growth and mortality rates; however, it is difficult to estimate a population's growth or mortality parameters without aging some fraction of the population. Aging fish is relatively expensive and, like any other measurement procedure, it is subject to error. In order to age as few fish as possible, it is important to know what effects error and variability in aging can have on models used to provide management advice, including models of yield and population fecundity.

Error in age determinations can come from randomly misaging certain specimens, from nonrandom sampling effects (e.g., size-selectivity of the sampling gear), or from a systematic misaging of older specimens. In addition, errors in estimating growth parameters can arise simply from suboptimal sample sizes. We are examining the effects of errors in aging, using the results of yield-per-recruit analyses as a benchmark. In particular, we are addressing the classic yield model of Beverton and Holt (1957), with the additional management measure $F_{0.1}$ that has been proposed by Gulland (1965) and others to avoid overfishing.

We expect that the knowledge gained will facilitate design of sampling plans for age determinations in the Chesapeake Bay region. If this is done, the quality of scientific advice available to managers should be improved for many species.

Objectives

1. Review fisheries modeling techniques that use data describing the growth and/or age-structure of a stock.

2. Determine the degree to which growth and age-structure data are collected, and have been collected, in Chesapeake Bay fisheries.

3. Develop simulation methodology to quantify the effects of aging error on yield models of typical populations.

4. Demonstrate how methodology developed in objective 3 can be used to determine efficient sampling regimes for Chesapeake Bay fisheries.

Progress

The first phase of this study was a literature review and synthesis of the uses of growth and age-structured data in fishery management. We have reviewed literature including journals, books and gray-literature reports, using computer-aided searching. To ensure coverage of earlier references, we also used print copies of abstracting services, including *Aquatic Sciences and Fisheries Abstracts* and *Oceanic Abstracts*. This phase of the study has resulted in a document, written at a relatively nontechnical level, that can introduce managers or others to the necessity for and uses of studies of growth and models incorporating growth information. The document is currently in second draft, having gone through external review and revision (in addition to several stages of internal review and revision).

In the second phase of the study, we surveyed local fishery management and research agencies (Virginia Marine Resource Commission, Maryland Department of Natural Resources, Virginia Institute of Marine Science, Old Domimion University, Center for Environmental and Estuarine Studies) to determine what growth and age-structured data are archived in this region. We have prepared a summary of this survey, which will be issued as a technical report. Our findings indicate little collection of age-structured data in Chesapeake Bay on a routine basis. However, growth studies have been pursued upon occasion for many Bay species. Thus, we have data for application of yield models in many cases, but not often for more advanced methods of stock assessment, such as virtual population analysis. Furthermore, since growth may vary with population density (Prager and MacCall 1988), more regular collection of growth information, as is being initiated at present around the Bay, will be of great value in management.

The third phase of the study includes an examination of the effects of aging error on the Beverton-Holt yield-per-recruit model, a widely used management tool. The focus of our study is the effect of aging error on estimates of $F_{0.1}$, which might form a reasonable management benchmark for several Chesapeake Bay fisheries. A literature review on previous studies of age-error effects has indicated this topic has not been studied before. Since collection of age-structured data is sparse in the Chesapeake Bay region, we are using both collected data and simulated data. At this point of the study, we are finishing computer programming on the simulation model that will allow study of this phenomenon.

The simulation model will use length-at-age data with error to estimate growth parameters of the population (for use in the Beverton-Holt yield-per-recruit model). The errors in the input data are varied stochastically, and Monte Carlo simulation will be used to explicitly describe the distribution of possible predictions of the yield model. This procedure is to be followed for several different levels of error in aging data. The results will be presented graphically and in tables.

As part of this phase of the study, we will attempt to demonstrate how the methodology developed for examinaing the effects of aging errors can be used to assess sampling regimes for aging data. While it may not be possible to conduct a detailed analysis of this question, we expect at least to provide a number of realistic and illustrative examples.

Benefits

The project is expected to yield improved knowledge useful in the design and analysis of sampling programs in the Bay region, particularly in the application of yield models. The Chesapeake Bay Stock Assessment Committee is developing a plan for sampling commercial and recreational fisheries. We believe that the proposed work will be useful in implementing that plan.

In a larger sense, this work is related to the increasing tendency in fishery science to examine the effects of errors in data, and issues related to statistical properties, especially statistical power, of our methods. In this connection, papers by Vaughan and Van Winkle (1982), Peterman and Bradford (1987), and de la Mare (1984), to name a few, are of interest. The use of such methods can result in clearer advice to managers, because the certainty and uncertainty in the biological advice is considered and made explicit. Thus, the manager has better information on which to make decisions.

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Improvement of Maryland Fisheries Statistics Management

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Introduction

The Fisheries Statistics Project of the Maryland Department of Natural Resources (MDNR) functions in two separate but related areas. It is responsible for the collection, storage, analysis and distribution of all fishery-dependent monitoring data in the Maryland portion of Chesapeake Bay. It is also responsible for the data management of the fishery-independent monitoring programs conducted by the Fisheries Division of MDNR. Both of these functions involve large data management systems.

The Fisheries Statistics Project now processes approximately 500,000 data records annually in all of its data management functions combined. Data entry is handled through the traditional key-to-disk process by a staff which fluctuates between two and five individuals. This type of data entry has become less acceptable for a number of reasons: staff turnover, increasing volume, a new fishery statistics collection system and inaccuracy.

To begin with, it has become increasingly difficult to recruit, train and keep high quality data entry staff — the work is low paying, monotonous and generally unrewarding. Though we have become more dependent upon temporary service workers, unfamiliarity with the data results in higher error rates by these workers. Second, the number of fish stock monitoring and assessment projects conducted by MDNR has increased as much as ten-fold over the last several years. Despite improvements in equipment efficiency and our ability to hire temporary workers, we have barely been able to meet present data entry demand, which will continue to increase. Third, the Chesapeake Bay Stock Assessment Plan has recommended establishment of a new, uniform system for estimation of fishery harvests. Based on a "trip ticket," this system would require a ticket to be completed each day by each active fisherman, with a copy sent to the management agency. In Maryland, this will result in a doubling of data entry demand. Not only would data entry volume increase dramatically but the need for quick turnaround of landings data will be paramount. Finally, each time data is transcribed or punched, errors are introduced. A system which could read field data sheets directly into computer storage would significantly reduce post-entry editing requirements. It is because of such data entry management issues, that the Chesapeake Bay Stock Assessment Committee has funded projects to improve and standardize the long term storage of data sets.

Objectives

The objective of this project was to develop automatic data entry system of all fishery-dependent monitoring data in the Maryland portion of Chesapeake Bay.

Progress to Date

The purchase of a scanner system capable of reading human hand printing of both alpha and numerical data directly into computer files has been completed. The system reads up to 100,000 characters per hour and is five to six times faster than human operators. Such speeds would free one or two data entry staff persons to be productive in other activities and will also increase data entry accuracy. This system is essential in handling the large volumes of data resulting from the MDNR daily trip ticket statistics system. The reader system connects to a standard IBM PC/AT and is capable of recognizing a wide variety of hand printing styles from prepared forms. Unreadable items are either corrected concurrently while the machine continues with further forms, or records are flagged and unreadable forms separated for later editing.

The lifting of the Striped Bass Moratorium in 1990 will change the statistical demands on the data base. Using the data base, we must be able to account for the total number of striped bass caught from three different groups: sport fishermen, commercial charterboat captains and commercial fishermen. Each group will be given a mark of the total number of striped bass allowed to be harvested for a limited season. If they reach the mark before the end of the season, MDNR can cut the season short. Data will be written daily and submitted weekly; the only feasible way of completing this task quickly and accurately is to use the scanner.

Work in Progress

The most urgent need for the new scanner is to format the current Sport Fish Licensing form. Through this form, we hope to generate a random creel survey mailing list. To date, the old form has been handwritten and the carbon copy sent to the department. Key punch operators attempted to read these poor copies, but so much information was either illegible and/or missing that the file was neither complete nor usable. Creating an accurate address file became of high importance. The scanner, with properly designed forms, will eliminate most of the problems. The new form is in block letter entry format, and the original will be returned to us. We expect approximately 400,000 forms returned throughout the year, with the majority of them coming in by the end of June (Figure 1). This data base will supply the state of Maryland with the much needed creel information from sport fishermen.

To improve statistical data the commercial license group has been divided into two groups: charterboat captains and commercial fishermen. These commercial license holders must now report their daily catch on a weekly basis. Questions for the charterboat captains are specific for each trip per day. Each day is then accounted for whether or not fishing was done. Only questions pertinent to the charterboat fleet are addressed (Figure 2); if charterboat operators also hold a commercial fishing license, they must report any catch for that on the appropriate form.

Development of a daily catch reporting system for the commercial fishermen will be similar to the commercial charterboat captains. They will record daily data but must mail those data in weekly. This system will include tracking information to indicate where the fish were sold. Questions will be specific to the commercial harvesters and include spaces for multiple gear types.

Future Directions

The MDNR database also includes reports for finfish dealers, sport crabbers, clam dealers and oyster dealers (Figure 3). We hope to develop scannable data entry sheets for all of these fishery-dependent studies as well as any long term fishery-independent study.

STATE OF MARYLAND
DEPARTMENT OF NATURAL RESOURCES

SECRETARY OF NATURAL RESOURCES

SPORT FISHING AND CRABBING LICENSE APPLICATION

DEPARTMENT USE

AGENT # | DATE | SIGNATURE

THIS FORM WILL BE COMPUTER SCANNED: PRINT USING CAPITAL LETTERS AS ILLUSTRATED: J A M E S

FIRST NAME | M.I. | LAST NAME

STREET ADDRESS

CITY | STATE | ZIP CODE

DATE OF BIRTH ☐☐ - ☐☐ - ☐☐

I HEREBY CERTIFY UNDER PENALTY OF PERJURY THAT I AM A RESIDENT OF THE STATE OF ________ AND THAT ALL STATEMENTS MADE HERE ARE TRUE, THAT I AM ELIGIBLE FOR ANY "NO FEE" LICENSES REQUESTED. AND I SHALL SUBMIT EVERY MONTHLY CATCH RECORD OR OTHER INFORMATION REQUIRED. BY THE DEPARTMENT PURSUANT TO NATURAL RESOURCES ARTICLE, SECTION 4-206, MARYLAND ANNOTATED CODE. I UNDERSTAND THIS LICENSE DOES NOT OF ITSELF PERMIT ME TO FISH ON PRIVATE PROPERTY.

SIGNATURE ______________________ DATE ☐☐ - ☐☐ - ☐☐

- -

SOCIAL SECURITY NUMBER ☐☐☐ - ☐☐ - ☐☐☐☐ | SEX (OPTIONAL) ☐ Male ☐ Female | HEIGHT ☐ Ft. ☐☐ Inches

PLACE AN [X] IN THE BOX OF THE LICENSE(S) DESIRED

SPORT CRABBING LICENSE VALID SEPTEMBER 1 THRU AUGUST 31	FEE
☐ RESIDENT NON-COMMERCIAL	$10.00
☐ NON-RESIDENT NON-COMMERCIAL	$20.00
☐ JUNIOR/SENIOR SPORT (RESIDENT)	NO FEE

CHESAPEAKE BAY LICENSE VALID JANUARY 1 THRU DECEMBER 31	FEE
☐ BAY SPORT FISHING STAMP 16-64 YEARS OF AGE, RESIDENT OR NON-RESIDENT	$5.00
☐ BAY SPORT FISHING STAMP 16-64 YEARS OF AGE, WHO HAS A CURRENT NON-TIDAL (FRESHWATER) LICENSE	$2.50
☐ FISHING: 16-64 RESIDENT OR NON-RESIDENT 3 DAY BAY SPORT FISHING LICENSE/STAMP VALID FOR 3 CONSECUTIVE DAYS. LIST COMMENCING DATE: ________	$2.00
☐ PLEASURE BOAT BAY SPORT FISHING LICENSE STICKER BOAT NUMBER/NAME: ________ STICKER NUMBER ISSUED: ________	$25.00

NON-TIDAL FISHING LICENSE (FRESHWATER) VALID JANUARY 1 THRU DECEMBER 31	FEE
☐ FISHING: SENIOR RESIDENT OR BLIND	NO FEE
☐ FISHING: REGULAR RESIDENT 16-64 YEARS OF AGE	$8.00
☐ FISHING: REGULAR, NON-RESIDENT	$15.00
☐ FISHING: 7-DAY NON RESIDENT (GOOD FOR 7 SUCCESSIVE DAYS - ENTER STARTING DATE) ________	$7.00
☐ POTOMAC RIVER: RESIDENTS OF VA., WV., AND D.C. TO FISH THE POTOMAC RIVER	$8.00
☐ REGULAR TROUT STAMP 16-64 YEARS OF AGE	$3.50
☐ SENIOR TROUT STAMP MARYLAND RESIDENTS ONLY, 65 YEARS OF AGE AND OLDER	$1.00

Restoring the Chesapeake Bay

TOTAL FEES $ ________

THIS COPY MUST BE RETURNED TO DNR

DNR - F-1 (11/89)

Figure 1.

PRE-DATED JAN 1- DEC 31 NUMBER 0000001

ARE YOU THE CAPTAIN OF A HEAD BOAT? YES____ NO ____

1. NUMBER OF HOURS SPENT FISHING

2. NUMBER OF PEOPLE FISHING INCLUDING CAPTAIN AND MATE

3. NUMBER OF LINES

4. AREA WHERE MOST OR ALL FISH WERE CAUGHT (SEE AREA CODES ON FRONT)

5. WAS THIS A FISHING TOURNAMENT YES NO

6. WHAT WAS THE PRIMARY SPECIES SOUGHT (SEE CODES ON FRONT)

7A. TOTAL CATCH KEPT (SEE SPECIES CODES ON FRONT)

SPECIES CODE	NUMBER OF FISH	TOTAL WEIGHT (POUNDS)
K		
K		
K		
K		
K		
K		

7B. RELEASED

SPECIES CODE	NUMBER OF FISH	TOTAL WEIGHT (POUNDS)
R		
R		
R		
R		
R		
R		

1. NUMBER OF HOURS SPENT FISHING

2. NUMBER OF PEOPLE FISHING INCLUDING CAPTAIN AND MATE

3. NUMBER OF LINES

4. AREA WHERE MOST OR ALL FISH WERE CAUGHT (SEE AREA CODES ON FRONT)

5. WAS THIS A FISHING TOURNAMENT YES NO

6. WHAT WAS THE PRIMARY SPECIES SOUGHT (SEE CODES ON FRONT)

7A. TOTAL CATCH KEPT (SEE SPECIES CODES ON FRONT)

SPECIES CODE	NUMBER OF FISH	TOTAL WEIGHT (POUNDS)
K		
K		
K		
K		
K		
K		

7B. RELEASED

SPECIES CODE	NUMBER OF FISH	TOTAL WEIGHT (POUNDS)
R		
R		
R		
R		
R		
R		

Figure 2.

DAILY SEAFOOD CATCH TICKET 000001

1.a. FISHERMAN'S LICENSE NUMBER

b. CAPTAIN'S LICENSE NUMBER (if different)

2. BUYER LICENSE NUMBER (if appropriate)

3. DATE (MONTH/DAY/YEAR)

4. GEAR TYPE USED (see front cover for codes)

5. TOTAL NUMBER OF PERSONS FISHING ON BOAT

6. a. AMOUNT OF GEAR (see front cover for units)

b. use as necessary and as directed on front cover

7. MESH SIZE (for gill nets)

8. HOURS FISHED TODAY

9. HOURS SINCE GEAR LAST FISHED (if gear left set in water)

10. HARVEST AREA (see front cover for codes)

11. COUNTY LANDED

12. CATCH INFORMATION (see back flap for species and unit codes)

a. PRIMARY SPECIES SOUGHT

b. CATCH AND PRICE

SPECIES CODE	AMOUNT	UNT	TOTAL PRICE

13. FISHERMAN'S SIGNATURE ______________________

DAILY SEAFOOD CATCH TICKET 000001

1.a. FISHERMAN'S LICENSE NUMBER

b. CAPTAIN'S LICENSE NUMBER (if different)

2. BUYER LICENSE NUMBER (if appropriate)

3. DATE (MONTH/DAY/YEAR)

4. GEAR TYPE USED (see front cover for codes)

5. TOTAL NUMBER OF PERSONS FISHING ON BOAT

6. a. AMOUNT OF GEAR (see front cover for units)

b. use as necessary and as directed on front cover

7. MESH SIZE (for gill nets)

8. HOURS FISHED TODAY

9. HOURS SINCE GEAR LAST FISHED (if gear left set in water)

10. HARVEST AREA (see front cover for codes)

11. COUNTY LANDED

12. CATCH INFORMATION (see back flap for species and unit codes)

a. PRIMARY SPECIES SOUGHT

b. CATCH AND PRICE

SPECIES CODE	AMOUNT	UNT	TOTAL PRICE

13. FISHERMAN'S SIGNATURE ______________________

Figure 3.

Recreational Fisheries Sampling Method Evaluation for Chesapeake Bay

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Introduction

Saltwater angling is an important recreational activity in Chesapeake Bay. Knowledge of the extent and impact of such fishing is important for effective management, which requires precise and accurate recreational angling statistics. This project, which is providing a comprehensive review of recreational fisheries survey designs that have been used in the Bay, will specify methods that result in accurate measures of recreational angling. In several instances, we have used computer simulation models to develop and expand our knowledge of the statistical theory and properties of estimation procedures. We are evaluating the information needs of management agencies and how these needs can be met through existing surveys such as the National Marine Recreational Fisheries Statistic Survey (MRFSS). This project will review the adequacy of the MRFSS for the Chesapeake and recommend other survey designs to augment the MRFSS. The results will provide fisheries managers with guidelines for sampling required to effectively manage the Chesapeake Bay fisheries stocks.

Objectives

1. Evaluation of historical information about recreational angler surveys. We will determine which data obtained from recreational angler surveys are available to meet the needs of informed fisheries management in Chesapeake Bay (this will include measures of effort, catch, demographics, economics and biological parameters). This work includes summarizing and evaluating current and historic, regionally limited, recreational angler surveys that have already been conducted in Chesapeake Bay.

2. Evaluation of the National Marine Fisheries Service (NMFS) Marine Recreational Fisheries Statistic Survey for Chesapeake Bay fisheries. We will include suggestions for improvement of survey design and guidelines on when to augment the basic survey.

3. Summary and evaluation of recreational user survey methods applicable to specific Chesapeake Bay fisheries. This information, which will be presented as species matrices, combines information gained in Objectives 1 and 2.

4. Analysis of methods of variance estimation for angler surveys. We will continue development of new variance estimation procedures in 1990.

5. Evaluation of current and future data requirements for assessment of recreational fisheries in Chesapeake Bay. We will suggest alternative surveys for specific situations that arise in the Bay.

Progress to Date

Since beginning this project in December 1988, we have held two workshops, in January 1989 and June 1989, and have made the following progress:

- Performing a general review of recreational angler survey methods and developing new survey methods. This work is in response to Objectives 3 and 5.

- Collected information from the state agencies, the National Marine Fisheries Service and local colleges concerning previous angler surveys and survey designs. This work is in response to Objectives 1 and 2.

- Held meetings with NMFS, the Virginia Marine Resources Commission (VMRC) and the Atlantic States Marine Fisheries Commission (ASMFC) to collect data and information.

- Currently studying recommendations made by ASMFC in a report about recreational fishing surveys for the Atlantic Coast: the recreational fishing surveys are being investigated for possible application to the Chesapeake Bay.

- Clarifying design considerations for specific types of surveys. These include the NMFS Marine Recreational Fisheries Statistics Survey, the use of aerial survey designs and the statistical bias associated with the roving creel survey. This is in response to Objectives 3, 4 and 5.

- Obtained telephone survey data from NMFS and have shown NMFS the results of our analysis of estimation considerations. We are making suggestions to NMFS on improvement to estimations and design procedures.

- Obtained MRFSS recreational intercept data from NMFS. We are analyzing these data to provide a quantitative analysis of timing and location of species catches for use in developing the species matrices.

Benefits

Commercial watermen and recreational anglers compete for many of the same fish species in Chesapeake Bay; this competition has led to conflicts over harvest allocation between these two groups. While the effort, harvest and economic values have been reported for the commercial sector for many years, until 1979 when the National Marine Fisheries Service began the Marine Recreational Fishery Statistics Survey, there were few data collected for the marine recreational fisheries. Management of the recreational and commercial fisheries of the Chesapeake Bay relies on accurate estimates of fishing pressure, catch and knowledge of biological parameters such as age and growth. In many Chesapeake Bay fisheries the recreational harvest may be equal to or exceed the commercial catch; consequently, reliable estimates of effort and harvest are of utmost importance for management of Bay-wide fisheries. Equally important for the fair and equitable allocation of increasingly scarce resources is the knowledge of the size and economic importance of recreational angling.

We are conducting a thorough evaluation of the historic and current angling surveys conducted in Chesapeake Bay. Both the practical applicability and statistical soundness of these historic surveys will be analyzed and recommendations made for their use. Recommendations will be made concerning specific fisheries-directed surveys, and which survey methods are best employed in specific situations. This information will be summarized in easily referenced data matrix tables for use by fisheries managers. The final report will serve as a handbook for the effective implementation of recreational angler surveys.

Improvement of Virginia Fisheries Statistics: Development of VMRC Biological Sampling Capabilities

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Introduction

In response to recommendations by Chesapeake Bay Stock Assessment Committee, the Virginia Marine Resources Commission initiated during the fall of 1988 a state-wide survey of commercial harvests to obtain biological data on finfish. The biological sampling survey is a permanent state funded program. The CBSAC project has served to augment the state program by providing funds for automated measuring boards and associated peripherals, and for contractual personnel to help with data base setup. The use of automated measuring boards was demonstrated by a previous CBSAC project at the Virginia Institute of Marine Science as a viable means of collecting and entering on computer large amounts of biological data in a one step process.

Objectives

The goal of this project was to complement the existing program of the VMRC to improve fisheries statistics.

Progress

The project and the first year of the survey is still underway. A planning document, The Stock Assessment Program of the Virginia Marine Resources Commission (May 1989), describes program procedures. To date, approximately 30 commercial fish dealers are cooperating with the survey. The total number of fish sampled has exceeded 15,000 (Figure 1). Size data have been recorded for all fish sampled. Sex data are recorded for a subsample of each species. Scales for subsequent age determination are being collected for striped bass, shad, flounder and grey trout.

The automated measuring boards were not purchased until the fall of 1989 to allow enough time to incorporate practical sampling experience in the design of the layout of the boards and the data system as a whole.

Benefits

The first year of the biological sampling program has taken on a broad challenge and will be used to determine how to best obtain the biological data necessary for stock assessment. The size, age and sex information derived from the survey will serve to better identify trends in abundance and the characteristics of the commercial fisheries. The data is also often a prerequisite for fisheries models, and will be used by researchers for stock assessment to complement fishery independent survey data.

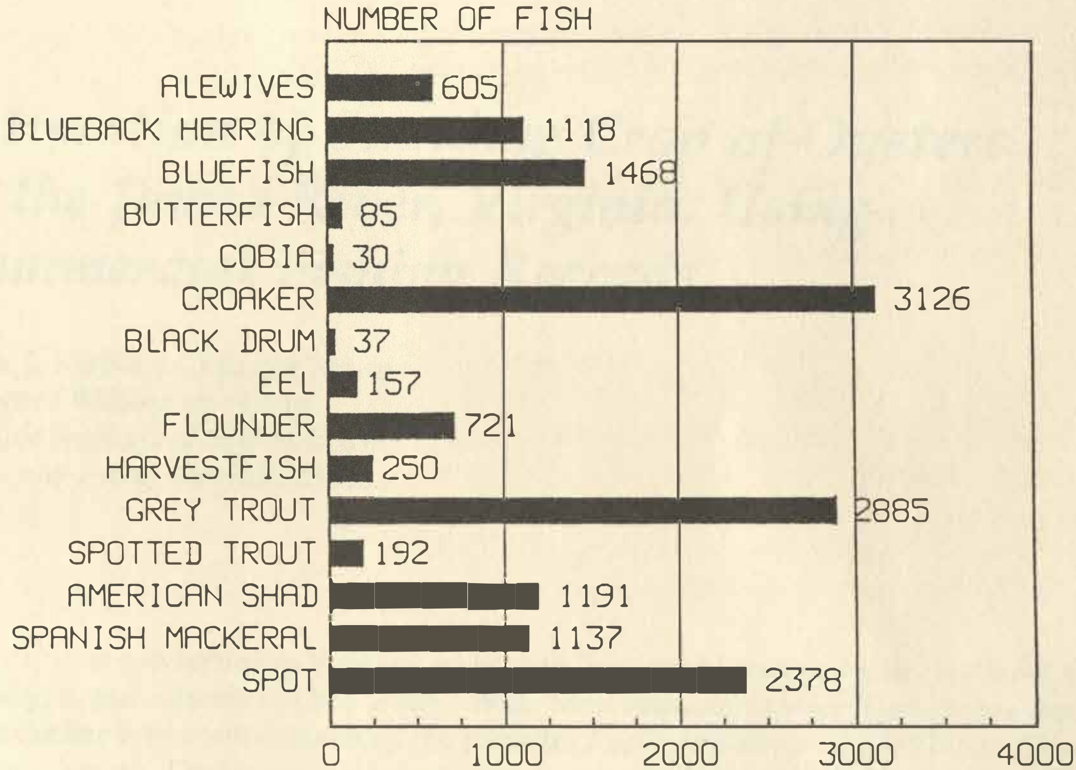

Figure 1. VMRC stock assessment program; 1989 fish samples (as of July 1989).

Estimation of Standing Crop of Oysters in the James River, Virginia, Using Commercial Fishing Records

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Oyster production in Virginia, which had fluctuated between 4 and 7 million bushels annually, began a drastic decline around 1960. Most important among the factors contributing to this decline is mortality caused by the parasites *Haplosporidium nelsoni* (MSX) and *Perkinsus marinus* (Dermo). Oyster mortalities which were initially limited to higher salinity regions of the lower Chesapeake Bay have gradually moved into the various subestuaries and are threatening to eliminate the entire fishery. Disease activity has become especially severe in recent years, probably augmented by below normal rainfall levels. The 1987-88 public oyster harvest in Virginia of 325,527 bushels was the lowest ever recorded.

As the result of disease mortality being most severe in areas with a mean salinity of 15 ppt or greater, the present oyster fishery in Virginia is essentially limited to the uppermost regions of the various subestuaries. These areas include the upper James River (where over 90% of public oyster harvest has occurred in recent years) and the upper Rappahannock River. It is known that oysters from the various regions of the Chesapeake grow at different rates and take on different physical characteristics, presumably the result of differing environmental conditions. Further, recent studies on water circulation and larval transport suggest that oyster larvae produced in the James River are retained in the river. These findings imply that in Virginia, if not the entire Chesapeake, the oyster fishery is composed essentially of isolated, independent fisheries. We believe that it is appropriate to manage the resource accordingly.

A vital component to the management of any fishery is an estimate of stock size. Change in stock size from one year to the next provides the fundamental statistic for estimation of survival and mortality rates. Change in stock size may be related to corresponding changes in the environment, in fishing, and in the effects of predators and disease. In spite of their importance to management, estimates of standing stock for the oyster fishery do not exist.

Present monitoring of the oyster fishery in Virginia by scientists at the Virginia Institute of Marine Science includes a semi-quantitative dredge survey of selected oyster bars in the spring and fall and a spatfall survey focusing on oyster settlement at selected locations. Although both of these programs provide an important long-term index of the condition of the oyster resource, they are not capable of providing an estimate of oyster standing stock. Moreover, an assessment of standing stock by representative quantitative sampling is essentially precluded by the heterogenous nature of the bottom, time and funding.

However, a method for estimating stock size using catch and effort data exists and is currently being applied to the James River oyster fishery (CBSAC 1V, Task 1.0) by Barber and Mann. Using a statistical technique known as the Leslie-DeLury method (DeLury 1947, DeLury 1951, Leslie and Davis 1939), the investigators are estimating initial population abundance of market-sized oysters in the James River from a regression of catch per unit effort (CPUE) versus cumulative catch for the past several years. The advantage to this approach is that the necessary data already exists, and standing stock estimates can be obtained without additional field sampling.

The investigators are attempting to apply this statistical approach initially to the oyster fishery of the James River. If successful, standing stock estimates will be available for the first time to managers of oyster fisheries in all regions.

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A Field Study of the Population Dynamics of the Blue Crab, Callinectes sapidus, *in the Chesapeake Bay*

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Introduction

This report on the activities and accomplishments of the field study of blue crab population dynamics in the Chesapeake Bay covers the period from June 1988 to December 1989.

Objectives

The research objectives are divided into three subprojects, namely:

1. Survey of the Maryland pot fishery
2. Fishery independent winter dredge survey
3. Tagging study

Objective 1 aims at obtaining size- and sex-specific measures of catch-per-unit-effort in the Maryland crab pot fishery; this work is being accomplished through regular sampling of the fishery, both at processing houses and on crabbing vessels. Objective 2 aims to develop a methodology for estimating the standing stock of blue crabs during the dormancy period of the winter months through a pilot dredging survey, and to estimate spatial distribution, overwintering mortality and potential recruitment in the 1989 season. Objective 3 aims to evaluate the efficiency of different types of tags related to retention during molts and to tag-related mortality, and to mount a mark and recapture study in 1989 in Maryland, to tag about 12,000 crabs.

Summary of Methods and Results

Survey of the Maryland Pot Fishery

About 20 processors agreed to participate in our 1989 sampling program. We chose companies to exhaustively cover the Eastern Shore of Maryland from Eastern Bay to Pocomoke Sound. We asked each company to assist us in the following ways: (1) allow us to measure a random sample of each market class of crab on their premises once or twice weekly, and (2) maintain a record of catch, effort and area fished for a subsample of crabbers regularly landing their catch at that establishment. Sampling took place at processing houses in the Tilghman Island, St. Michael's, Cambridge, Hooper's Island, Fishing Bay, Deale Island, Crisfield and Pocomoke Sound areas. This sampling regime effectively covered water areas on the eastern side of Chesapeake Bay (at least) and its eastern tributaries from the Bay Bridge to the Virginia state line.

Sampling was expanded to include the beginning of comparable efforts in Virginia, in cooperation with the Virginia Marine Resources Commission. The sampling period was from July 5 to October 31, 1989. Some processors were able to provide us with records from the start of the season in April through the end in November. Similar catch and effort sampling was done by Virginia Marine Resources Commission personnel in Virginia using a logbook approach; comparable size frequency data were not collected. Catch data were recorded either by one of our field personnel or by a processor's representative from the records kept on daily landings on each crabber. Effort data were obtained by a representative of each processor periodically asking the crabber being sampled how many pots he was fishing.

Our main interest in size-frequency sampling by market category is to acquire the data to express catch per unit of effort by sex and size class. This enables us to examine the seasonal dynamics of the age and sex structure of the population, for example, grams per pot of females in the 140 to 149 mm size class (where each measurement is carapace width).

The results of our analysis of these data are summarized in Figures 1 to 6 for all processors. In 1988, the seasonal trend in catch per unit of effort (CPUE) appears to be have been very similar in all areas of Maryland and to a lesser extent in Virginia. By comparing the weekly mean CPUE values pooled over all dealers to similar values obtained for each major area (by pooling all crabbers in each area), there appears to be a close correspondence both among areas and between each area and the whole. There is correspondence in both trend and magnitude, and it is particularly evident in CPUE for females.

In 1989, blue crab fishery research has been initiated combining the approaches used in 1987 and 1988. A "logbook" method has been set up (as in 1988) with 10 dealers in Talbot, Dorchester and Somerset counties recording daily catch and effort data on a selected group of crab potters landing their catch at each respective processor's establishment. In addition, the catch, effort and size and sex distribution of the catch of two crabbers from each of six regions in

Maryland counties — St. Mary's, Calvert, Talbot, Dorchester and Somerset (2) — were sampled on a biweekly basis from June through October.

Fishery Independent Winter Dredge Survey

Year-to-year variability in the reported landings of blue crabs in Chesapeake Bay has historically been relatively high. Since 1945 maximum reported catch was about two times the minimum reported catch over the same time period. Efforts to predict recruitment into the fishery have been made, for example, by relating megalopal abundance to subsequent recruitment. However, to date it has not been possible to forecast how the fishery will fare in subsequent seasons. The winter dredge survey is viewed as a pilot study to develop a long-term, baywide-survey methodology to be used as a tool in predicting the availability of blue crabs to the fishery in the forthcoming seasons.

Both phases of dredging commenced during the week of December 5, 1988. A considerable amount of the time spent in the field to date has been directed towards developing a consistent and useful sampling design, namely, the configuration of the gear and the duration and speed of each dredge tow. We settled on a standard Virginia crab dredge modified with a one-half inch wire mesh liner. We arrived at a protocol wherein we make our first dredge tow at each station a 30-second tow to ascertain the substrate type. If the bottom is not excessively muddy (the bag is full after 30 seconds), we then do three additional tows at the same station. If the bottom is excessively muddy, we move on to another station, because it has been our experience that crabs are not found often or in large quantities in thick, viscous mud.

Preliminary conclusions include the following: (1) more crabs are found in river systems and tributaries than in the open Chesapeake Bay, (2) crabs in the river systems are on average much smaller and include many young-of-the-year, and (3) sex ratios vary widely between the upper and lower Chesapeake Bay, and among rivers.

Tagging Study

The tagging study began in September, 1988. To date two types of tags have been used in our tagging activities. The first is laminated plastic and is attached to the back of the crab by a piece of copper wire that is passed through the tag and wrapped around each point of the crab. The second, a FLOY #FTSL-73 plastic streamer tag, is shaped like an hourglass and comes with a surgical steel needle attached. Information on tag-retention as observed in crabs kept in tanks over several months indicates that these plastic steamer tags are not retained as well as the laminated plastic. Data from the field recoveries appear to reinforce this fact in that of the 46 returns for which we have the information, 37 were recovered with just the laminated crab tag; only nine crabs had both tags when they were recovered.

Following the first stage of tagging, begun in September, 1988, and continued through the fall, the second stage commenced in mid-May, 1989, and was continued throughout the summer and into the fall, 1989. Table 1 summarizes all completed tagging events and return rates for all returns up to June 30, 1989. Note that recovery rates range from about 0 to 50 percent, with an overall rate of about 11 percent. These data may enable us to estimate exploitation rates, partitioned by commercial and recreational effort and by gear. We are aiming to tag approximately 12,000 crabs this season. The laminated plastic crab tag attached to the back of the crab by a piece of copper wire passing through the tag and wrapped around each point of the crab is being used exclusively this season. Tagging is being done on a proportion of the sublegal catch of each crabber involved in our on-vessel sampling. In addition, we have three days of intensive trawling and tagging reserved on the University of Maryland Center for Environmental and Estuarine Studies research vessels, one each in June, July and August. Further tagging is being done with crabs captured incidentally on the CHESFISH trawl-sampling cruises from May to October with the CHESFISH study, a cooperative program between the Chesapeake Biological Laboratory and the Virginia Institute of Marine Science.

Table 1. Dates, areas of tagging, numbers tagged, returns and percent returns.

Date	Area	Number Tagged	Recaptures	Percent
09-20-1988	Lower Patuxent	292	36	12.3
09-23-1988	Middle Patuxent	225	32	14.2
10-03-1988	Middle Patuxent	287	26	9.0
10-04-1988	Middle Patuxent	177	8	4.5
10-14-1988	Middle Patuxent	193	26	13.4
10-18-1988	Middle Patuxent	256	16	6.3
10-21-1988	Drum Point	57	4	7.0
10-25-1988	Drum Point	110	26	23.4
11-16-1988	Drum Point	6	0	0.0
05-22-1988	Upper Bay	8	3	37.5
05-23-1989	Upper Bay	28	6	21.4
05-24-1989	Tangier Sound	7	2	28.6
05-25-1989	Tangier Sound	27	2	7.4
05-26-1989	Lower Patuxent	19	2	10.5
06-01-1989	Drum Point	18	1	5.6
06-02-1989	Drum Point	21	1	4.8
06-07-1989	Drum Point	29	14	48.3
06-09-1989	Talbot County	21	3	14.3
06-12-1989	Pocomoke Sound	16	1	6.3
06-12-1989	Drum Point	33	1	3.0
06-13-1989	Potomac River	25	0	0.0
06-19-1989	Potomac River	8	1	12.5
06-19-1989	Drum Point	39	3	7.7
06-20-1989	Helens Bar	144	14	9.7
06-20-1989	S Broome's Is.	53	10	18.9
06-20-1989	N Broome's Is.	48	9	18.8
06-20-1989	Solomons	27	3	11.1
	TOTAL	2174	250	11.5

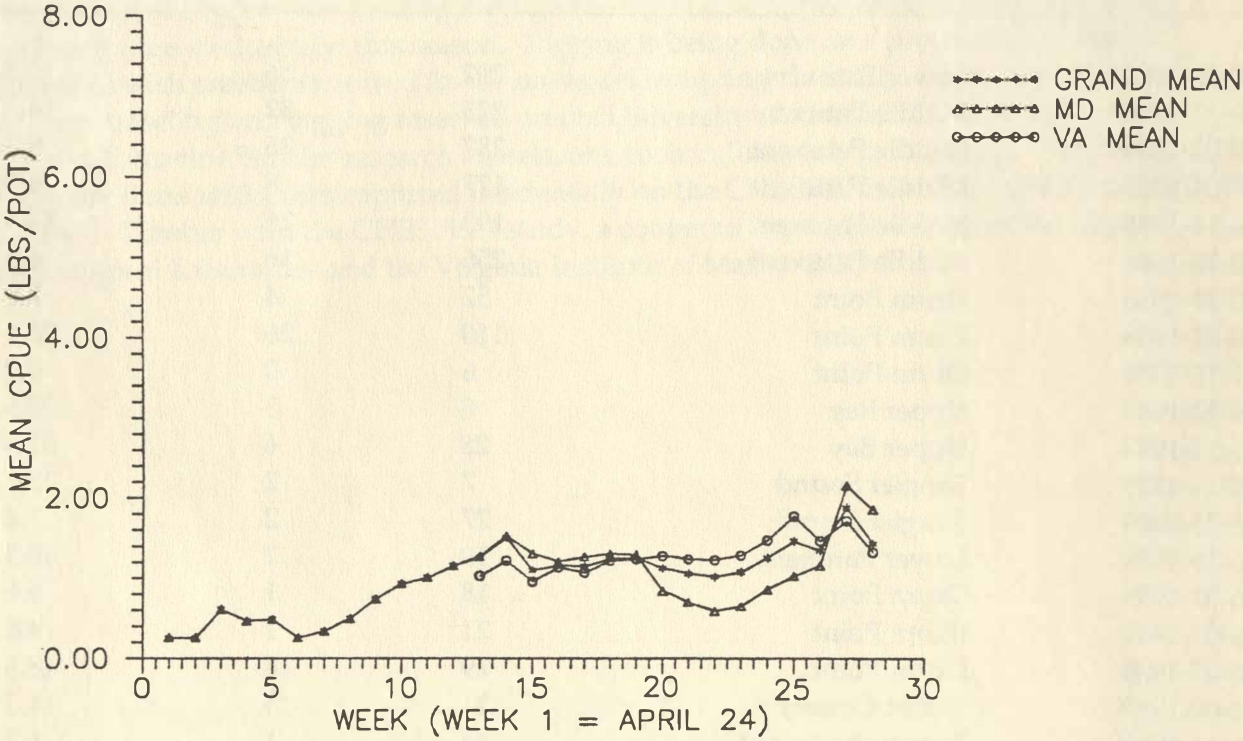

Figure 1. Mean daily catch per unit of effort (pounds/pot) of male blue crabs for each week of the 1988 season for Maryland, Virginia, and combined. (Means are weighted by number of crabber days for each area.)

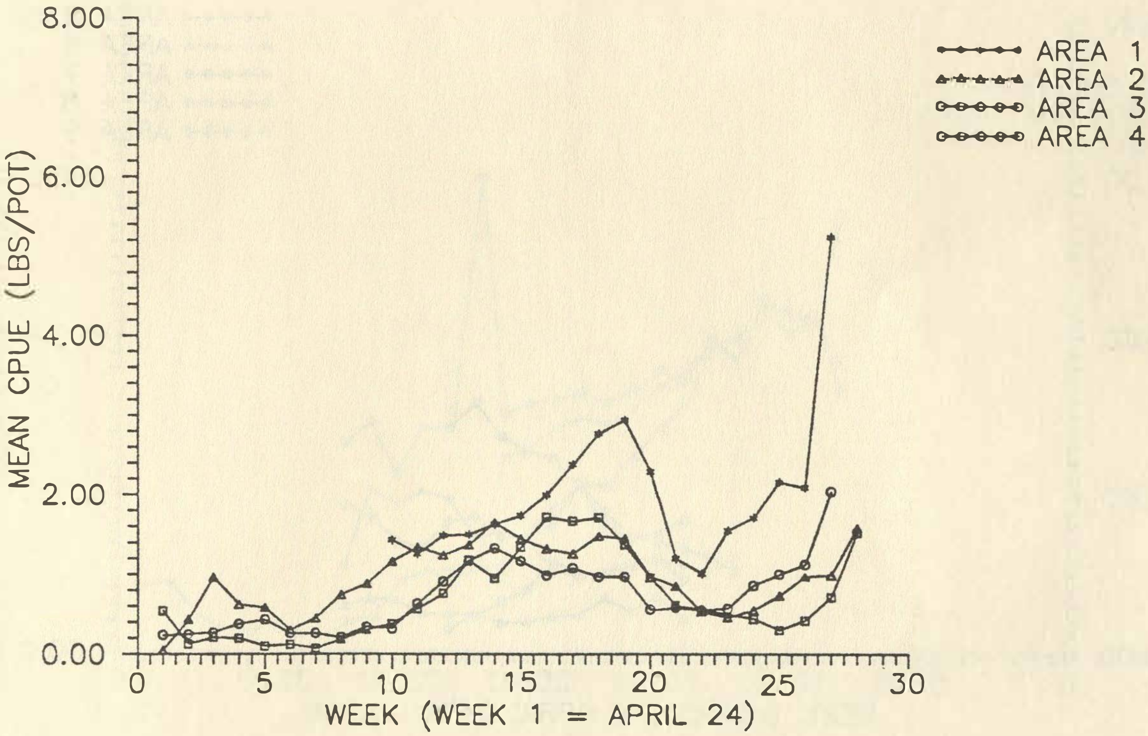

Figure 2. Mean daily catch per unit of effort (pounds/pot) of male blue crabs for each week of the 1988 season for four areas in Maryland. (Means are weighted by number of crabber days for each area.)

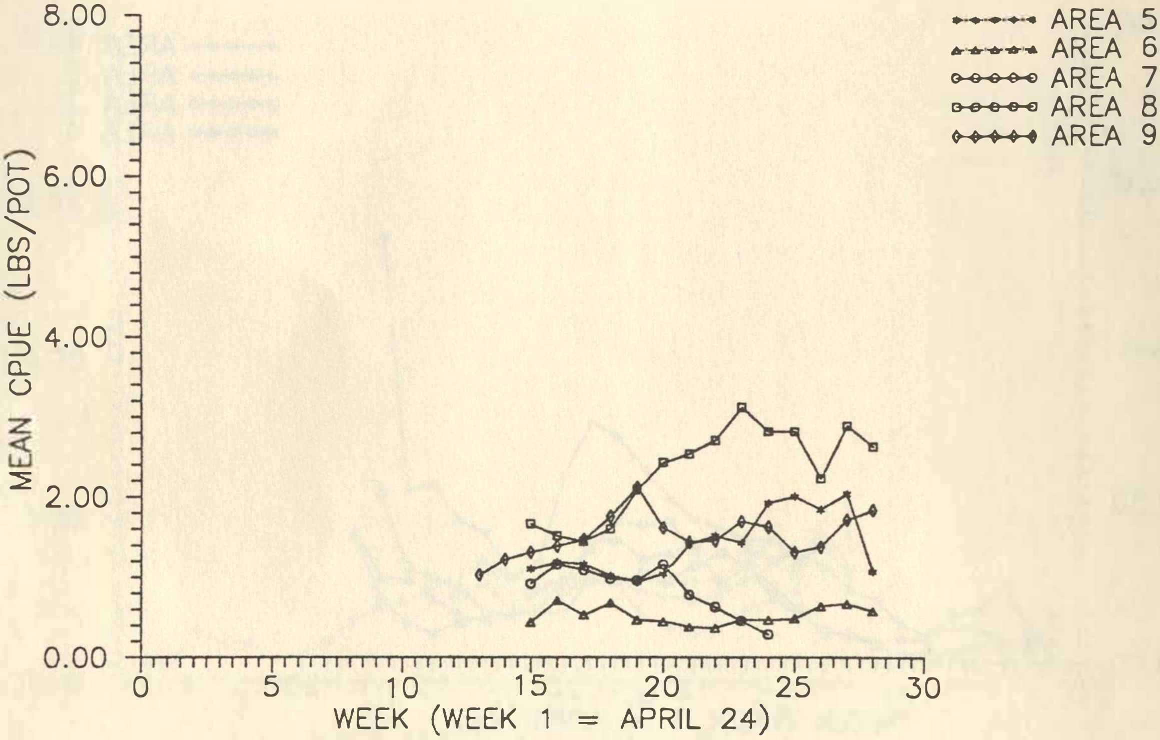

Figure 3. Mean daily catch per unit of effort (pounds/pot) of male blue crabs for each week of the 1988 season for five areas in Virginia. (Means are weighted by number of crabber days for each area.)

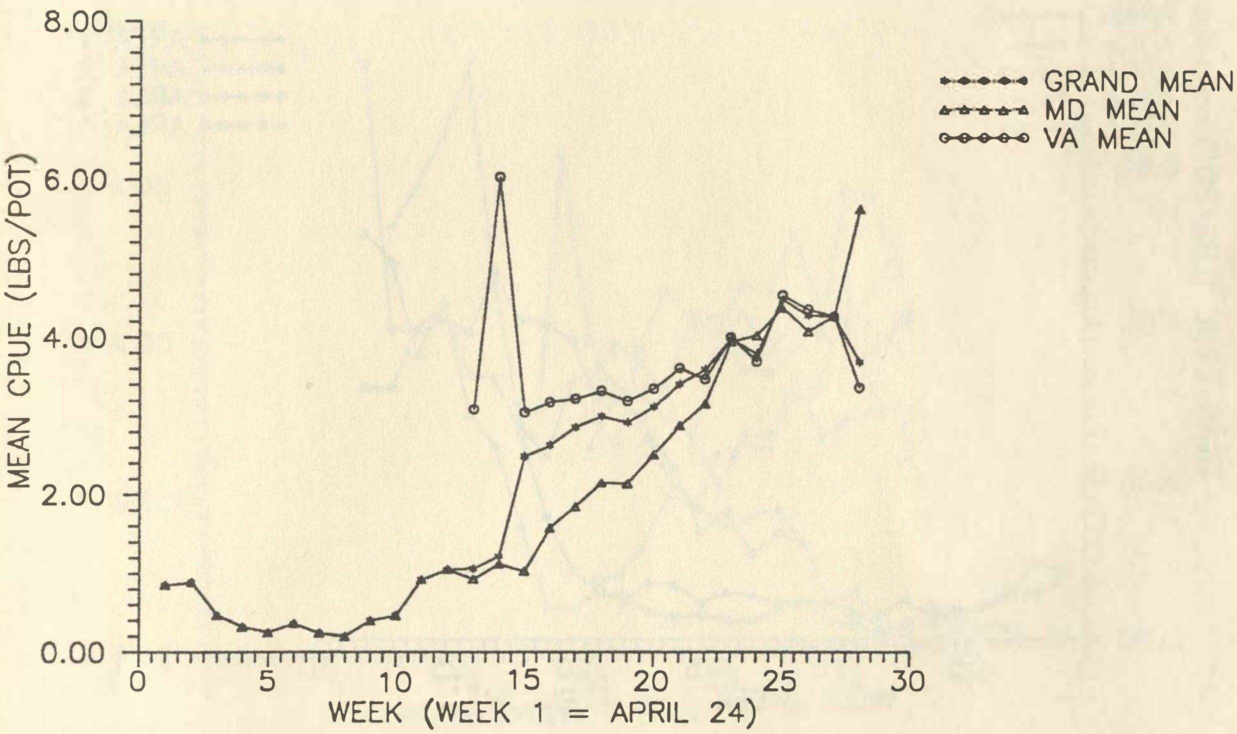

Figure 4. Mean daily catch per unit of effort (pounds/pot) of female blue crabs for each week of the 1988 season for Maryland, Virginia, and combined. (Means are weighted by number of crabber days for each area.)

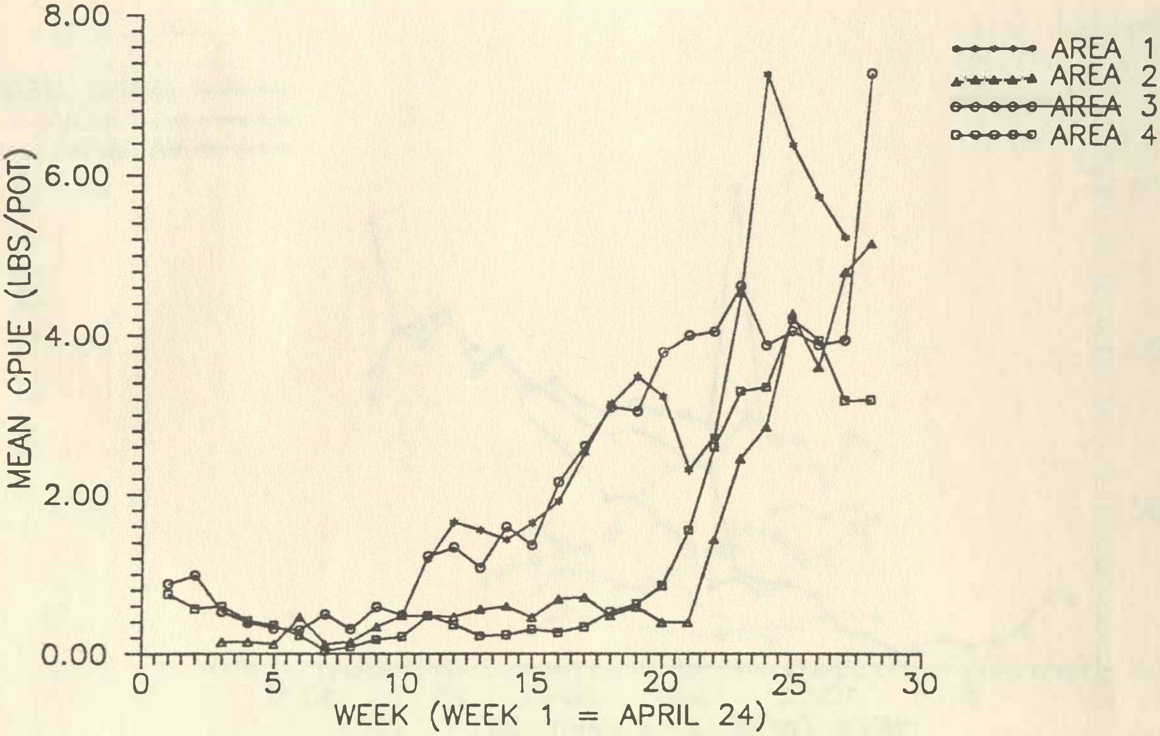

Figure 5. Mean daily catch per unit of effort (pounds/pot) of female blue crabs for each week of the 1988 season for four areas in Maryland. (Means are weighted by number of crabber days for each area.)

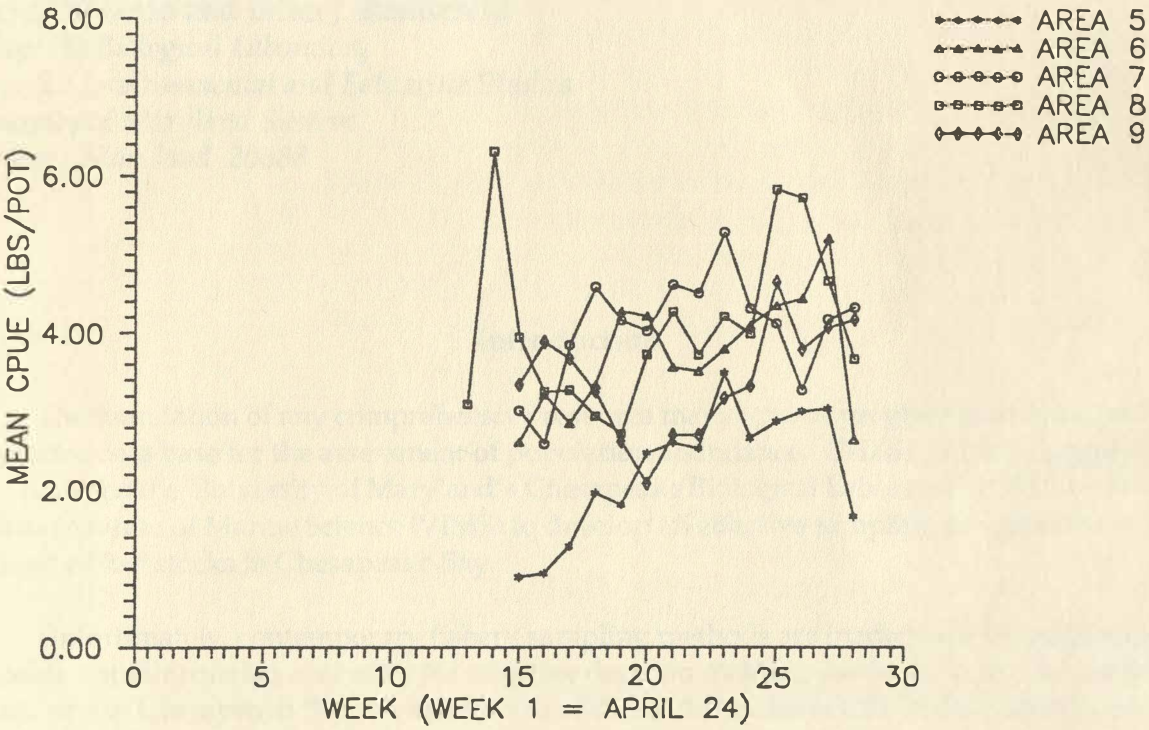

Figure 6. Mean daily catch per unit of effort (pounds/pot) of female blue crabs for each week of the 1988 season for five areas in Virginia. (Means are weighted by number of crabber days for each area.)

Development of Sampling Expert System: FISHMAP

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Introduction

The foundation of any comprehensive resource management program is a consistent and precise data base for the assessment of population abundance. CHESFISH is a cooperative study between the University of Maryland's Chesapeake Biological Laboratory (CBL) and the Virginia Institute of Marine Science (VIMS) to develop an effective sampling program for the assessment of fish stocks in Chesapeake Bay.

Unfortunately, contemporary fishery sampling methods are inadequate for generating the consistent information necessary for effective decision making, particularly for the complex of problems in Chesapeake Bay. In an effort to address this problem CBL is developing a sampling system called FISHMAP. This system will provide a framework for producing optimal trawl sampling procedures. In particular, the system will have the capability of defining the temporal and spatial characteristics of the sampling process, i.e. where, when and how often to sample. Also, once engaged in the field component of the sampling process, researchers will access environmental and biological information aboard the research vessel that will enable them to determine where and when to fish the trawl.

The system will be made up of several components: data input, map model, decision-making meetings, operations research and system coordination (Figure 1). The data input component houses pertinent data that will be used towards development of the FISHMAP system. Three data sets are in this component: historical trawling data (1960-1975), recent trawling data (1988), and real-time current data. The historical and recent trawl data sets comprise area and species specific estimates of catch-per-unit-effort and environmental data. The real-time current data will include information observed on board the research vessel during the actual sampling process.

The data housed in the data input component will be used to construct maps of fish and shellfish distribution. This information will also be used to develop strategic and tactical sampling models. The strategic models will define the spatiotemporal characteristics of sampling, that is, where and when to sample. Once on board the research vessel, investigators can use the tactical model to define when and where to deploy the sampling gear. Next, a round-table management meeting will evaluate the program and set the specifics of sampling: gear types, target species, types of data to collect, the temporal and spatiotemporal characteristics of sampling, and sampling platforms. The statistical tradeoffs associated with the decisions will be evaluated. Once the specifics of the sampling process have been defined, the operations research component will assess the costs and benefits associated with collecting the data and outline optimal procedures to collect the data (i.e., vessel-routing, number of vessels to employ in the sampling and where to deploy the vessels). The coordination of all of the components will be facilitated through the use of an expert system.

The development of a system to identify and update an optimal cost-effective sampling methodology to report on the dynamics of fish in Chesapeake Bay is the primary goal of this project. The components outlined above are all essential to the development of such a system. The user of this system, however, would have to be proficient in a number of diverse disciplines during both the strategic and tactical phases. Since an experienced user may not always be available, a system that allows the user to imitate the decisions of an "expert" is needed.

The problems detailed above can be largely overcome by integrating the disciplines through the use of an expert system. The fundamental premise of the FISHMAP system is that the use of techniques in the data input, map models, decision-making workshops, and operations research components in the sampling of fish populations — integrated in the setting of an expert system — represents a significant advance in the application of these techniques to stock assessment. Integration of the system is made tractable through the use of expert system technology. Improvement in the application of these techniques is gained through the expert system facility for interpreting very large data bases in approximately real-time.

Given the constraints of budget and time, more precise estimates of fish abundance can be achieved by optimizing the sampling effort through the FISHMAP system. The system will provide an optimally efficient, adaptive, real-time sampling procedure capable of pinpointing which data need to be collected to arrive at more precise estimates. The capability for doing such operations should improve management of the resource. The project will provide data which describe population dynamics in space and time; it will enable managers to evaluate the effects of the environment, fishing, stock enhancement measures or Chesapeake Bay clean-up activities on the population of a given species in the Bay, and to initiate appropriate management actions regarding these effects.

Progress to Date

Monthly trawling was conducted in the Patuxent River and adjacent Chesapeake Bay transects in the vicinity of Solomons, Maryland in 1988. In 1989 the program was expanded to include the entire mainstem of Chesapeake Bay in Maryland and an additional tributary, the Choptank River. A sampling scheme of random and fixed stations has been devised based on depth, salinity regime, and historical data. All of these recent data have been entered into computer spreadsheets which will soon be converted to dBase IV files.

The historical trawl data from 1965 to 1975 contained inconsistencies which have now been rectified. Originally one large file, it has been broken up and organized into more useful files. A series of FORTRAN programs were developed to process these data; in addition, a second set of historical data spanning 1960 to 1965 is currently being entered into files for later processing. These historical and recent trawl survey data sets are being compiled and analyzed to provide detailed information on spatial and temporal variation, life history and population dynamics including growth, maturity and mortality on selected species. The first two species under analysis are white perch and striped bass. In addition, these data sets have enabled a comparison of species diversity and fish abundance in the Patuxent River between 1965-68 and 1988-89.

A database design utilizing dBase IV has been completed. This project has been complicated by the fact that the raw data collection methods differed in many ways among the two historical sampling periods and the recent sampling period. A series of menus provide for easy data input, perform error checks, and generate standard calculations, reports, summaries, etc.

Historical and recent trawl information are being used to create species-specific map models. These maps show the relationship between species density and location, time of year and environmental parameters (temperature, salinity and dissolved oxygen) for a particular species. Maps are being produced for white perch, striped bass, blue crab, spot, Atlantic croaker and weakfish. These maps can be used to guide future sampling.

A sampling simulation model is being developed to assist in the identification of an efficient sampling design to estimate stock abundance. This model allows a comparison of various sampling designs in an effort to determine which combination of procedures provides the most efficient estimate of stock abundance. An operational prototype of the sampling simulation model has been developed for white perch and is in the process of being computerized. A strategic sampling model for striped bass has been developed using historical trawl data. This strategic model will be used prior to actual field sampling to define where and when to sample for striped bass.

Computer interfaces for use on the IBM PC, AT, XT or IBM compatible are being constructed to facilitate access and ease of use of a number of fisheries management programs currently in FORTRAN. These interfaces will be distributed to the Maryland Department of Natural Resources and any other educational or state facilities who desire them.

Progress to Date

Fourteen [illegible] interviews were conducted [illegible] and [illegible] in key [illegible] in the [illegible] 1988. In 1989 [illegible] the entire [illegible] of Chesapeake Bay in Maryland and [illegible] the [illegible] River. [illegible] sampling [illegible] of [illegible] and [illegible] stations [illegible] length, weight, and [illegible] data. All of these [illegible] data have been entered into computer [illegible] files [illegible] will [illegible] be converted to dBase IV files.

[illegible] from [illegible] to 1977 [illegible] has been [illegible] and [illegible] dBASE IV programs were developed to [illegible] data [illegible] from 1980 to 1986 is currently being entered into [illegible]. These historical and recent [illegible] survey data sets are being compiled and analyzed to provide [illegible] information on spatial and temporal variations, [illegible] including [illegible] salinity and temperature on [illegible] white perch and striped bass. In addition, these data sets have [illegible] abundance in the [illegible] River between [illegible] and [illegible].

A database design utilizing dBase IV has been completed. This project has been complicated by the fact that the raw data collection methods differed in many ways among the two historical sampling periods and the recent sampling period. A [illegible] approach for easy data [illegible], performing [illegible] and [illegible] calculations, [illegible] etc.

Historical and recent [illegible] information are being used [illegible] specific [illegible] models. [illegible] maps [illegible] of the [illegible] and location, time of year, and environmental [illegible] for [illegible] species. Maps [illegible] for white perch, striped bass, [illegible] and [illegible]. These [illegible] will be used in [illegible] sampling.

A sampling [illegible] model is being developed [illegible] sampling design [illegible]. This model [illegible] sampling design [illegible] to determine [illegible] properties of [illegible] model has been [illegible] and [illegible] sampling [illegible] model [illegible] data [illegible].

Computer interfaces for use on the IBM PC, AT, XT or IBM [illegible] are being [illegible] to facilitate access and ease of use of a number of [illegible] programs [illegible] in dBASE IV. These interfaces will be distributed to the [illegible] Department of Natural Resources and any other [illegible] who [illegible].

Collection and Evaluation of Historical Data on Fisheries, Hydrographic Conditions and Contaminant Loadings to Chesapeake Bay Tributaries

Foster Stroup
Versar, Inc.
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Introduction

Population levels of commercially harvested fish and shellfish typically exhibit large annual fluctuations. Historically, fisheries biologists have rigorously studied the response of fish populations to commercial exploitation to account for this historic variability, often assuming constant recruitment and ignoring environmental effects. Researchers have determined that climatic and environmental conditions (e.g., water temperature, water quality) during early life stage development of many species can directly alter the magnitude of recruitment. Since the environment is constantly changing and exposing populations to variable conditions, environmental conditions potentially have a great effect on fish population abundances and recently have been incorporated into models of recruitment success.

While these natural environmental conditions can cause major year-to-year changes in the abundance and composition of populations in estuarine waters, anthropogenic influences on fish stocks (e.g., contaminant loadings, habitat alteration) are superimposed on these natural fluctuations and thus are difficult to identify and quantify. Chesapeake Bay supports a large number of commercial and recreational fisheries and shellfisheries. The Chesapeake Bay Stock Assessment Committee and the Maryland Tidewater Administration have been conducting stock assessments within Chesapeake Bay and its tributaries over the past two years in order to (1) document declines in harvest levels of many stocks, (2) evaluate casual relationships between these declines and contaminant loads to individual basins and (3) examine relationships between these declines and natural fluctuations of the environment (e.g., climatic variability).

Objectives

Versar, Inc. will examine relationships among variation in stock abundance, climatic variation and contaminant loadings to Chesapeake Bay tributaries as a part of the overall effort. To ascertain potential causes of historical variation in estuarine stock sizes requires information describing the time histories of:

- Population abundance, for example, recruitment indices, population size, parent stock size, catch per unit effort.

- Climatic or hydrographic variables, for example, temperature, wind events, freshwater discharge.

- Contaminant loadings, for example, industrial loadings of individual heavy metals, urban or agricultural runoff of biostimulants, municipal sewage loadings.

- Other anthropogenic stresses, for example, habitat changes.

To accomplish the objective of disassembling the time history of an individual fish stock to attribute its historical variation to potential causes, consistent long-term data sets for the four types of variables described above must be developed. Versar, Inc. will locate and collect data concerning climate, habitat changes and water quality for two Chesapeake Bay tributaries, the Choptank and Rappahannock rivers, between 1929 and the present, develop time series histories from the data, and incorporate all data into a centralized data base. Data will then be analyzed in conjunction with information concerning population abundances of six species provided by the Maryland Tidewater Administration, Fisheries Division: white perch, striped bass, American shad, Atlantic croaker, blue crab and American oyster.

Categorical regression analysis is a technique which permits time series data of unknown probability to be incorporated into a rigorous statistical evaluation of relationships. Categorical regressions will be run sequentially for all target stocks in each estuary using lagged stock (i.e., a variable representing the time lag between spawning and recruitment into the fishery), and hydrographic and macropollution conditions at the time of spawning and/or early development.

Tag-Recapture Study of the Spawning Stock of Chesapeake Bay Blue Crabs

John R. McConaugha
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Norfolk, Virginia 23529

Introduction

The blue crab is one of the most important commercial and recreational fisheries in Chesapeake Bay. In Virginia, landings for 1988 exceeded 38 million pounds and had a dockside value in excess of $9 million. This fishery has experienced wide fluctuations in catch, but has always been considered to be healthy. However, with the decline of other fisheries in Chesapeake Bay, increased effort has been directed towards blue crabs in recent years and concern among watermen, managers, citizens and scientists for the long-term health of this important commercial stock has been growing. For a species like the blue crab, which has a short life history (2 to 4 years), the effect of recruitment overfishing can be immediately felt and can result in a crash of the fishery. To refine management strategies that will effectively mitigate against such crashes, it is essential to have knowledge of both environmental and anthropogenic factors contributing to annual fluctuations in recruitment success.

One method for gathering the necessary biological and harvest data that contribute to recruitment success is to capture crabs that have previously been tagged, a strategy this project has been developing. In this way a number of observations can be made about exploitation, migration and reproduction success.

Objectives

- Determine the exploitation rates from the fishery.
- Estimate the ratio between commercial and recreational catches.
- Measure migration patterns of the spawning stock.
- Estimate average time female blue crabs spend on the spawning ground.
- Estimate number of broods produced per female.
- Determine average time between broods.

Progress To Date

The target population for this study is the terminally molted mature female. A simple strap tag attached across the carapace with stainless steel wire was used to tag 11,000 female crabs in the lower Chesapeake Bay. One thousand crabs were tagged in September and October 1988, as part of a preliminary study to develop tagging techniques and establish communication channels with the watermen.

The preliminary study provided interesting data on exploitation rates in the winter dredge fishery and on migration of female blue crabs in late fall. Data from this effort suggests that primiparous females entering the lower bay can be divided into two groups: (1) a small fraction that migrates out of Chesapeake Bay to the continental shelf and south into North Carolina waters (Albemarle and Currituck Sounds) and (2) a larger fraction that overwinters in the Bay and is subject to the winter dredge fishery. Exploitation of this latter group has often been assumed to be high, greater than 70% (Lipsius pers. comm.).

Tag returns to date suggest that the exploitation rate may be substantially less and in fact may be only a small fraction of the total population. It should be noted that (1) these results are based on the release of only 1,000 tags, (2) vigorous statistical analysis has not been completed, and (3) the preliminary study was designed to evaluate logistical techniques for the larger study of the spring-summer population. Despite its limitations, this study raises several important questions about Chesapeake Bay spawning stocks. For example, what is the proportion of primiparous females that migrate out of the bay and thus do not contribute to the future reproductive potential of the population? What is the exploitation rate of the winter dredge fishery on the spawning stock, i.e., is there a substantial impact on future reproductive potential? What is the fate of multiparous females especially those females entering the spawning stock late in the spawning season to the future reproductive potential of the Chesapeake Bay population, i.e., do they contribute during future spawning seasons?

Ten thousand mature female crabs were tagged during May, June and July 1989. By fall 1989, approximately 10% of the tags were returned. As the pot fishery declined during the fall months, tag returns also declined. We anticipate a substantial number of returns when the dredge fishery begins November 1, 1989 since a large number of tagged crabs were released or migrated into the summer spawning sanctuary. Data analysis has begun and we expect to complete it by early spring of 1990. We anticipate continuing the present study through 1990. Expanded effort would be placed on the winter dredge fishery with 5,000 to 10,000 additional tags released. An additional 5,000 to 10,000 tagged crabs will be released during the summer of 1990.

Status of Stocks Knowledge Workgroup

Herbert M. Austin
College of William and Mary
Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

When the Chesapeake Bay Stock Assessment Committee was formed in 1985, Terms of Reference were developed for several work groups. It was the original intent of CBSAC to conduct much of its actual work through these work groups. One group was the Status of Stocks Knowledge Work Group, whose original charge was to:

- Identify important finfish and shellfish stocks.
- Identify information needs for stock assessment.
- Prepare a report for CBSAC review and general distribution which would summarize the current status information relative to identified needs and identified information gaps.

In conducting this charge, the Work Group brought together several experts (Table 1). As charged the work group identified important finfish and shellfish stocks; these included both economically important fishery species and several ecologically important species (e.g., killifish). The subsequent report edited by Austin and Furman (1987) contained the information needs and status of information relative to needs in a matrix and extensive bibliography. The matrix (Figure 1) was patterned after that used by Lionel Walford in a presentation to the Atlantic States Marine Fisheries Commission in 1946. The report was submitted to CBSAC in December, 1987.

A similar species-information needs matrix was developed at the Virginia Institute of Marine Science in 1979 and has been used to guide fishery research efforts. The purpose of the work group's effort, to identify important species (fisheries) and information needs, and the resultant matrix, was to provide CBSAC and other committees and agencies working in the Bay with a guide for research funding and priorities. The bibliography will provide an initial starting point for researchers investigating Bay stocks.

1988-1989

Following their development of the Status of Stocks Knowledge matrix and bibliography in 1987, the Work Group and experts developed an initial annual Status of Stocks Report. It was formatted after the NMFS/NEFC Status of Stocks Report that is circulated annually.

The format includes a paragraph on the species biology, a section on current fisheries, descriptions of particular problems, recent legislation/regulations and an annually updated commentary of stock status; this would be accompanied by graphics of commercial landings. Also included, as of 1989, are the juvenile indicies.

CBSAC decided that the Chesapeake Bay Data Center would be the source of the commercial landings for the report. In preparing the report, however, it was discovered that data submissions by Maryland and Virginia to the Center were not within a time frame that would allow their inclusion in an annual report. The editor decided to use data from the Center as the base for graphics, but data directly from Maryland Department of Natural Resources and Virginia Marine Resources Commission for the most recent years. This report was submitted to CBSAC in early 1989.

During 1988 the MDNR and VMRC produced a status and trends report independently of the Work Group's report. Because of duplication, CBSAC asked the workshop editor to reformat the 1989 edition.

1989-1990

Current efforts are directed at a reformated Status of Stocks annual report that will incorporate juvenile indices. By August 1989, all commercial landings were updated through 1988, including the Maryland juvenile indices. Personnel from the Virginia Institute of Marine Science are working on a rapid means of accessing the Virginia juvenile indices for each species taken by trawl.

References

Austin, H. and C. Furman. 1987. Determine short- and long-term facors affecting mortality and recruitment of key commercial and recreational species, including fishing mortality and both natural and man-induced environmental impacts on mortality and recruitment. CBSAC/SOSK Report, 96pp.

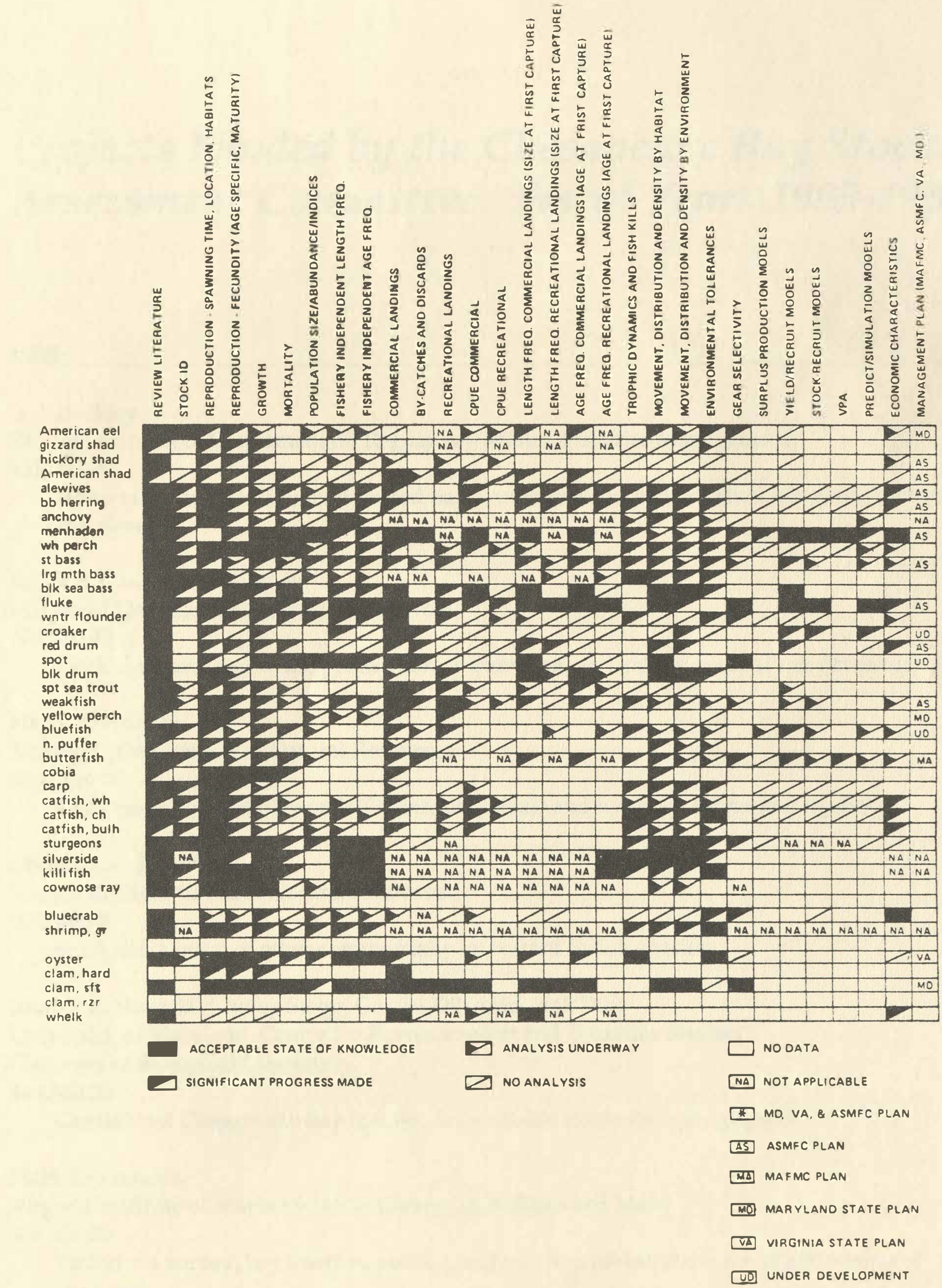
REVIEW LITERATURE
STOCK ID
REPRODUCTION - SPAWNING TIME, LOCATION, HABITATS
REPRODUCTION - FECUNDITY (AGE SPECIFIC, MATURITY)
GROWTH
MORTALITY
POPULATION SIZE/ABUNDANCE/INDICES
FISHERY INDEPENDENT LENGTH FREQ.
FISHERY INDEPENDENT AGE FREQ.
COMMERCIAL LANDINGS
BY-CATCHES AND DISCARDS
RECREATIONAL LANDINGS
CPUE COMMERCIAL
CPUE RECREATIONAL
LENGTH FREQ. COMMERCIAL LANDINGS (SIZE AT FIRST CAPTURE)
LENGTH FREQ. RECREATIONAL LANDINGS (SIZE AT FIRST CAPTURE)
AGE FREQ. COMMERCIAL LANDINGS (AGE AT FRIST CAPTURE)
AGE FREQ. RECREATIONAL LANDINGS (AGE AT FIRST CAPTURE)
TROPHIC DYNAMICS AND FISH KILLS
MOVEMENT, DISTRIBUTION AND DENSITY BY HABITAT
MOVEMENT, DISTRIBUTION AND DENSITY BY ENVIRONMENT
ENVIRONMENTAL TOLERANCES
GEAR SELECTIVITY
SURPLUS PRODUCTION MODELS
YIELD/RECRUIT MODELS
STOCK RECRUIT MODELS
VPA
PREDICT/SIMULATION MODELS
ECONOMIC CHARACTERISTICS
MANAGEMENT PLAN (MAFMC, ASMFC, VA, MD)
American eel
gizzard shad
hickory shad
American shad
alewives
bb herring
anchovy
menhaden
wh perch
st bass
lrg mth bass
blk sea bass
fluke
wntr flounder
croaker
red drum
spot
blk drum
spt sea trout
weakfish
yellow perch
bluefish
n. puffer
butterfish
cobia
carp
catfish, wh
catfish, ch
catfish, bulh
sturgeons
silverside
killifish
cownose ray
bluecrab
shrimp, gr
oyster
clam, hard
clam, sft
clam, rzr
whelk
ACCEPTABLE STATE OF KNOWLEDGE
SIGNIFICANT PROGRESS MADE
ANALYSIS UNDERWAY
NO ANALYSIS
NO DATA
NA NOT APPLICABLE
* MD, VA, & ASMFC PLAN
AS ASMFC PLAN
MA MAFMC PLAN
MD MARYLAND STATE PLAN
VA VIRGINIA STATE PLAN
UD UNDER DEVELOPMENT

Figure 1.

Projects Funded by the Chesapeake Bay Stock Assessment Committee: Fiscal Years 1985-1989

1985

Jack Buckley
DC Deptartment of Consumer and Regulatory Affairs, Fisheries Management
$32,597.00
Survey for adult and juvenile striped bass, American and hickory shad, blueback herring and alewife.

James F. Casey, S. Minkkinen
Maryland Department of Natural Resources
$79,710.00
Stock assessment of white perch (*Morone americana*) and yellow perch (*Perca flavescens*).

Harry T. Hornick
Maryland Department of Natural Resources
$104,866.00
Stock assessment of blue crab (*Callinectes sapidus*) and weakfish (*Cynoscion regalis*).

Christopher F. Bonzek
Maryland Department of Natural Resources
$55,000.00
Stock description of other commercially important finfish species.

Brian J. Rothschild, Cluney Stagg, Gerard DiNardo, Jack Dibb
University of Maryland, Center for Environmental and Estuarine Studies
Chesapeake Biological Laboratory
$44,500.00
Coastal and Chesapeake Bay species: Information needs for management.

Mark Chittenden
Virginia Institute of Marine Science, College of William and Mary
$95,450.00
Pound net survey, bay trawling survey, and patterns of distribution and abundance of spawners.

Jim Colvocoresses, Herbert Austin
Virginia Institute of Marine Science, College of William and Mary
$21,950.00

Intercalibration and refinement of estimates of abundance of Chesapeake Bay juvenile striped bass.

John McConaugha, Michael Prager
Department of Oceanography, Old Dominion University
$53,000.00

A characterization of the blue crab spawning stock in Chesapeake Bay.

Herbert M. Austin, Brian Meehan
Virginia Institute of Marine Science, College of William and Mary
$74,300.00

Establish a stock identification laboratory.

Brenda Norcross
Virginia Institute of Marine Science, College of William and Mary
$15,015.00

Climate/fisheries resources interaction studies.

Herbert M. Austin
Virginia Institute of Marine Science, College of William and Mary
$8,285.00

Stock assessment committee travel.

G. P. Patil, M. T. Boswell
Center for Statistical Ecology & Environmental Statistics
Pennsylvania State University
$210,000.00

Mathematical, statistical, and data analytical issues, investigations, and interpretations for the NOAA Chesapeake Bay stock assessment program.

1986

Jack Buckley, Marta Nammack
DC Deptartment of Consumer and Regulatory Affairs, Fisheries Management
$54,000.00

Survey for adult and juvenile american and hickory shad, blueback herring, alewife, white perch, and striped bass in the waters of the District of Columbia.

James Casey, S. Minkkinen, J. Soldo
Maryland Department of Natural Resources
$109,919.00
Characterization of Choptank River populations of white (*Morone americana*) and yellow (*Perca flavescens*) perch.

Harry T. Hornick
Maryland Department of Natural Resources
$138,802.00
Stock assessment of blue crab (*Callinectes sapidus*) and weakfish (*Cynoscion regalis*) in Maryland's Chesapeake Bay.

Christopher F. Bonzek
Maryland Department of Natural Resources
$58,279.00
Maryland fisheries statistics — improvement of the Maryland living resources data base.

Brian J. Rothschild, Cluney Stagg, Philip Jones
University of Maryland, Center for Environmental and Estuarine Studies
Chesapeake Biological Laboratory
$105,000.00
Blue crab stock dynamics in Chesapeake Bay.

Mark E. Chittenden, Jr.
Virginia Institute of Marine Science, College of William and Mary
$100,260.00
Improve data management systems to support Chesapeake Bay waters trawling programs.

Jim Colvocoresses
Virginia Institute of Marine Science, College of William and Mary
$34,448.00
Development of recruitment index for white perch in the Virginia tributaries of Chesapeake Bay.

John McConaugha, Michael Prager, Cynthia Jones
Department of Oceanography, Old Dominion University
$66,750.00
A characterizationof the blue crab spawning stock in Chesapeake Bay.

Brian W. Meehan
Virginia Institute of Marine Science, College of William and Mary
$73,638.00

Genetic investigation of coastal and estuarine stocks that are dependent on the Chesapeake Bay and its tributaries.

Brenda L. Norcross
Virginia Institute of Marine Science, College of William and Mary
$30,522.00

Develop data files and model for time series models.

Brenda L. Norcross
Virginia Institute of Marine Science, College of William and Mary
$9,356.00

Field sampling/monitoring on the Eastern Shore of Virginia.

Herbert M. Austin
Virginia Institute of Marine Science, College of William and Mary
$12,750.00

Status of stocks knowledge workgroup.

G. P. Patil, M. T. Boswell, G. J. Babu, W. L. Myers
Center for Statistical Ecology & Environmental Statistics
Pennsylvania State University
$95,000.00

Mathematical, statistical, and data analytical issues, investigations, and interpretations for the NOAA Chesapeake Bay stock assessment program.

1987

Jack Buckley
DC Department of Consumer & Regulatory Affairs, Fisheries Management
$80,000.00

Fishery-independent survey of white perch and anadromous fishes in the Potomac and Anacostia Rivers.

Chris Bonzek
Maryland Department of Natural Resources
$74,990.00

Maintenance and improvement of access to the Maryland living resources data base.

Steven Brandt
Maryland Department of Natural Resources
$132,956.00
Hydroacoustics as a stock assessment technique in the Potomac River.

Kevin Summers, Foster Stroup
Versar, Inc.
$110,000.00
Collection and evaluation of historical data on fisheries, hydrographic conditions and contaminant loadings to Chesapeake Bay tributaries.

Mark E. Chittenden
Virginia Institute of Marine Science, College of William and Mary
$242,500.00
Document abundance of economically important species.

Brenda L. Norcross, David M. Wyanski
Virginia Institute of Marine Science, College of William and Mary
$14,415.00
Climate/fisheries resources interaction studies.

Erik Barth
Virginia Marine Resources Commission
$52,890.00
Improvement of Virginia fisheries statistics: development of VMRC data management capabilities.

Herb Austin
Virginia Institute of Marine Science, College of William and Mary
$22,010.00
Virginia CBSAC travel and logistic support.

G. P. Patil, G. J. Babu, M. T. Boswell
Center for Statistical Ecology & Environmental Statistics
Pennsylvania State University
$50,000.00
Mathematical, statistical, and data analytical issues, investigations, and interpretations for the NOAA Chesapeake Bay stock assessment program: partitioning fish mortality in the Chesapeake Bay using multiple time series techniques.

1988

Brian J. Rothschild
University of Maryland, Center for Estuarine and Environmental Studies
Chesapeake Biological Laboratory
$220,000.00

A field study of the population dynamics of the American oyster, *Crassostrea virginica*, in the Chesapeake Bay.

Christopher Bonzek
Maryland Department of Natural Resources
$85,040.00

Improvement of fisheries statistics.

Bruce Barber, Roger Mann
Virginia Institute of Marine Science, College of William and Mary
$22,000.00

Estimation of standing crop of oysters in the James River, Virginia, using commercial fishing records.

Michael Prager
Department of Oceanography, Old Dominion University
$73,750.00

Assessing multi-gear and multi-sector fisheries.

John McConaugha, Cynthia Jones
Department of Oceanography, Old Dominion University
$164,033.00

Tag-recapture: study of spawning stock of Chesapeake Bay blue crab.

Herb Austin
Virginia Institute of Marine Science, College of William and Mary
$15,191.00

Virginia CBSAC travel and logistic support.

Cynthia Jones
Department of Oceanography, Old Dominion University
$121,825.00

Recreational fisheries sampling method evaluation.

Erik Barth
Virginia Marine Resources Commission
$37,068.00

Improvement of Virginia fishery statistics: development of VMRC biological sampling capabilities.

G. P. Patil, M. Boswell
Center for Statistical Ecology & Environmental Statistics
Pennsylvania State University
$75,000.00

Mathematical, statistical, and data analytical issues, investigations and interpretations for the NOAA Chesapeake Bay stock assessment program: integrative sampling designs for Chesapeake Bay trawl survey.

1989

Brian J. Rothschild
University of Maryland, Center for Estuarine and Environmental Studies
Chesapeake Biological Laboratory
$225,000.00

A field study of population dynamics of the blue crab, *Callinectes sapidus*, in Chesapeake Bay.

Romuald Lipcius
Virginia Institute of Marine Science, College of William and Mary
$275,000.00

A field study of population dynamics of the blue crab, *Callinectes sapidus*, in Chesapeake Bay.

Cynthia Jones
Applied Marine Research Laboratory, Old Dominion University
$81,984.00

Development of recreational fishing survey methods.

Mark Chittenden
Virginia Institute of Marine Science, College of William and Mary
$79,956.00

Evaluation of spatial/temporal sources of variation in nekton catch and the efficacy of stratified sampling previously used in the Chesapeake Bay.

John McConaugha
Department of Oceanography, Old Dominion University
$142,011.00
Tag-recapture study of the Chesapeake Bay.

Jack Musick
Virginia Institute of Marine Science, College of William and Mary
$12,246.00
Logistic support and CBSAC travel.

Erik Barth
Virginia Marine Resources Commission
$35,000.00
VMRC stock assessment internship.

Michael Prager
Old Dominion University
Department of Oceanography
$2,516.00
Travel and logistic support.

Chesapeake Bay Stock Assessment Committee Final Work Plan, October 1988

Charge:

The Chesapeake Bay Stock Assessment Committee will undertake a program for the bay-wide assessment of fishery resources and will support studies designed to estimate the relative influence of fishing mortality, natural mortality, pollution, and habitat modification on patterns and trends in abundance. The process which follows provides the framework for achieving these objectives.

I. Annually recommend amendments to cooperative agreements to support fisheries statistics and stock assessment research projects, if funding is available

- Prepare a request for proposals which is responsive to the short and long-term fisheries assessment and management needs of the Chesapeake Bay region.
- Send request for proposals to the four state contacts of the Chesapeake Bay Stock Assessment Committee (CBSAC) for distribution to the Bay research and management community. State contacts include those CBSAC members who administer NOAA/state cooperative agreements in Maryland, Virginia, Pennsylvania and D.C.
- Follow proposal review procedures approved by CBSAC in October 1988.

II. Provide guidance and review to CBSAC working groups

- At every CBSAC meeting, or at least quarterly, review activities of the two Fisheries Statistics Working Groups and the four Stock Assessment Working Groups and provide necessary guidance.
- Annually, review progress reports from all Working Groups for use in the CBSAC Annual Report.
- Revise Working Groups' charges, approved in October 1988, as necessary, following reviews.

III. Review progress of cooperative agreement projects to improve bay-wide fisheries statistics and stock assessment

- Evaluate progress and annual reports of funded projects and recommend redirection if necessary.

- Review final reports and extended abstracts of all funded projects for (1) technical review purposes to advise the NOAA Contracting Officer and (2) publication in the CBSAC Technical Report Series.

IV. Produce annually a *Fisheries Statistics Report*, *Status of Stocks Report*, and CBSAC *Annual Report*

- Review the two Fisheries Statistics Working Groups' combined *Fisheries Statistics Report* and prepare for publication.

- Review the four Stock Assessment Working Groups' combined *Status of Stocks Report* and prepare for publication.

- Compile and publish the Committee's *Annual Report*, including Committee and Working Group summaries of activities, extended abstracts of completed research projects, list of current research priorities and data needs, and projects during the past year.

V. Produce other reports periodically

- Direct the Stock Assessment Working Groups to update the *Status of Stock Knowledge Report* as needed.

- Review for inclusion in the CBSAC Technical Report Series, in-depth stock assessments produced by the Stock Assessment Working Groups' in support of the development of Bay-wide fisheries management plans or for other purposes. These would be prepared periodically in addition to the annual *Status of Stocks Report*.

- Review for inclusion in the CBSAC Technical Report Series, workshop reports and any other technical reports prepared by the Working Groups.

VI. Coordinate CBSAC activities with the development of bay-wide resource management plans, pursuant to the Chesapeake Bay Agreement

- Direct the Stock Assessment Working Groups to be prepared to provide stock assessment analyses to the Bay-wide Fisheries Management Group according to the *Schedule for Developing Bay-wide Resource Management Strategies*.

- Direct the Fisheries Statistics Working Groups to acquire and have available the necessary long-term data to support stock assessment analyses according to the schedule above.

- Incorporate assessment research needs necessary for the development and implementation of Bay-wide resource management plans into request for proposals issued by the Committee.

VII. Explore ways to develop and enhance stock assessment expertise and capabilities in the Chesapeake Bay region over the long-term