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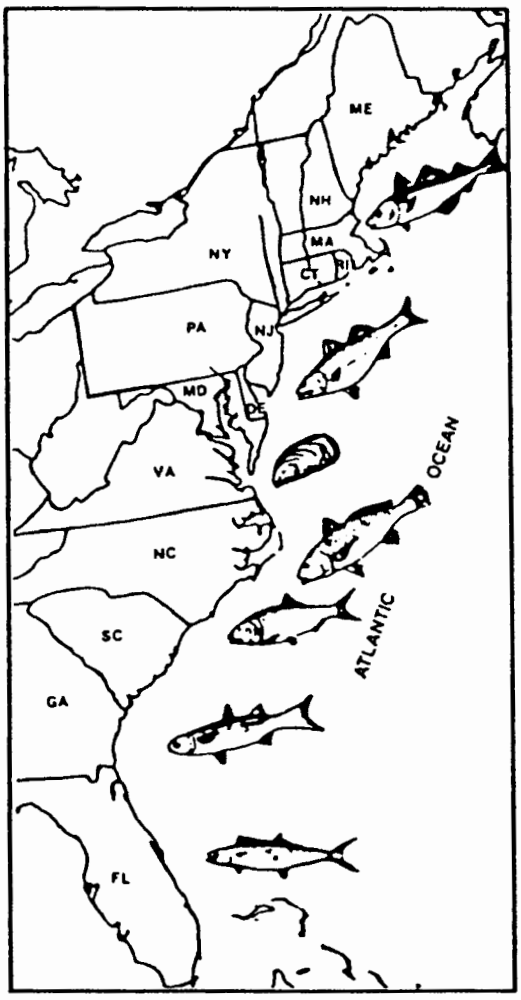

PROCEEDINGS OF A WORKSHOP ON BOTTOM TRAWL SURVEYS

AUGUST 1989

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Proceedings of a Workshop on Bottom Trawl Surveys

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Thomas R. Azarovitz
Joseph McGurrin
Richard Seagraves, editors

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WORKSHOP SUMMARY

Paul Perra

State and Federal researchers met on November 1, 2, and 3, 1988 in Woods Hole, Massachusetts for a Workshop on Bottom Trawl Surveys convened under the auspices of the Atlantic States Marine Fisheries Commission (ASMFC) and the National Marine Fisheries Service (NMFS). The main purpose of the workshop was to provide a forum for information exchange among researchers who are planning or conducting fisheries resource assessment using bottom trawl surveys.

Individual reports describing present and future plans for trawl surveys were given for the States of Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia and Florida. National Marine Fisheries Service personnel also gave overviews on the cooperative state-federal Northern Shrimp Survey in the Gulf of Maine, the NMFS spring and fall trawl surveys conducted between Cape Hatteras and Nova Scotia, and the South Atlantic cooperative state-federal SEAMAP Trawl Survey.

The States of Massachusetts, Rhode Island, and Connecticut are conducting trawl surveys and have, to varying degrees, integrated these programs with the NMFS-Northeast Fisheries Center (NEFC) surveys. The State of Maine also is considering a trawl survey program for the Gulf of Maine. This program should be strongly encouraged because data generated could improve the nearshore regional data bases used for managing New England fisheries. The State of New Jersey has just instituted a trawl survey along its coast and Delaware will be conducting a trawl program for Delaware Bay beginning in 1989. There was a consensus among workshop participants that these programs, as well as other new trawl surveys should be developed in a complementary manner and integrated with existing database management systems (preferably the Northeast Fisheries Center database).

In the Chesapeake Bay region, Virginia has a long-term trawl survey, but the use of this time series is limited because of numerous gear changes and data collection gaps. Both Maryland and Virginia are considering experimental trawl survey programs through their Chesapeake Bay Stock Assessment Committee (CBSAC). These programs will be developed into a coordinated Chesapeake Bay survey within the next few years. Workshop participants suggested that efforts to develop regional database systems with comparable information for New England, Delaware Bay, and Chesapeake Bay should be given a high priority in the future.

The South Atlantic States of North Carolina, South Carolina and Georgia are cooperating with NMFS in a joint Southeast Area Marine Assessment Program (SEAMAP). Through this program, they conduct a state-federal trawl survey in South Atlantic waters using a single research vessel staffed with cooperating state and federal scientists. The data are entered through a state-federal database program set up through the NMFS-Miami Center. SEAMAP serves as a good example of a joint program collecting coordinated information on a regional basis. Similar programs should be encouraged in other coastal areas.

In addition to SEAMAP, a number of South Atlantic states conduct special juvenile trawl surveys for shrimp and finfish. For example, the State of Florida does not conduct a major offshore trawl survey, but does have extensive juvenile sampling programs with a variety of gears within a diversity of habitat types. Florida will be expanding its juvenile sampling program in the next few years. Data collected on coastal migratory species from Florida's programs should be integrated with the NMFS-Miami Center's data management program. Beyond the Florida situation, workshop participants emphasized the need for coordinating the results of all state juvenile fish surveysin a single database. The system design should allow researchers conducting stock assessments on migratory species to access juvenile abundance data on a regional basis.

A series of speakers also addressed the workshop attendees on special topics of broad interest that included: Trawl survey design; Selection and standardization of sampling gears; Data handling; Alternate and/or complementary sampling techniques; and,New applications for trawl survey data. Based on these presentations and discussions of the individual agency trawl survey reports, the following recommendations were supported by a majority of workshop participants:

1. Plans for new trawl survey programs should be coordinated with existing survey activities.

2. Data collected for migratory species from individual programs should be integrated into regional database systems.

3. Further workshops should be conducted by ASMFC in order to compare and calibrate the different trawl survey gears used in different areas, and

4. NMFS should conduct periodic workshops and seminars oriented to upgrading state personnel capabilities in survey design, data handling, and analysis of results.

SPECIAL DISCUSSION SESSIONS

Session 1
Trawl Survey Design - Random Vs Fixed Stations

Michael J. Fogarty

Rapporteur: Stephen H. Clark

The Speaker began with the observation that a great many survey designs were in use; consequently, a review of basic principles and the pros and cons of various sampling designs would be appropriate. The present discussion is focused on the relative attributes of stratified random and systematic sampling.

Some general properties of stratified random and systematic sampling designs are:

Stratified Random	Systematic
Estimates of mean unbiased	Estimate of mean can be biased
Variance properties are well known	Variance estimation can pose problems
Spatial coverage is generally good	Provides uniform coverage over broad areas

Overall, the stratified random design is clearly a very useful one for many types of surveys. Since it is widely used and its properties are well known, the focus of this talk will be on systematic sampling. In using systematic sampling designs, it must be remembered that unless caution is exercised, estimates of the mean may be biased and either underestimate or overestimate the true population mean. Deriving a valid estimate of the variance may be an even bigger problem, requiring knowledge or inferences about the underlying mature of the distributions being sampled.

When setting up a systematic sampling program, one should use an element of randomization, (e.g. by randomly choosing the first sample location in a grid design, the sampling locations will occupy the same relative position within the remaining grids). There are a number of potential approaches to designing a systematic sample including "aligned" and "unaligned" patterns. An effective design which allows a valid estimate of the variance is a systematic sample with multiple random starts; that is, each grid section contains at least two samples and the initial locations of these samples are randomly chosen. In any case, there should be a probabilistic element in the selection of sample sites or one will not be able to make valid statements about the nature of the population being sampled.

The relative merits of stratified random and systematic sampling are determined by the spatial structure of the population; one may achieve better precision with a systematic design depending on the degree of autocorrelation of the sample data points. The variance of a systematic sample is:

$$V - X = S^2 [1 + (n-1) r]$$

where S^2 is defined as the population variance and r is the correlation between pairs of samples within the systematic sample. If there is a positive correlation between the samples, the variance of the systematic sample will be high. This focus on the correlation between stations within the systematic sample is extremely important and it can dictate the analytical approach taken.

Autocorrelation between adjacent data points is common in inshore surveys due to high sub-sampling intensity. One approach to taking advantage of spatial structure of this type is to use "geostatistical" methods that have been specifically developed for this purpose. Unlike the methods described above, the geostatistical approach is "model-based"; that is, it depends on specific models of the underlying spatial structure. The form of the underlying model is determined by empirically examining a "semi-variogram" which depicts the variance between stations as a function of their distance apart. Typically, the samples that are closest in space have the lowest semi-variance (i.e. are most highly correlated) and eventually the semi-variance reaches a plateau (i.e. stations farther apart are not correlated). The form of the relationship between the semi-variance and the distance between stations provides the basis for the model-based estimates of the mean and variance. One of the most common geostatistical techniques is "kriging" in which estimates of the mean population size and its variance are developed from weighted estimates of abundance. The weighing factors are derived from the semi-variance.

Points raised during the talk and the ensuing discussion included the following:

1) It is difficult to devise truly optimal stratification schemes (e.g. for a range of species) in multi-species surveys. For specific applications it may be advantageous to "post-stratify" the data so as to improve precision of the estimators. Post-stratification may introduce other problems, (e.g. sample allocation will no longer be proportional), but these are not generally significant.

2) Although it has been common practice to do so, it is not necessary to select different station locations each year in a stratified random survey; initial

randomization ensures that there is no bias. Continued sampling at the same locations may be useful in situations where considerable heterogeneity is expected within strata, although it implies the potential for loss of information. Probably the best strategy would be to locate a portion of the samples at random in each survey and leave the remainder "fixed"; data may still be analyzed using standard procedures.

3) Stratified random surveys may be extended to compensate for differences in distribution or other changes, although the resulting indices will obviously not be directly comparable. One may also incorporate a systematic sampling design, (e.g. fixed stations to monitor environmental changes, within a stratified random type). Such "mixed" designs are adequately treated in the statistical literature.

4) If geostatistical techniques, (e.g. kriging) are to be used, a systematic sample (grid design) can be very effective. However, such methods can also be applied to random and stratified random designs.

Session 2
Selection and Standardization of Sampling Gear

Charles Byrne, NEFC, Woods Hole Laboratory
Janice Forrester, NEFC, Woods Hole Laboratory

Rapporteurs: Janice Forrester, Charles Byrne

The selection and standardization of gear are multi-faceted problems, each with their own implications. The purpose of this presentation was to stimulate thought and provoke discussion relative to these problems.

The first speaker discussed sampling gear selection and standardization of operations. A number of factors need to be considered when choosing or designing a piece of sampling gear. First, the purpose of the field work must be defined. Are quantitative samples required? Multiple purposes (or multiple species) to be served by one piece of gear should be prioritized. All further gear selection considerations should be made with these priorities in mind. The life history, and the life history stage(s) of species to be sampled are basic to gear selection.

Characteristics of the area in which sampling is to be conducted are very important. Factors such as depth, topographical and substrate characteristics (both natural and anthropogenic), currents, and obstructions or hazards (fixed gear or piers for example) must be considered. Can sampling be conducted from shore and existing structures, or must it be conducted using a vessel? Depending on the answer, a trawl survey may not be necessary.

If a vessel is to be used, characteristics of the vessel must be considered: horsepower; length, width and draft; side vs. stern configuration; deck space and work area; equipment available to handle the gear (winches [line speed, line pull, capacity], trawl warp diameter and amount of wire, "A" frames, booms, etc.); electronics; electrical power supply (if electronic gear are to be brought aboard); laboratory space; licenses or certifications required; size of the crew and their willingness and ability to handle and maintain the gear; and, the number of scientists that can be accommodated are among those things that must be weighed.

The ease of using, transporting and storing the gear are considerations. Ease of use is reflected in the level and type of personnel needed to use the gear and the resulting success with the gear. Obviously, a piece of gear with a large rigid frame significantly increases handling, transportation and storage problems.

Design complexity and size are directly reflected in cost, and problems associated with construction, use and maintenance of the gear. If development of a time series is a possibility,

future as well as present component availability is an important consideration. Chances of the introduction of significant bias increase each time a component substitution is made. Ideally the gear should be a relatively simple, easily built, easily standardized, robust piece of gear that is large enough to obtain representative scientific samples dependably, but no larger. Large catches require more people and/or time to process, and may actually increase the variability in catch data due to an increased need to subsample or estimate large catches.

If survey data are to be used for resource management, it may be desirable to look for gear which is both recognized and respected by the commercial fishing community. While, this may have little bearing on the scientific success or value of the survey, it can be of significant political and public relations importance.

Finally, comparability with ongoing or historical studies should be considered. When gear is changed or modified during a time series, expensive, time consuming studies are required to standardize the fishing power of different sampling gears to each other.

After a piece of sampling gear has been selected, standardization of gear and operations become the most significant problems in maintaining a survey time series. Among the first steps that must be taken to standardize a trawl survey time series is the development of a detailed set of drawings and specifications of the gear (trawl, wires, hardware and doors). Ideally, these specifications should be critiqued by potential contractors to assure that the specifications are complete, easily understandable, and that construction variability due to "artistic license" will be held to a minimum. It is highly desirable to reduce potential construction variability by limiting the number of people authorized to build or repair the gear. Strict adherence to established specifications (even to the color of the twine used in a trawl) and the verification of the finished product are essential to maintaining an unbiased survey.

Although less apparent, the need for standardizing vessels used during a survey time series is nearly as great as that for gear. The same vessel factors that were considered during the gear selection process apply to vessel standardization. There have been documented cases where differences in catch rates for sister vessels, using the same gear, have been attributed to very subtle differences between the vessels.

The importance of operational standardization is obvious. An established protocol should include elements that define: tow methodology (direction, scope, speed, duration, setting and hauling the trawl, etc.); survey limits (sea state limitations, time of day requirements, limits that define the acceptability of a tow, etc.); and, catch processing and data recording

methodology. Another important element is assuring that survey gear is functioning correctly during surveys. The NEFC currently monitors the performance of the survey trawl periodically, using an acoustic monitoring system. Trawl performance is checked when it is first used, periodically throughout the survey, and immediately after any repairs or modifications are made. Before the present system was employed, special cruises (using a third wire system) were conducted to certify trawl performance prior to survey use.

Another standardization consideration relates to ongoing or historic survey time series. How similar are the gear, vessels and operations to other surveys? If differences exist, must the sampling units be standardized to each other? If so, expensive time and resources will be required to conduct related studies.

The second presentation dealt with the design of gear standardization studies. The purpose of a standardization study is usually to determine the magnitude of any significant differences in performance between gear types. Catch is usually used as an indicator of gear performance because gear changes impact a survey when catches are affected by the change. Factors to consider when designing a gear study include gear type, equipment limitations, and spatial and temporal variability.

There will almost certainly be a change in vessels at some time during an ongoing trawl survey program especially if the survey continues for a number of years. Vessel comparison studies usually consist of parallel towing, either in a special study or by "piggybacking" during a trawl survey. Extraneous variability between the two vessels is reduced by keeping towing speed, tow direction and duration, gear type and towing depth constant.

Sometimes a vessel change during a trawl survey is accompanied by a gear change. In this situation the new gear cannot be used with the new vessel to determine fishing power changes. The vessel/gear combinations are then considered experimental units. Paired towing as described above can be used to determine if differences in catchability exist between the original and new vessel/gear combinations.

Comparing other types of gear is more difficult. For example, the experimenter may wish to compare two gear types on the same vessel. Parallel towing is not possible in this situation, but it is possible for the vessel to do a tow, change the gear and do another tow in the same spot. The disadvantage here is the multiple gear changes necessary to carry out the study. The number of gear changes can be reduced by doing a series of tows using the first gear type, changing the gear, and repeating the series in the same locations. Variability can be reduced by taking time of day, depth, tidal currents and weather into consideration.

In conclusion, try to eliminate as much variability as possible when planning and conducting a gear experiment. The resulting data set will be much more meaningful and will be easier to analyze.

The group then discussed factors that may influence catch. These included vessel noise, tidal current, sea state, bottom type, sonar, twine color, net rigging, net opening and door spread. Protocol for trawl mensuration was also discussed, as well as the conventions followed during a standard NEFC bottom trawl survey tow.

Session 3
The Joys of Sub-Sampling and Making Sense of the Data the Day After.

Tom Currier, Massachusetts Division of Marine Fisheries
Linda Despres-Patanjo, NMFS, Woods Hole, MA.

Rapporteur: Donald Flescher

The first presentation by Tom Currier focused on deck sampling of large catches, also known as sub-sampling. The manpower available plays a major role in determining sampling procedures: what works for 5-6 people on deck will be different from what 2-3 people can accomplish. Another trade-off involves having procedures that are fast enough to get on with the cruise versus slowing down to obtain more complete data collection.

In a typical sampling sequence when the catch is dumped on deck, the watch chief determines how to process it. Different sub-sampling techniques require different sorting procedures. Whether or not you should sub-sample depends on the size of the catch and the steaming time to the next station. To prevent bias (e.g., large fish preferentially picked for the sample), each person sorts one sector of the catch. If bias is suspected, one can use a "Dutch shuffle" to remix the sample before selecting a portion to measure.

The experience of the scientists is used to determine what constitutes an adequate size sample. The sample must cover the range and magnitude of each mode. When unsure of sample size, the sampler should err on the side of oversampling, not undersampling. If the fish cover a large size range, (e.g., ocean pout and spiny dogfish) and are without distinct modes, one must measure more individuals. For small fish that are numerous, a person can sub-sample by volume or weight (e.g., 1/4 or 1/8 of the catch will be measured).

The following procedure is used for handling a mixed species sample ("mixes"):

1. Remove those species that are represented by a small number of individuals.

2. Remove the larger individuals of those species that have young in the mix. Also remove the species that only occur as relatively large individuals (e.g., skates).

3. The "mix" is what is left, and is composed of similar size individuals of more than one species. Mixes are usually sub-sampled further.

In regards to discards, discarding can be done by weight or volume (e.g., count the number of baskets equally filled to the same level which are thrown over the side), or by number (e.g.,

count the numbers of large fish such as spiny dogfish thrown over the side). Spiny dogfish present their own unique problems. Scientists handle the two sexes as if they were two species, since the females grow larger and each sex has a different length-weight relationship. Since there are no distinct modes, many individuals must be measured. When large schools of spiny dogfish are encountered, it has been the policy of the marine agencies in Maine and Massachusetts to haul back after as little as two minutes. The question then arises whether expanding this to a 20 minute tow distorts the data.

Other problems to address include the fact that debris may make separations difficult and large amounts of eelgrass or sponges complicate obtaining a representative subsample. In addition, nets should be picked clean so as not to contaminate subsequent tows. For example, sand lance left hanging in the meshes may wash down into the codend during the next tow.

In summary, subsampling is a timesaving tool, but it must be done so as to represent the entire catch.

The second presentation by Linda Despres-Patanjo covered audits as developed and conducted by the Northeast Fisheries Center (NEFC). It should never be assumed that the data are "clean" and ready for analysis after being collected. The audit takes place between the collection of the raw data and its archiving in final form prior to use by the assessment scientists. NEFC has 26 years of experience with random stratified trawl surveys upon which the audits are based. However, routines are still being improved.

Some of the causes of error at sea are weather, people who are ill or tired, poor lighting and space, and the difficulty of hearing distinctly. Logs are reviewed and coded at sea as soon as possible after the data are collected in order to catch errors early. All data are located on one double-sided waterproof log. The watches coordinate their techniques to prevent inconsistencies.

Standardized species names and codes are used in all sampling efforts* (The same codes are used by NEFC and the State of Massachusetts.). Fish maturities are recorded using criteria defined in a photo book, learned from a videotape and during hands-on training workshops. The maturity criteria are also available in written form*. Station data for all fields are defined in a coding detail booklet*. It is very important that all procedures used are well-defined and standardized. Any deviations should be documented.

A cruise track is charted immediately after the cruise. The cruise track does double duty, appearing in both the cruise results and the Fishermen's Report . Errors are also detected in this process. The completed logs are reviewed on shore prior to

keypunching which is usually completed within three days after the completion of the cruise.

The NEFC Fishermen's Report* is based on unaudited trawl survey data. The report has 3 parts: 1) Station information (date, latitude, longitude, loran bearings, depth, etc.), 2) Catches by station for 23 species that are of commercial interest, and, 3) Distribution plots for the same 23 species. During production of the Fishermen's Report, errors such as incorrect locations and unreasonable catch sizes, are found and corrected.

The current NEFC auditing system includes both a "station audit" to locate errors in station data fields (location, duration of tow, etc.) and a biological audit for catch data. Seventy-three fields are crosschecked in the station audit. In this process, data are flagged if they don't fall within certain minimum and maximum values. The station audit is run at least 3 times in order to catch all errors.

During a bio-audit a length-weight equation is used to calculate a weight for each species at each station. This calculated weight is then compared with the observed weight. Auditors decide when to change or delete records that have a poor match between the calculated and the observed weights. On occasion required changes can be subjective, therefore auditors must be experienced. The bio-audit treats one species at a time, making it easier to find errors. The bio-audit is also run at least 3 times in order to locate all errors. The procedure is time consuming and expensive but a necessary process to ensure a standard data set. Since fatigue may affect the auditor, a final review is done by a different individual. The final step involves archiving data in master data format. The entire process takes about 6-8 weeks to complete.

*Copies of these booklets and reports are available upon request.

Session 4
Alternative and Complementary Sampling Techniques

Charles Barans South Carolina Wildlife and Marine Resources Department
Jim Dawson, BioSonics Inc.

Rapporteur: Joseph McGurrin

The presentations of the coastal states on their trawl survey activities underscored the wide diversity of habitats and fish stocks found from Maine to Florida. This diversity highlights a basic problem faced by any fishery scientist conducting a trawl survey. The problem involves accommodating sampling practices to variations in habitat and target fish species. One approach to solving this problem is to employ alternative and/or complementary sampling techniques within a trawl survey program. Charles Barans of the South Carolina Wildlife and Marine Resources Department and Jim Dawson of Biosonics, Inc. provided information on these techniques.

Charles Barans reviewed the experiences of the South Carolina trawl survey which covers both open sandy bottoms and rocky live bottom areas. This has led to the use of both alternative gears and complementary techniques for sampling. In terms of alternatives to the use of trawls, a variety of equipment may be employed. This equipment runs the gamut of fish capture techniques including traps, hook and line, trotlines and gillnets. The choices about equipment will be a function of the type of habitat and the target species,

In terms of complementary equipment for use with trawls, the advent of new technologies with acoustic and visual equipment can improve the efficiency of trawl program efforts. Visual techniques such as underwater video and sidescan sonar can be used to confirm habitat features and trawl operating characteristics. Acoustic techniques can be used in both a qualitative and quantitative sense to better estimate habitat and sample attributes.

In sum, the wide variety of alternative and complementary sampling techniques available to a trawl program offer the fishery scientist an additional opportunity to confirm habitat type, improve trawl efficiency, and thus provide a better sample estimate across a diversity of environmental conditions.

The second speaker, Jim Dawson of BioSonics, focused on hydroacoustics as a complementary sampling technique. To understand the potential of hydroacoustics as a complement to trawl surveys, it is necessary to provide a brief overview of hydroacoustic techniques and applications. Hydroacoustic techniques can make sample estimates on fixed locations (i.e. at fish ladders, power plant intakes, artificial reefs, etc.) or in conjunction with mobile surveys (trawls). From fixed locations, hydroacoustics can provide information on passage rates in terms

of overall magnitude, and seasonal and diel variations. Sonar also can provide data on fish behavior. Used in conjunction with mobile surveys, hydroacoustics can give information on: 1) density/abundance 2) area distribution 3) size distributions (uses target strength) and, 4) species composition - (identification by inferences).

In terms of the specifics of using sonar with trawl equipment, hydroacoustic additions can improve efficiency and provide general information on fish location and behavior. However, sonar can not be a substitute for the precise sample data (i.e. age, length, weights of fish) provided by a trawl. Some examples of successful use of sonar with trawl equipment include squid distribution studies, Pacific whiting stock estimates and forage estimates in Lake Michigan.

The discussion of the above presentations focused on technical questions about sampling techniques. Throughout the questions, a single theme emerged. That was, regardless of a scientist's overall knowledge of the technical aspects of trawl and other sampling techniques, the overall success of a sampling program depends on clear goals and objectives. With a clear focus of study, it is possible to use a variety of sampling tools to obtain effective estimates of fish population parameters.

Session 5
Exploring New Applications for Trawl Survey Data

Stuart Wilk, NEFC, Sandy Hook Laboratory
Thomas Polacheck, NEFC, Woods Hole Laboratory

Rapporteur: Jay Burnett

The traditional role of bottom trawl surveys has been to monitor trends in abundance and distribution of fish and invertebrate populations, primarily for purposes of management. This session examined other ways in which trawl surveys themselves, or the data routinely collected during these surveys, could be used to address specific scientific questions or complement ecological studies.

The first presentation by Stuart Wilk illustrated the utility of a trawl survey as a major component within an on-going multi-disciplinary study of the 12 Mile Dump site in the New York Bight region. This three year cooperative study, coordinated by the Northeast Fisheries Center's Sandy Hook Laboratory, was designed to collect baseline environmental, biological, and chemical data from a sewage sludge dump site and to evaluate habitat recovery following the cessation of dumping (details regarding experimental design, methodology, and sampling operations are contained in NOAA Technical Memorandum NMFS-F/NEC-55).

Twenty-eight fixed trawl stations were selected based on historical information to represent a gradient of environmental impact. Systematic broadscale sampling was performed on 25 stations, with intensive replicate sampling conducted on the remaining three. The types of information obtained from this sampling included synoptic observations of species composition and abundance, pathological conditions, and rates of movement. The presentation concluded by emphasizing the value of a directed trawl survey program as a means to quantitatively assess environmental impact and to scientifically characterize processes of habitat degradation and recovery.

The second presentation by Thomas Polacheck examined new applications of existing trawl survey data in ecological studies, with particular emphasis on the NEFC bottom trawl survey database. Several appealing aspects associated with trawl surveys were discussed, including standardized extensive and intensive sampling, long time series, ancillary environmental data, and the presence of related data bases. Some of the problems involved with using trawl survey data in ecological studies centered around sampling designs inappropriate for hypothesis-testing and the variability in spatial and temporal catchability and availability of many species.

Three specific examples of studies which might successfully utilize existing trawl survey data were proposed:

1) Studies of biological processes, such as growth, maturation, fecundity, recruitment, and natural mortality. Although these processes are partially modeled for individual species as a prerequisite for analytical stock assessments, there has been little progress in doing so in a comprehensive, multi-species manner or to a resolution capable of delineating density-dependent mechanisms;

2) Studies of community processes. Trawl survey data have been successfully utilized in describing regional species assemblages, changes in species composition, species overlap/co-occurrence, and predator-prey dynamics, but any multi-species approach to management will necessitate an even greater understanding of these species interactions; and

3) Studies of spatial dynamics. Techniques such as geostatistical modeling of trawl survey data may identify relationships between species abundance and location, and provide the basis to enhance the precision of survey-derived estimates.

The presentation concluded with the observation that much of the data routinely collected during trawl surveys were under-utilized and represented "gold mines" for further research and management efforts.

Session 6
Potential Areas of Cooperation and Coordination in Trawl Survey Programs

Richard Seagraves, DE Division of Fish & Wildlife
Paul Perra, Atlantic States Marine Fisheries Commission
Thomas Azarovitz, Northeast Fisheries Center

Rapporteur: Scott Moseley

There are a number of potential areas for cooperative and coordinated multi-agency efforts in trawl survey programs. Initial discussion emphasized the value of these workshops and raised the possibility that they take place on a regular basis. It was suggested that a meeting be held every three to four years or that a permanent working group be formed and incorporated into the SAW forum. A core group of State and Federal people dedicated to coordinating programs and exchanging data would be useful.

The point was made that survey programs exist to provide managers with information regarding relative abundance, biomass, and age composition of fish stocks. To provide this information, especially on migratory stocks, a coordinated effort between State and Federal agencies is required. It was stated that the SEAMAP program could be looked to as a model of such coordination. It was suggested that a program be built to coordinate the collection and archiving of samples and data and to facilitate the sharing of data. Fish hard part and stomach content samples were of primary interest in this discussion. The point was raised that all survey programs should include sampling for these items even if they will not be routinely examined. Many states already do this, but it was emphasized that there is little sharing of data, no central location for archived samples, and no directory to sample and data repositories and where and how these were collected. It was pointed out that such a directory would be useful step towards the goal of coordinated efforts. It was stated that NMFS cannot currently build such a coordination program, but can provide advice in the areas of survey design, sampling protocols, optimum sampling levels, and sample processing and archiving.

OVERVIEWS OF AGENCY TRAWL SURVEY PROGRAMS

Federal, Regional, State/Federal Surveys

The trawl survey programs involving federal and cooperative agency efforts include a variety of surveys that range from a single species emphasis to multiple species surveys over large regions. Data collected in these surveys are used in a variety of ways such as in population assessments, management actions, and in research and monitoring programs.

Northeast Fisheries Center Trawl Surveys

Thomas R. Azarovitz

Introduction

The Northeast Fisheries Center (NEFC) of the National Marine Fisheries Service (NMFS) has historically supported and conducted finfish and shellfish resource surveys. Currently two shellfish surveys are conducted, one for surf clams and ocean quahogs, the other for sea scallops. The clam surveys are scheduled every two or three years and the scallop surveys are conducted annually. Complete information about the shellfish surveys can be obtained by contacting the Resource Surveys Investigation at the NEFC Woods Hole Laboratory.

Bottom trawl surveys are conducted twice a year, in the spring (March-April), and the autumn (September-October). The surveys are designed both to gather fishery independent abundance and distribution data for management purposes and to provide data for broadscale ecosystem research. The twenty-first and twenty-seventh spring and fall survey cruises, respectively, were completed in 1988. The resources necessary to conduct standardized semi-annual trawl surveys covering almost 300,000 square kilometers are considerable, but the benefits are also considerable. This is especially true in the case of the NEFC survey which, because of its longevity, makes the data more applicable today, given the concerns of overharvesting, environmental degradation, and the potential effects of weather and climate on these resources. The following is a brief outline of how trawl surveys are conducted by the Northeast Fisheries Center. A bibliography of some key publications providing more detail and information is included.

Time Series History/Platforms

NEFC spring and autumn surveys cover the Atlantic shelf from Cape Hatteras to Nova Scotia. Stations are made in depths of 9 to 365 meters. Before 1972, the 27-meter contour marked the shallowest sampling. In the 1970's and early 1980's, coverage was extended south of Cape Hatteras to Cape Fear and sampling was also initiated in shallow waters of less than 9 meters, especially in the Mid-Atlantic. Since the beginning of the survey program over 26 years ago, sporadic surveys were conducted during the summer and winter months. Summer surveys were focused on inshore areas and recreationally important species, while winter surveys were designed to sample some of the more pelagic species, e.g., Atlantic mackerel and herring.

Most survey cruises have been conducted on the R/V Albatross IV, a 57-meter long stern trawler. Some cruises were on the Delaware II, 47 meters long and also a stern trawler. Albatross

IV is scheduled to be decommissioned in 1989 after which the Delaware II will be used exclusively for NEFC bottom trawl surveys. This will force some reduction in sampling and in our ability to support cooperative research programs because of limited laboratory space and accommodation for only ten scientists on Delaware II, compared to fourteen on Albatross IV. The vessel change also creates a potential fishing power problem which is discussed in detail elsewhere in this report.

Survey Methods

Beginning with the first trawl survey in 1963 it was decided that a multispecies, ecosystem approach was required. In addition to collecting as much biological data as possible, another objective of the survey was to provide a statistically valid quantitative sample, one that would give estimates of sampling error or variance. A stratified random approach enables us to achieve the above and can still be adapted to provide a fairly uniform spacing of stations for distribution studies. The study area has been stratified by depth. The stratum depth limits are < 9 m, >9 m - 18, >18 - 27 m, >27 - 55 M, >55 - 110 M, >110 - 185 M, and >185 - 365 m. Most strata are further subdivided into sampling units to achieve more even sampling distribution. Stations are then randomly selected, the number of stations being proportional to area. The total survey area is 283,137 sq. kilometers, about the same size as all of the New England states plus New York. We currently complete about 320 hauls a survey, providing one station for every 885 sq. kilometers. In the late 1970's and early 1980's as many as 450 stations were occupied on a survey, additional stations were mainly in critical habitat areas such as Georges Bank. Sampling south of Cape Hatteras, on Browns Bank (near Nova Scotia), and in the Bay of Fundy, has been completely dropped and coverage has been curtailed on the same inshore (>18 m) and offshore (>110 m) strata.

On most survey cruises, a standardized #36 Yankee Otter Trawl has been used. From 1972 until 1981, a larger #41 Yankee Trawl was used on spring surveys and a 3/4 Yankee Trawl was used on some of the inshore surveys from 1972 until 1975. The two larger trawls are rigged for hard bottom with wire foot rope and 18 inch roller gear. Since juvenile fish abundance is important to our time series, all trawls have been lined with a 1.25 cm stretched mesh liner. On all surveys until 1985 BMV Oval doors were used. A change to Polyvalent doors occurred at that time because the older types could not be manufactured to our standard specifications. The change in doors is probably the most significant disruption to have been introduced to the time series to date. Preliminary results of our evaluation tests indicate that the change in doors may indeed be more important than the switch in primary vessel from Albatross IV to Delaware II. (See Special Session 2, this report).

During the early years of the surveys a third wire trawl

mensuration package was developed. Initially trawls were tested and certified standard using the above instruments prior to a survey. For a period of several years, attempts were made to use the instrument package routinely, monitoring the trawls during surveys to assure standard performance. This obviously is the best approach. However, it proved not to be practical. In deeper water the wire appeared to affect trawl performance and the instruments were not robust enough to be used all the time. In 1986, a wireless acoustic link system was used for the first time. It was hoped that this impact protected instrumentation designed for use on big mid-water trawl operations would be dependable enough for routine use. The instrumentation package proved to be robust, but because of the high number of stations that are made and the manner in which gear must be deployed and retrieved on the ships, routine use has again not been practical. Therefore, this instrumentation is presently used on about a third of the survey tows. In addition to the basic mensuration data of trawl height and wingspread, bottom temperature is also recorded. The digital data stream has been linked to a computer for recording and analysis programs are now being developed to analyze the data in real time to assure trawls are performing to specifications.

Operations on all our surveys are conducted on a twenty four hour basis. Watches are usually six on, six off with the scientific party divided into two groups. Since time of day can significantly affect trawl catches for certain species, scientists using the data must take this possibility into account. Trawl hauls are made for thirty minutes at 3.5 knots over the bottom (as opposed to through, the water). Tow direction is randomized by towing towards the next random station but seas and currents occasionally force changes in this procedure.

The entire catch is sorted to species. The species weight is recorded to 0.1 K and all fish and most invertebrates are measured. If the catch is so large that it's impractical to measure (a rare occurrence these days) the catch is quantitatively subsampled so the data can later be expanded to the total amount. During or immediately after the measuring process a series of samples are taken for age, growth, maturity, fecundity, pathology and other studies. Although many of the above parameters are recorded in detail on the vessel, many samples are preserved for subsequent workup and analysis in the laboratory.

Data are recorded on two sided waterproof paper forms. Automated data entry at sea has been a long sought objective of the survey program. A prototype system for shellfish cruises has been developed but the system is still dependent on the completion, by hand, of the log. The combination of manual data recording and keyed entry of data at sea has been proven cumbersome and inefficient. Future plans are to develop automatic systems of data recording and entry eliminating the need for

the written log. An electronic measuring board developed by NMFS was recently tested on our surveys but was found to be in need of improvements in basic hardware and software design.

Data logs are manually preprocessed at sea and data are entered into preliminary data files within a week following the cruise. A series of audits is then initiated to eliminate recording or entry errors. Data are available for assessments or other research within 2 months (see Special Session 3 this report).

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Southeast Area Monitoring and Assessment Program (SEAMAP)

Elizabeth Wenner

In 1986, the Southeast Area Monitoring and Assessment Program (SEAMAP) established a bottom trawling project, to provide long-term monitoring of the coastal zone. The South Atlantic SEAMAP program is a cooperative program between the southeastern states and the National Marine Fisheries Service with objectives to collect, manage, and provide fishery independent information as needed by management and research agencies. The three year (1986-1988) pilot phase involved a cooperative study of the coastal zone by Georgia Department of Natural Resources, the South Carolina Wildlife and Marine Resources Department, and the North Carolina Division of Marine Fisheries.

For the 1986-87 FY, the survey was designed to determine temporal and latitudinal changes in species composition, biomass, size, and relative abundance of fish and invertebrate inhabitants of the coastal zone. Because seasonal data had been previously collected by the MARMAP program in the South Atlantic Bight from Cape Fear, North Carolina to Cape Canaveral, Florida, their stratified random sampling design was adopted with some minor modifications. The SEAMAP study included all of the strata sampled by MARMAP from depths of 4.6-9.1 m, with the exception that six new strata were established off North Carolina from Cape Fear to Cape Hatteras. Including these additional strata, 19 total strata (seven off North Carolina, seven off South Carolina and five off Georgia) were subdivided into, nautical mile squares from which five sites, excluding those with, obstructions, were randomly chosen. At each site, hydrographic and atmospheric data, a neuston sample and a trawl sample were taken.

Trawls used in sampling were 9.1 m mongoose-type Falcon trawls with tickler chains. All nets were made by the same manufacturer (Beaufort Marine Supply, Burton, S.C.) to the same specifications for consistency in gear among the three states. A 39 m three-lead bridle was attached to a pair of wooden chain doors which measured 1.22 m x .61 m, and to a tongue centered on the headrope. The headrope, excluding the tongue, was 9.1 m and the footrope was 9.8 m. The body of the trawl was constructed of #9 twine and had 45 mm stretch mesh, while the codend tail-bag was constructed of #30 twine, and had 39 mm stretch mesh. A tickler chain attached to each door was positioned to drag over the bottom 0.9 m ahead of the footrope.

Trawls were towed for 20 minutes at 2.5 knots during daylight hours which was defined as 1 hour after sunrise to 1 hour before sunset. Because each state agency conducted the survey on board its vessel, there were some differences in effort for the three regions. Both North Carolina and South Carolina towed paired trawls while Georgia fished a single rig. The contents of each net was processed separately, and all fishes,

decapod crustaceans, stomatopods and cephalopods were sorted and weighed by species to the nearest gram. Fishes, blue crab, commercially important penaeid shrimp, and squids were measured individually to the nearest centimeter. For large catches, total number was estimated from total weight and weight of a random sub-sample which consisted of 30 to 50 individuals of each species that were measured. All other invertebrates were combined and a total weight noted for each collection. Although the contents of each net were processed independently, the catch per standard tow for North Carolina and South Carolina was defined as the combined catch from both trawl nets fished simultaneously at each randomly chosen site within a stratum.

The stratified random design was useful in that it allowed for calculations of variance and stratified mean catch per tow and use of parametric statistical analyses, other problems about sampling needed to be solved. The main problem was that sampling was being conducted on three different vessels by three different crews. This introduced considerable bias into the data. Because of scheduling and weather problems, there was some temporal separation among the sampling efforts with the result that sampling of North Carolina and Georgia extended over a longer time period and into colder weather than that off South Carolina. Although each research crew was composed of qualified biologists, levels and areas of taxonomic expertise differed among crews. The vessels themselves were very different from each other. The most obvious difference was that Georgia vessel which towed a single net. The South Carolina vessel was a 75 ft. St. Augustine shrimp trawler which was large to tow 9.1 m nets. The North Carolina vessel was a 50 ft. double-rigged trawler and was well suited to tow 9.1 m nets. These variables undoubtedly affected results from the first year.

The sampling design was modified in FY 1987-88 to reduce bias by conducting all sampling from the same platform. The South Carolina trawler Lady Lisa was chosen for the task because it was best suited for extended sea duty. The size of the paired Falcon trawls was increased to 22.9 m which was more compatible with the size of the vessel. On the 22.9 m trawl, the headrope, excluding the tongue, measures 22.0 m and the footrope was 22.9 m.

Three new objectives were included in the scope of work for Years 2 and 3 of the pilot study. Along with latitudinal difference, we also wanted to determine what the effect of location (inlet, beach offbeach) was on abundance, what temporal patterns of abundance might occur; and if differences in catch occurred between day and night. To incorporate a latitudinal gradient, four fixed stations were chosen, approximately equidistant, throughout the sampling region: off Bogue Banks and Bogue Inlet, near Cape Lookout, North Carolina; Long Beach and Lockwood Folly Inlet, near Cape Fear, North Carolina; Kiawah Island and Stono Inlet, near Charleston South Carolina; and Cumberland Island and Saint Andrews Sound Inlet, near Brunswick, Georgia (Fig. 2). so that locational differences in catch could

be evaluated at a station. The order in which the trawling sites were sampled at each station was determined by random selection. Samples were collected on cruises from August 10 through November 23, 1987 and from May through November 5, 1988. On each cruise, one sample was taken at each site per station during day and again at night. An index station located near the Charleston Harbor jetties was sampled at the beginning of each cruise leg.

Samples were taken and processed in the same manner as in Year 1, with the exceptions that primary sampling and analytical emphasis was placed on eighteen commercially and recreationally important species, which were counted, measured individually and the combined weight of each recorded. Beginning in May 1988, ovarian condition of female Penaeus, presence of spermatophores on male and female Penaeus, and presence and color of eggs on Callinectes sapidus was noted. The contents of the nets were sorted into taxonomic groups (elasmobranchs, cephalopods, stomatopods, bony fishes, decapod crustaceans, and miscellaneous invertebrates) and the combined weights as well as a species list were recorded for each group.

Conclusions from FY 1987-88 were:

1. A significant difference in mean biomass was found among stations with the Cape Fear station contributing significantly greater biomass than the others.

2. Mean biomass per tow for pooled station data declined until late fall, when there was an increase due to emigrations of sciaenids offshore.

3. Mean biomass per tow among trawling sites was not significantly different, although inlet sites tended to product slightly higher catches.

4. Night catches produced significantly greater biomass than day catches among cruises and stations.

5. A total of 155 species were collected during this survey with an average of 97 kg per tow.

6. Cluster analysis showed that group formation was related more to similarity in species composition among stations and cruises than to time of day.

Technical results for FYs 1986-87 and 1987-88 are available upon request. Requests may be sent to Dr. Elizabeth Wenner, Marine Resources Research Institute, Box 12559, Charleston, SC 29412.

After three years of the pilot study, the states in the southeastern region have agreed upon a final design. We will return to the stratified random design using inshore (4.6-9.1 m) and offshore (9.6-19 m) strata established from Cape Hatteras to Cape Canaveral by NMFS. The number of stations per stratum will

be determined by proportional allocation (and funding level). Inshore strata will be sampled in spring (April-May), summer (July-August), and fall (October-November), while offshore strata will be sampled in spring and fall. Sampling dates were chosen to target spawning populations of brown shrimp in fall and white shrimp in spring, as well as juvenile king and Spanish mackerel in summer. All sampling will be done at night.

State-Federal Northern Shrimp Survey

Stephen H. Clark

The Northern Shrimp Scientific (Technical) Committee has provided stock assessments and other information to the Northern Shrimp Section of the Atlantic States Middle Fisheries Commission (ASMFC) since 1974. From 1974- 1982 the Committee relied on two sources of survey data: a summer survey by the State of Maine and Northeast Fisheries Center (NEFC) spring, summer and autumn bottom trawl surveys. The State of Maine survey was basically an extension of earlier biological studies (Apollonio et al. 1986) to elucidate life history and distinction and relation to environmental factors.

While data from these surveys were useful in stock assessments neither set was wholly satisfactory. The Maine survey employed a small shrimp research trawl with a chain sweep which could be used in very few areas (the survey sampled only a dozen fixed stations). Thus, there was no flexibility for broad-scale sampling in response to industry needs, and the Committee was repeatedly criticized for the limited scope of the survey, the gear used, and perceived discrepancies between survey and fishery trends. The NEFC survey, which has employed general purpose groundfish trawls equipped with codend liners and a "stratified-random" sampling design has avoided the coverage problem and appears to have tracked resource trends reasonably well although considerable variability has been evident. Thus, neither survey has been adequate for refined sampling of this species. The need was for a survey designed specifically for Gulf of Maine conditions that could provide reliable information on trends in abundance, distribution, and biological parameters, together with reliable indications of future recruitment.

In the Spring of 1982, the Committee began work on a new research trawl in cooperation with the NEFC Fisheries Engineering Group at the Narragansett Laboratory with funding and other support provided by ASMFC and the National Marine Fisheries Services's Northeast Regional Office. Based on a review of trawl designs used in other areas and subsequent testing of two prototypes in 1982 and 1983 a modification of a west coast 4-seam design has been adopted and used in all surveys beginning in 1983. This trawl is constructed of nylon twine (1 3/8-inch stretch mesh in the body of the trawl and 1-inch stretch mesh in the extension piece and codend) with a 70-foot headrope and an 80-foot footrope. "Rockhoper" ground gear, consisting of rubber disks 9-14 inches in diameter, is used to permit sampling on rough bottom. Detailed specifications and other information are given by Blott et al (1983).

The actual survey has been run in early August of each year (beginning in 1983) aboard the NEFC's R/V GLORIA MICHELLE, a 65-foot, 96 gross ton (GT) stern trawler powered by a 365 HP

Caterpillar diesel. The vessel carries a crew of 4 and a scientific party of 6. Fieldwork is performed by Committee members and other biologists from the participating states (Maine, New Hampshire, Massachusetts) and the NEFC; data summarization, coding and analyses have usually been done by the NEFC. The survey is timed so as to provide coverage when mature male and female (age 2+) shrimp are fully available to the gear and certain biological characteristics (e.g., those differentiating "first" and "second" spawning females) can be distinguished.

A stratified random sampling design is used, requiring stratification of the western Gulf of Maine region. The survey area is divided into 12 strata bounded by 68 0 W longitude to the east and the 50-fathom contour to the west, with the exception of the Massachusetts Bay-Stellwagen Bank areas where the survey region extends inshore to the 30-fathom contour. For the remaining areas, two principal depth zones are recognized: 50-100 fathoms and >100 fathoms. As for NEFC bottom trawl surveys, stratification is based primarily on depth, latitude/longitude, and historical fishing patterns. Stations are allocated to strata roughly in proportion to area and are assigned to specific locations within strata at random; with the provision that intensity is doubled in strata known to harbor large concentrations of shrimp. Between 50 and 60 tows have been taken on most surveys.

Standard NEFC sampling procedures are followed. At each station, hydrographic data are recorded and a 15-minute tow taken at a vessel speed of two knots. Sampling is confined to daylight hours to compensate for diel changes in availability. Catch weights in kilograms (kg) of pandalid shrimp, finfish, and key invertebrate species (e.g., scallops) are recorded, and length frequencies collected for selected finfish species as time permits. Sub-samples of selected fish species are also examined for food habits data. A 2-kg sample of pandalid shrimp is retained for determination of species composition and (for northern shrimp) length measurements and sex/spawning stage determinations. All northern shrimp in the sample are measured (mid-dorsal carapace length to nearest 0.5 mm below) and determinations of sex made for a 1-kg sub-sample. Results are summarized in a detailed report e.g. Northern Shrimp Technical Committee (MS 1987) and used in subsequent assessment workshops and for biological research.

With the completion of the Summer 1988 survey cruise 6 years of data are now available; and from evaluations of these data in relation to fishery trends it would appear that the survey has been entirely successful in meeting its objectives. The major success story involves detection and monitoring of the strong 1982 year class, which appeared at age 1 in the first summer survey cruise and dominated survey catches in subsequent years. With the survey data, the Committee has been able to make accurate inferences concerning future resource conditions and

effects of exploitation and has gained considerable credibility with industry as a result. The Committee plans to continue this survey on an annual basis in future years; time and funding permitting. Work with submersibles and acoustic measuration gear is planned for Summer of 1989 to further evaluate gear performance and efficiency. The most recent survey results reveal the presence of the apparently strong (1987) year class which will be closely monitored in future survey work.

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State Programs

The presentations of the coastal states on their trawl survey activities underscores the wide diversity of habitats and fish stocks found from Maine to Florida. This diversity highlights a basic problem faced by any fishery scientist conducting a trawl survey. The problem involves accommodating sampling practices to variations in habitat and target fish species. Thus, the following reviews of trawl survey programs encompass a great variety of gear types and sampling protocols, and include comments on the benefits and limitations in using different techniques.

State of Maine Groundfish Survey

Richard W. Langton

In 1978 and 1979 the state of Maine conducted a groundfish survey as part of the Fisheries and Development Project of Maine's coastal zone program which was administered by the Maine State Planning Office. The bottom trawl surveys were modeled after the National Marine Fisheries Service groundfish surveys in the Gulf of Maine and it was anticipated that these surveys would develop a time series of data on the relative abundance and distribution of the important finfish occurring along the Maine coast. Tagging work for selected species was included in this program as well as collection of biological data such as age and growth information and stomach contents data. Unfortunately these surveys were not continued due to loss of funding. Nevertheless, the preliminary results of these studies are reported in a completion report to the Maine State Planning Office (Walton, 1979) and the raw data is in the DMR computer data bank.

The State of Maine acquired a new research vessel in 1988, the ARGO MAINE. This vessel is an 85 foot boat that was obtained from the National Science Foundation by the Association for Research in the Gulf of Maine. The boat is owned and operated by the Maine Maritime Academy for the institutions making up the ARGO MAINE consortium. The Maine Department of Marine Resources is currently fitting out the vessel to conduct groundfish research in the Gulf of Maine. We have purchased and installed two single drum winches that accommodate 200 fathoms of three-eights inch cable. This will give us the capability to fish throughout the Gulf. At the present time we are also having trawl nets constructed and will initiate a series of experimental tows this fall and winter. The trawls are 3/4 whiting nets based on the design used by the state of Massachusetts on their groundfish surveys.

The survey design has not yet been finalized. However, based on previous experience, as summarized above, a stratified random sample design is not realistic. It is therefore likely that fixed stations will employed. To date, we have done some sidescan sonar survey work as well as sampling with a Smith-McIntyre grab to characterize potential trawl sites. Our choice of stations has been based on data collected by the National Marine Fisheries Service port agents as well as an old (1929) report by Walter Rich which describes the fishing grounds of the Gulf of Maine.

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State of Massachusetts Inshore Bottom Trawl Survey

Arnold B. Howe

Abstract : Strengths of the 11-year Massachusetts inshore bottom trawl survey program include its synoptic, seasonal coverage of the study area, intensive sampling effort (1 station/19 sq n mi), consistently used trawl gear, and standardized survey procedures and methods. The data provide an integral portion of NEFC fishery resource assessment data base. Reviewed are survey net and vessel selection considerations, adapting stratified random sampling to a relatively unfamiliar seabed topography, a change in survey vessels, shifting gear maintenance responsibilities, and integrating MSMF and NMFS survey differences and needs with respect to data coding, auditing, and data analysis. Operational difficulties center on gear conflicts, early haulback considerations, and a gradual trend toward preemption of towable bottom by commercial fixed gear. The latter threatens the integrity of the data base and the obvious solution has proven difficult to implement.

Since 1978 standard spring and autumn bottom trawl surveys of Massachusetts inshore or territorial waters have been conducted by the Resource Assessment Project, Massachusetts Division of Marine Fisheries (MDMF) in cooperation with the Northeast Fisheries Center (NEFC). The purpose of this ongoing daytime survey was to obtain fishery-independent data on the distribution, relative abundance, and size composition of finfish and certain crustaceans and mollusks. Data collected on the surveys have been used for management purposes, biological studies, and to evaluate impact of alterations to nearshore habitat. Information on abundance of pre-exploitable fish has been especially valuable in establishing state fishery regulations and evaluating regulatory proposals. With the data integrated into the NEFC data base, National Marine Fisheries Service (NMFS) scientists have incorporated it into assessments of certain stocks.

Otter trawl sampling was based on a stratified random design using depth strata (<30', 31-60', 61-90', 91-120', 121-180', and >181') and a loran-based grid (about 1.0 sq n mi). The study area was divided into five physiographic regions which, in turn, were subdivided into 23 strata. For each survey, about 100 stations are allocated to strata approximately in proportion to the area of each stratum. No stratum was assigned less than two stations in order to provide an estimate of sampling error (variance). Specific sampling sites within grid units are chosen at sea on the basis of bottom type and distance from fixed gear. For 22 surveys, 2,277 sets have been attempted and 2,096 stations completed. On average, 95 stations are made per cruise or one

station for every 19 square nautical miles.

During the early years, when we were learning the location of suitable bottom for trawling, unbiased station selection was achieved by having the vessel captain continually search for towable bottom. Usually a tow was attempted on first encountered "good bottom" within a stratum. By maintaining "master charts" with all previous station plots, repetition of prior cruise station tracts was minimized and knowledge of the sea bottom in the study regions enhanced. After the initial 10 surveys, grid sites in all strata sets but one were generally determined prior to departure. Within Massachusetts Bay however, limited towable bottom coupled with extensive seasonal commercial fixed gear fields has practically precluded utilizing predetermined random sampling sites.

Sampling gear consists of a 3/4 North Atlantic type two seam ('whiting') trawl (39' headrope/51' footrope). Net mesh varies depending upon the section (3.5", 2.5" ,1.5"), and there is a fine mesh (0.5" stretch) codend liner. The trawl is rigged with a rubber disc (3.5") chain sweep, rectangular wooden doors (6' X 40", 325 lbs), and 10 fathom wire top legs and chain bottom legs. Twenty-minute tows are made along depth contours, generally against current, at a speed of 2.5 knots with a towing warp scope of 3:1. Trawl mensuration efforts using a third wire package have indicated a fishing height of 1.5 m and wingspread of 8.5 m. The 1988 prices of unassembled net sections plus sweep and a fully rigged net is about $1,500 and $3,000, respectively.

The net design and size were selected because of its known fishing efficiency for pelagic species in Great Lakes research vessel surveys and for mixed groundfish and flounders in the Middle Atlantic Bight. Additional considerations favoring this net included its adaptability to small-and medium-sized (0-150 GRT) New England draggers. Because of its size and weight, it can be handled and operated by two fishermen. Light nylon twine allows the net to tear free of hang-ups rather than snag thus minimizing gear loss. Small mesh size prevents gilling of dogfish with consequent time and labor advantage. Average catches in a standard 20-minute set do not overtax biological processing capability.

There are two problems with the 39/51 research trawl. Net sections are occasionally difficult to obtain because of minimal demand. Tear-ups are common, necessitating the availability of fishermen skilled in net mending. On the early cruises, 10-17 stations/cruise were aborted because of hangs and/or tear-ups with 15-35 man-hours required to repair nets at sea. Now 4-8 aborted stations/cruise is normal and less than 10 man-hours required for mending. Because present crew members are less skilled at mending, the survey vessel carries four complete nets and spare net sections to expedite operations. After each survey has concluded, major repairs are undertaken ashore by the MDMF research vessel captain. Headropes and footropes are measured,

sweep chains inspected for wear, and all necessary net repairs are made.

The F/V Frances Elizabeth, a 55' stern trawler (36 GRT, 170 SHP), was chartered for the first eight surveys. Major considerations favoring this vessel included its cost, relative seaworthiness and deck space, Loran C, and not to be underestimated, the fishermen's experience and empathy for the scientific mission. By consulting with the Massachusetts Inshore Draggermen's Association in the planning process and then chartering a respected member's vessel, the program acquired immediate credibility with commercial fishermen.

During 1982, escalating charter costs (due primarily to a more than doubling in diesel fuel price) coupled with substantial budgetary cutbacks for the agency, nearly terminated the survey. Fortunately, NMFS reaffirmed their commitment to the program by permitting MDMF to charter the R/V Gloria Michelle at reasonable cost. Following NMFS's acquisition of the 65' stern trawler (96 GRT, 355 SHP) from U.S. Custom Agents, it was refurbished and staffed by the Fisheries Engineering Group.

Changing vessels led us to consider differences in the vessels' fishing power, gear handling and maintenance. Serving as a consultant on the first Gloria Michelle cruise, the owner/skipper of the Frances Elizabeth was most helpful in achieving the transition. The R/V Gloria Michelle was able to "down power", without loss of control, to the lighter gear more properly suited for a vessel with less power and displacement. Gear performance trials undertaken aboard the first vessel in 1981 and on the R/V Gloria Michelle in 1983 showed identical average fishing height and wingspread. A comparative fishing study between the two vessels was not undertaken because of budgetary and time considerations. Because the R/V Gloria Michelle is larger than the Frances Elizabeth and equipped with bilge keels that serve to stabilize the vessel, we are rarely weathered-out -- whereas prior to 1982, an average of five days were lost per cruise due to weather or crew fatigue.

Fourteen surveys have now been conducted using the R/V Gloria Michelle. About 200 hours of sea time are required per survey for an average of 11.5 hrs/day, dock-to-dock. To insure maximum catch processing efficiency and adherence to sampling protocol standards, two of the four project members plus one volunteer from within MDMF participate on a daily basis. Scientists from other agencies and institutions occasionally take part. The MDMF devotes an average of 598 staff hours to each survey. Seventeen sampling days involving seven ports-of-call illustrate the importance of personnel scheduling and vehicle logistics in cruise planning.

Surveys are conducted over the same time span during the months of May and September, periods that approximately coincide with the seasons when principally important species' adults or their progeny are inshore. Catch parameters reflect, in part, this seasonality:

	Spring	Fall
Mean # Species/Cr.	69	86
Mean # Species/tow and range/Cr.	16 (4-28)	17 (1-33)
Mean Catch Weight (kg)/Cr.	18,408	23,340
Mean Catch Number/Cr.	88,169	204,049

About six sets are attempted per sea day. Hydrographic data collected at each station include surface and bottom temperatures and surface salinity. Standard survey protocol is followed in sorting and processing the catch. These operations, including sub-sampling procedures, have been described in a "Watch Chief's Guide" that is available upon request. Data are recorded on the standard NMFS "trawl log". As time permits, special biological sampling is undertaken according to priority: 1) requested special collections; 2) age, growth, maturity; and, 3) external pathology. A total of almost 117,000 specimens or an average of 56/station has received some form of special attention and handling. In recent years, changing MDMF priorities have led to extensive examination and preservation of fish livers for histopathological study. Live tank studies aboard ship have also been undertaken to study survivability of softshell/trawl damaged lobster and sublegal-length flatfish. These studies illustrate other possible initiatives that may also be undertaken as part of survey operations.

Within several weeks of cruise completion, trawl logs are finalized and coded for computer processing. Coding details are described in a MDMF "Trawl Log Coding Manual", available upon request. Major differences in trawl log coding between MDMF and NEFC are our expansion of short tows to a 20 minute standard and modification of certain data fields to accommodate our needs. Trawl logs are submitted to NEFC for entry onto the Woods Hole Oceanographic Institute's VAX computer. Concurrently, station information and special sampling data are tabulated as part of a "Preliminary Cruise Result Report" that is forwarded to individuals/agencies receiving samples or data. Tow locations are plotted on "master" nautical charts. Shortly, we hope to utilize developed software to accurately plot tows directly onto nautical charts of any scale.

After data entry at NEFC, the resulting data files are audited by us to check for errors. Stratified mean weight and number for each tow, stratum, region, and cruise; and length-

frequency analysis for each stratum, region, and cruise by species are produced using the NMFS survey analysis program. These data are then run through our report generating programs to turn out report quality tables for an annual report. Since 1985, assessment emphasis has been placed on seven of the state's most important fisheries resources (i.e., Atlantic cod, yellowtail flounder, winter flounder, summer flounder, scup, black sea bass, and long-finned squid). Utilizing the time series of survey information, we have generated indices of stock abundance and recruitment and compared them to commercial landings data from state territorial waters (0-3 mi) in order to annually update the status of inshore fishery resources. Survey abundance indices tend to reflect, if not actually mirror, trends in commercial catch validating the survey data base.

There are three operational difficulties. Avoiding gear conflicts with commercial fishermen, (often in regions seasonally or permanently closed to mobile gear fishing), has been a longstanding problem. Before each survey we alert the industry of our intentions and the Division of Environmental Law Enforcement to our survey itinerary. We usually avoid areas where the fishing industry has set fixed gear; however, because gear is often inadequately marked, it may be inadvertently intercepted. We return repairable "ghost" pots and compensate fishermen for damaged gear. Recently implemented MDMF fixed gear marking standards that must be met by April, 1989 should help reduce gear conflicts.

Non-randomness in station selection due to preemption of bottom by commercial fixed gear has been a concern over the last three years. Increasing amounts of fixed gear (lobster, fish and conch pots and gillnets) and changing deployment patterns of fixed gear have forced us to either relocate predetermined stations or lose up to four strata in Massachusetts Bay. Either way, we are now being denied access to specific habitat formerly sampled (e.g., spring access to a significant shoal spawning area in Nantucket Sound utilized by black sea bass and other species). We have attempted to deal with these developments by following-up a Massachusetts Lobstermen's Association suggestion to request specific fishermen to temporarily remove gear on a specified day allowing us access to selected towable areas. Failing to respond to newsletter pleas, attempts at identifying these individuals, most of whom fish 25-pot trawls, were largely unsuccessful. On the day of scheduled tows, no fishermen showed despite VHF broadcasts. Another written and verbal request for the temporary lifting of fish pots on designated stations in Nantucket Sound was complied with by at least several fishermen but not by enough for us to risk a set without possibly damaging gear still present. In this case, fishermen appeared to be more cooperative so we will try again next spring - this time buoying sites ahead of time.

Always problematical is the representability of the catch from a set that deviates from the 20-minute standard. Reasons

for early haul-back and the consequent high percentage of short tows in MDMP surveys include: bottom configuration, situations that affect vessel heading and steerage, indications of fixed gear, and the presence of large schools of spiny dogfish. Ordinarily, if a tow lasts at least 13 minutes before haul-back (conforming to NMFS percentage standard), the station is counted, assuming that any net damage is within specified tolerances.

There is one situation in which a tow less than 13 minutes is acceptable. Heavy concentrations of spiny dogfish often necessitate an early haul-back. We have found that keeping the trawl nets intact while attempting to get bulging catches (sometimes extending to the sweep!) aboard ship was usually hopeless, frustrating and unacceptable in terms of lost time and net damage, and not without potential danger to the crew. A practical approach involved monitoring headrope (fish) sensor or white-line and chromoscope read-out to estimate cumulative catch, and then accordingly shortening tow time to obtain manageable but representative catches of dogfish. On the 1988 fall survey, reasonable gear preservation was achieved but at a sacrifice of 17% of overall tow time occurring over 40% of completed stations. Furthermore, species expansions may be unrealistic relative to net capacity.

This program has always been partially funded through the Commercial Fisheries Research and Development Act (P.L. 88-309), now the Interjurisdictional Fisheries Act (P.L. 91-659) of 1986 under project 3-IJ-3. Current plans call for the indefinite continuation of the survey series.

Rhode Island Bottom Trawl Surveys

Timothy R. Lynch

In 1968, the Division of Fish and Wildlife began monitoring fish populations at four stations in Narragansett Bay. This continued through 1977, and provided monthly identification of finfish inhabiting the bay. As commercial and recreational harvests increased, the need for accurate stock assessments became increasingly apparent. To this end, the Rhode Island Division of Fish and Wildlife initiated a comprehensive coastal fishery resource assessment on April 1, 1979. Funding for this program was provided through Public Law 988-309 and is presently seeking continuation through the Interjurisdictional Fisheries Act. To date, ten years/20 seasonal sets of abundance and biomass data exists.

A stratified random design was employed in the allocation of sampling stations in each of eleven depth stratum located within Rhode Island territorial waters. A grid system (0.25 sq. na. mi.) was established and stations were randomly selected. At each station, a 3/4 scale 340 High Rise bottom trawl was towed for twenty minutes at an average speed of 2.5 knots. This is accomplished utilizing the Division's 42' research vessel, the Thomas J. Wright. Lengths and weights are recorded at each station for all finfish, squid, skate, and lobster. Lobsters are also identified as to sex. In addition, air and water temperatures, wind speed and direction, sea condition and depth, and cloud cover are recorded. Indices of relative abundance and biomass are expressed as stratified mean number and weight (kg) per tow.

Since its inception, the realities of operation, namely untowable bottom, have facilitated modifications to the sampling universe. Between 1979 and 1986, the sampling universe in Narragansett Bay, Rhode Island Sound, and Block Island Sound was modified three times. In addition, (and far more important for data continuity) the validity of a stratified random design for Rhode Island and Block Island Sounds had become questionable.

Discussions at various Stock Asseesment Workshops (SAWs) centered on the desirability of stratified random allocation and it was concluded that (in many cases) the necessity and practicality of a fixed allocation scheme is real. Discussion of the validity of incorporating data derived from a fixed allocation with that of the existing stratified time series left assurance that this approach is feasible.

The trawl survey was modified once again in 1988 to incorporate a fixed allocation scheme in Rhode Island and Block Island Sounds while Narragansett Bay remained stratified random. The methodology employed in the allocation of fixed stations was based on the frequency of replicate stations per stratum since

1979. In the case of Block Island Sound, priority was given to those stations that were located within the discharge plumes of adjacent coastal ponds. It is anticipated that this allocation scheme will remain as the basis for a continued assessment.

To augment this survey, a coastal ponds survey was initiated in 1987, and incorporates the Little Narragansett Bay/Pawcatuck River Estuary and the South County coastal ponds. In addition, a similar survey is planned for the Narrow River and Estuary. Both surveys utilize (where possible) skiff trawls, fyke nets and gill nets to assess finfish populations. With reference to Narragansett Bay, a juvenile beach seine survey was initiated in 1986. As these data bases broaden with time, integration of these data sets with that of the "trawl" survey, should prove most beneficial in gaining a better understanding of the finfish resources of Rhode Island and Southern New England.

State of Connecticut Marine Finfish Bottom Trawl Survey

Penny Howell

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

Methods

The survey has been conducted since 1984 using a combination sweep net (30 ft. headrope, 46 ft. footrope, two-seam tapered net with 2 inch codend - all stretched measure) to sample all unobstructed ground within Long Island Sound (Greenwich to New London and the Race inclusive of New York waters). Forty 30 min. tows are taken each month, stratified by depth and bottom type, from April to November, for a total of 320 samples per year. This sampling design yields variance-to-mean ratios (CV) of 8-25% for the 15 most abundant species. Statistically, the present level of sampling effort permits the detection of a 9% difference in true annual mean abundances, with a 5% error rate, with CV's of 25%. It is also intensive enough to permit decomposition of the data by month or area, a procedure often required to address regulatory questions for single species.

Bottom strata are delineated into mud, sand, and mud/sand transition using criteria established for the NOAA Environmental Baseline Survey of Long Island Sound (Reid et al. 1979). Verification of bottom sediment type also was done at selected sites with a van Veen bottom sampler. Depth strata are in 30 ft. increments from zero to greater than 90 ft. Trawl sampling intensity is one station per 20 sq. nautical mi. Trawl stations are allotted to each of the 12 areal strata (4 depths x 3 bottom types) according to the area in each stratum divided by 20, with a minimum of two stations per stratum. Known obstructed ground and stratum areas less than the sample unit (1 x 2 n. mi. square) were eliminated. Within each stratum, sample stations were selected randomly. All samples are taken during daylight hours.

Fish taken in trawl samples are divided into three categories for processing: 1) Species heavily exploited by the sport and commercial fisheries-blackfish, bluefish, scup, summer flounder and winter flounder-are counted, measured to length, and hard parts for aging taken from a random sample (<50); 2) Species that are principal forage fish-butterfish, weakfish, squid, and windowpane flounder-species are counted and length measured from a random sub-sample (<50)y 3) Untargeted species, which make up only incidental sport and commercial by-catch, are counted. All length frequencies are expanded to the entire catch, and hard parts aged generating an age frequency of the catch. Bottom water temperature and salinity are also measured at one site per stratum (depth x bottom type x month) as time and weather permit. Lobster carapace length, sex, and shell condition is recorded for

assessment by other agency biologists.

An abundance index (geometric mean number per standard tow) is calculated for each species taken annually, and by month for the 25 most abundant species.

Variance component analysis of the 1984 and 1985 data for the 25 most abundant species showed that an average of 22% (range 2-57%) of the variation in the catch of each species was attributed to month of sampling. An average of 9% (range 0-50%) of the variance was explained by bottom sediment type, 5% (range 0-24%) by depth, for a total of 36% (range 8-60%). Therefore, it appears that temporal rather than spatial factors are most important in determining the abundance of most species in the catch. Changes in the degree of contagion, or patchiness, through time appear to have an important effect on the availability of a given species to trawl gear. Infrequent sampling through time would greatly reduce the reliability of each year's index.

New York Juvenile Finfish Trawl Surveys

Alice Weber

In July of 1985, the New York State Department of Environmental Conservation initiated a small scale trawl survey in the Peconic Bay estuary, located on the eastern end of Long Island. This trawl study began as a direct result of research recommendations included in the Atlantic States Marine Fisheries Commission's Fishery Management Plan for Weakfish (Mercer, 1985). The plan recommended that each state participating in the weakfish plan "develop a recruitment index and examine the relationship between parental stock size and environmental factors on year class strength". The Peconic Bay study, originally designed to assess the production of young of the year weakfish, was later expanded to include the collection of fisheries data on all finfish species (primarily juveniles) available to the trawl gear. Since the spring of 1987, catch per tow as well as length frequency data has been collected from over 50 species of fish inhabiting the Peconic Bay system. In addition to the fisheries information, environmental data (salinity, dissolved oxygen, water temperatures, and secchi disc readings) are also recorded at each of the approximately 400 trawl stations sampled each year.

It is expected that information collected from this survey can be used not only to describe the occurrence, distribution, and relative abundance of juvenile fishes inhabiting Peconic Bay, but can also provide us with the much needed baseline environmental data so lacking from previous surveys of New York's inshore waters. While it is too early to assess the accuracy or reliability of recruitment indices derived from this survey, it is anticipated that indices will be developed for such target species as weakfish, winter flounder, bluefish, and scup.

Methods

The Peconic Bay system was chosen as the study area because of its relative importance as a major spawning and nursery area for weakfish in New York waters (Perlmutter, 1938), as well as for the fact that historically this area accounts for over 60 per cent of New York's commercial landings of weakfish. Peconic Bay has also long been regarded as a popular location for recreational landings of weakfish in New York.

The Peconic Bay study area is a series of shallow, interconnecting bays approximately fifteen miles long and six miles at its widest point. Water depths generally range to 30 feet in depth, but some sites include depths to 90 feet. To sample the study area, a simple block grid system was chosen as a means of providing uniform sampling areas. The grid was superimposed over a map of Peconic Bay, with each block corresponding to 1' latitude by 1' longitude, except where it overlaps land. Each of the 77 blocks was consecutively numbered

beginning at the northernmost point. Each week, from May through October, fifteen to twenty stations are randomly chosen and sampled by otter trawl during daylight hours only. Tows are contained within the chosen sampling block by monitoring Loran C coordinates while underway. If a selected tow site is abandoned due to hangs or other debris, a nearby site within the same sampling grid is chosen and the tow is redone.

The trawl net used in this survey is a 16 foot Marinovich semi-balloon trawl made of nylon netting (1.5 inch stretch mesh in the body and 1.25 inch stretch mesh in the cod end) with a 0.5 inch stretch mesh codend liner. This net was chosen because it is comparable to ones being used by other states participating in efforts to assess weakfish young of the year abundance. The rigging consists of 12 by 24 inch doors attached to 200 feet of 3/8 inch nylon tow lines. The trawl net is towed by a 35 foot Bruno Stillman, with tow speeds averaging approximately two knots during each 10 minute tow.

All fish caught in each tow are sorted, identified, and measured to the nearest millimeter (fork or total length). Due to sampling constraints, some baitfish species such as anchovies and silversides were not recorded in the first year of the survey (1985), nor was any environmental data collected. Large catches are generally sub-sampled, with length measurements taken on 30 randomly selected individual fish of each species.

Results

To date, almost 1,000 tows have been completed within the Peconic Bay study area during three years of survey work. Over 200,000 fish have been collected, consisting of 53 species representing over forty families of fish. Catches are usually dominated by "baitfish" or forage species such as anchovies, silversides, and juvenile herrings. Other species that have been caught in relatively large numbers include the winter flounder, scup, windowpane flounder, bluefish, and smooth dogfish. The 1988 collections were marked by large increases in the numbers of bay anchovies, Atlantic silversides, herring species, and American sand-lance, as well as notable increase in the numbers of butterfish, northern puffer, and rough scad. This dramatic increase in the total finfish catch per tow for 1988,which was driven primarily by the large numbers of bay anchovies collected in late summer and early fall, may be related to the absence of the 'brown tide' organism (Aureococcus anorexefferens) which has bloomed in Peconic Bay since 1985.

The catch per tow of young of the year weakfish has shown a downward trend since the inception of the trawl survey in 1985. Young weakfish first appear in the survey's trawl collections in late June or early July, and remain available to the trawl gear until mid-October. The seasonal peak in catch per tow of young weakfish in Peconic Bays has occurred progressively later in each year of the survey. In 1985 catches peaked in July, in 1987 in

August, and for 1988 the highest catch per tow of weakfish occurred in September. The young of the year recruitment index derived from the trawl survey data will be compared to indices of adult weakfish year class success. Adult indices are being developed from commercial pound net and ocean haul seine catch/effort and age composition monitoring programs currently underway.

References

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New Jersey Trawl Surveys

Donald M. Byrne

Introduction

The State of New Jersey requires accurate, reliable information on the occurrence, distribution, and relative abundance of marine recreational fishes to wisely manage these species in the coastal waters of the state and to actively participate in the management of these species on an interstate and national basis. New Jersey has never assessed the fisheries resources of its coastal waters although surveys of fishermen have determined that important fishing grounds exist along our shores.

The current stock assessment program is an effort to satisfy these requirements and collect fisheries data on important marine habitat. Program objectives include the following:

1. To develop a comprehensive baseline of data for coastal recreational fishes and their forage items.

2. To develop recruitment indices for recreational fishes and document annual relative abundance of young-of-year fish.

3. To provide a scientific basis to formulate or modify existing management plans for recreational fishes.

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

Efforts during the first year of this program consisted mainly of survey preparation and included mapping the survey area for sampling purposes, the charter of a survey vessel, the development of trawl net specifications, the purchase of trawling gear, and the purchase or construction of the numerous equipment and supply items required for an ocean trawl survey. No survey sampling was conducted during the 1987/1988 program year. This was a consequence of both program retro-funding, in which funds were approved November 25, 1987 but with an effective starting date of July 24, 1987, and as a consequence of the slow purchasing procedures practiced by the New Jersey Department of Treasury. A one day shakedown cruise was accomplished, however.

Survey Area and Sampling Methods

The survey area consists of New Jersey coastal waters from Ambrose Channel, or the entrance to New York Harbor, south to Cape Henlopen Channel, or the entrance to Delaware Bay, and from

about the 3 fathom isobath inshore to approximately the 15 fathom isobath offshore. This area was divided into 15 sampling strata. Latitudinal strata boundaries are identical to those which define sampling strata of the National Marine Fisheries Service (NMFS) for their Atlantic groundfish survey. Exceptions were those strata at the extreme northern and southern ends of New Jersey. Where NMFS strata extended into New York or Delaware waters, boundaries were drawn which truncated these strata to include only waters off New Jersey. Longitudinal boundaries consisted of the 5, 10, and 15 fathom isobaths. Where these bottom contours were irregular, stratum were not identical to the corresponding NMFS boundaries.

Each stratum was divided by grid lines into blocks which represent potential sampling sites; each block was identified by a number assigned sequentially within each stratum. The dimensions of mid-shore (5-10 fath) and offshore (10-15 fath) blocks were 2.0 min long x 2.5 min lat; inshore (3-5 fath) blocks were 1.0 min long x 1.0 min lat. Inshore blocks were smaller because inshore strata were generally narrower and smaller in area than mid- and offshore strata. This small block size permitted a greater number of potential sampling sites than would be possible with dimensions of 2.0 min long x 2.5 min lat. This is important relative to statistical analysis of the data and follows the strategy devised by NMFS for their groundfish survey. Dimensions of blocks transected by stratum boundaries are less than above; and any blocks reduced in area by more than one-half were generally not assigned a number.

Sampling sites will be determined by blindly picking disks numbered to correspond to stratum blocks and mixed to assure randomness. Initially three sites will be sampled in each inshore stratum and two sites in each mid- and offshore stratum; this may be revised once sampling cruise experience is obtained.

Reduced nautical charts showing sampling strata and grid blocks are included in a jacket attached to the end of this report.

Survey Vessel

A New Jersey commercial fishing trawler, the Amy Diane, has been chartered to conduct trawl sampling. The Amy Diane is a steel-hulled 81 ft stern trawler with a 600 hp diesel engine, 6:1 gear reduction ratio, and a single 72 inch diameter propeller. The vessel's captain has over ten years experience trawling in coastal New Jersey waters and elsewhere; is familiar with bottom conditions relative to trawling along much of the New Jersey coast; and is expected to be an important asset to the survey.

Survey Gear

A fisheries engineer with the Sea Grant Program of the

Massachusetts Institute of Technology, Cliff Goudey, was retained to provide trawl net specifications for the survey. Specifications were developed based upon the power of potential survey vessels, which included horsepower, gear reduction ratio, and propeller diameter, and target species, which included summer flounder, winter flounder, weakfish, bluefish, tautog, black sea bass, young-of-year fishes, and forage fishes. We basically desired an all-purpose net that would provide us with representative samples of the total bottom-dwelling fish fauna, both demersal and epidemersal fishes.

Mr. Goudey provided specifications for a version of the three-in-one trawl used by some New England fishermen. We accepted this as our standard sampling gear. Features of the trawl included a footrope of approximately 100 ft, a headrope of about 82 ft, 3 inch mesh throughout most of the body, a 0.25 inch mesh codend liner, and a rubber cookie sweep. The trawl doors were wooden New England style. Some modifications of the specifications may be made by the net maker contracted to construct the trawl. The complete specifications are available upon request.

Shakedown Cruise

A shakedown cruise was performed June 30/July 1, 1988 to permit survey biologists to familiarize themselves with the constraints of the survey vessel relative to sampling requirements and procedures, and to permit the survey vessel crew to acquaint themselves with sampling operations and the biologists. Because standard sampling gear was not yet available, this cruise employed one of the commercial trawls used by the vessel. One 30 minute tow was performed, and at the start of a second tow the gear became caught on a bottom obstruction and was severely damaged. This terminated the shakedown cruise. Although only one tow was performed, the trip was successful in that most sampling setup and procedure problems were addressed.

Future Objectives

Future objectives are the same as those listed in the introduction. In August 1988, the standard trawl gear for the survey was obtained in total and a full coast-length cruise was accomplished between August 18 and September 2, 1988. Five more cruises have been scheduled during the remainder of the 1988-89 program year and their results, together with those of the August 1988 cruise, will be presented in the next annual report.

Delaware Bottom Trawl Surveys

Richard J. Seagraves

In 1977, the Delaware Division of Fish and Wildlife began conducting a survey of the Delaware River Estuary nursery area to assess annual production of juvenile blue crab utilizing a 4.9-m otter trawl. In 1980, this program was expanded to include catch frequency data of juvenile fishes to determine their relative abundance, temporal and spatial distribution, and where possible, as an indicator of year class strength for selected species.

A 4.9-m (16-ft.) semi-balloon otter trawl is towed monthly from April through October at 35 fixed stations in the western portion of Delaware Bay. Sampling is conducted aboard a 7-m aluminum hull boat powered by a 165 hp I/O. Each sample consists of a ten minute tow usually made against the prevailing tide. After each tow is completed the catch is sorted by species and all are enumerated. A random sub-sample of 30 individuals of selected species are measured. Standard hydrographic collections are made at each station.

Data reduction includes monthly and annual summaries of catch data including number of species taken, total number taken by species, and mean number taken per ten tows for each species. Length frequencies are constructed for selected species. The most recent survey results or references to previous work may be found in Cole et al. (1988).

In 1966, Delaware initiated a bottom trawl survey designed to determine the temporal and spatial distribution and relative abundance or selected fish species in Delaware Bay (targeted primarily as adults). Sampling was conducted monthly with an 8.5-m (28 ft.) otter trawl until sampling was terminated in November 1971. In order to develop a more comprehensive data base for stock assessment purposes, a similar but expanded monthly fish trawl survey was begun in 1979. Sampling in the more recent survey continued until 1985 but was discontinued due to the lack of an adequate research vessel.

In both surveys Delaware Bay was divided into five minute sectors of latitude and longitude. A systematic sample design was employed at ten fixed stations. Station locations were chosen based on bottom depth, topography and the absence of obstructions. In the 1979-84 study, a small-mesh liner was inserted in the cod end during September to sample young-of-the-year fish.

Sampling in each sector consisted of towing an 8.5-m (28') otter trawl for 30 minutes (1966-71) or 20 minutes (1979-84). Average tow speed was 2.4 knots during 1966-71 and 2.9 knots from 1979-84. The trawl used had 76-mm stretch mesh in the wings and body and a 51-mm mesh in the cod end. In September a 25-mm liner

was inserted in the cod end. The gear was towed from a 42 or 47-ft. stern trawler operated by the University of Delaware. Standard hydrographic collections were made at the end of each tow.

After each tow, the catch was dumped on deck and sorted by species. During the 1979-84 survey each species group was weighed to the nearest 50 g and counted (no weight determinations were made in the earlier work). Out of each species group, a random sub-sample of 50 individuals (all if less than 50 were taken) were measured. All data collected were coded and are presently stored on magnetic tape. A summary of results for both surveys was given by Smith (1988). A proposal was recently submitted for Wallop-Breaux funding to resume monthly sampling using the same gear beginning in the fall of 1989.

Maryland Chesapeake Bay Trawling Project (CHESFISH)

Madhusudan Bhandary,

Introduction

CHESFISH is a 5-year trawling project. The main purpose is to develop statistical methodology as well as operations research techniques to have a quick idea about estimating standing stock abundance in an optimal cost-efficient way. The research started in 1988. The program of research in the first year is to have a pilot study in order to identify efficient trawling gears, to utilize sources of variability associated with trawling, to construct spatio-temporal distributional maps for selected species, to have a preliminary analysis of northern Chesapeake Bay historical trawling data and the development of a multidimensional spatio-temporal catch model for use in the sampling expert system.

The research plan for the second year will be to find out from the past data some optimal points of locations where we can get maximum catch of fish with greater confidence for some species and then to build up an optimal routing of these points in a cost-efficient way by the techniques of operations research. Finally, a sampling design will be identified and then integrated with the computer expert system.

Efforts in the third year will be spent on building the expert system baywide. The fourth year and fifth year will be spent on developing statistical models and components of operations research baywide.

Summary of 1988 Research

Up to September 19, 1988, 533 trawls have been conducted. A total of 124,604 fish (and 6,172 blue crabs) have been caught comprising of 44 species. The Wilcox high-rise net was considered to be the most efficient trawl in the sense that it has more fishing power. During this experiment we have taken into consideration the following variables which contributed to the biomass caught 1) depth of water, 2) bottom type, 3) tow-direction in relation to tidal flow, 4) period of day (day or night), 5) tow-speed, 6) salinity of water, and 7) temperature, etc. Using these variables we can develop a prediction model of total biomass caught. We have historical trawl data coming from previously used trawl stations which have been grouped into eleven areas. Each area was further divided into 3 depth zones, 0-30 ft., 31-50 ft., and >51 ft. For each area and depth zone combination, a monthly number of trawls have been tallied. Once we have the historical data, we can put these data into spatio-temporal maps which will provide distributional information that is paramount in the identification of an optimal sampling design and allocation of sampling efforts.

Multidimensional Spatiotemporal Catch Model

The historical data for the past 10 years is divided month by month and for each month data is for different locations and different species. We are interested in developing a predictive catch model for the next month based the past data and also the starting time, location, and species. In otherwords, based on the past data, we want to decide first where to go and at what month and for which species? The predicted catch model is:

$$W_T = W_{T-1} + B_1 X_{T1} + \ldots + B_p X_{Tp} + E_T \quad (1)$$

where $T = (t, S_1, S_2, i)$

t = time when fish is caught (in month)

S_1 = altitude of the location where fish is caught

S_2 = longitude

i = species

W_T = total biomass caught at multidimensional time T.

$B_1, \ldots, B_p$ are regression parameters.

$X_{T1}, \ldots, X_{Tp}$ are the variables we have considered under sources of variability at multidimensional time T.

E_T is the random error at T.

We can select the starting point for trawling based on areas of maximum catch in the past or where we can get the maximum predicted catch based on the model (1) above. Another problem is that once we are on the boat moving from one location to another on the same day, what will be the predicted catch for the next point of time at the next location? Based on the predicted catch, we can decide in advance our strategy about where to go the next time.

The model is as follows:

$$W_j^T(i) = B' X_{\underset{\sim}{T}j}(i) + E_j^T(i), \quad j = 1, \ldots, n$$

where $T(i) = (t_j, S_{1j}, S_{2j})^{(i)}$ = j=th spatio temporal time for species ij

$\underset{\sim}{B}$ = regression parameter vector

$\underset{\sim}{X}_T(i)$ = vector of variables under sources of variability.

$W_j^T(i)$ = total biomass caught at $T_j^{(i)}$

$E_{T_j}(i)$ = random error assumed to be autocorrelated, i.e.

$$E_j^T(i) = E_{j-1}^T(i) + n_{T_j}, \quad j = 1, \ldots, n.$$

In both cases parameters can be estimated by the maximum likelihood method, the later one is introduced by Cochran and Orcutt (1949). We plan to run our past data on these models to further develop them.

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Virginia Institute of Marine Science Trawl Survey Programs

Jim Colvocoresses

Background and History

The Virginia Institute of Marine Science (VIMS) began regular monitoring of juvenile fish and blue crab populations in the Virginia tributaries and lower Chesapeake Bay in late 1955, when sampling was commenced at fixed stations. Mid-channel stations spaced at five mile intervals from the mouth of the Bay along a transect up the York River system, continuing up the Pamunkey River to river mile 50. Sampling was conducted with an unlined, 1 1/2" stretch mesh. A 30' semi-balloon otter trawl was towed along the bottom for either 15 (lower portions of rivers and Bay) or 7.5 (upper rivers) minutes at each station. Sampling was attempted on a monthly basis after April of 1956, but for logistical reasons not every month could be sampled. Some stations were not successfully completed during certain sampling periods, particularly during the winter months.

In 1964, sampling was expanded to include the lower 40 miles of the James River, again utilizing fixed stations spaced at about five mile intervals. Sampling was further extended into the lower 40 miles of the Rappahannock River the following year, with the gear and sampling design remaining the same. This scheme of sampling (monthly, mid-channel, fixed station sampling in the lower Bay and three mainstream major tributaries with a 30' unlined trawl) was continued until August of 1972, when a series of major changes in gear and sampling strategy were initiated.

In July of 1970, in addition to the regular survey described above, exploratory sampling utilizing a smaller (16') otter trawl with a liner (1/4" bar mesh) sewn in the cod end was done in two of the smaller tributaries (Piankatank River and Mobjack Bay system) of the lower Chesapeake Bay. The success encountered with this gear prompted the implementation of parallel sampling along with the main survey in the York River. Starting in July of 1971, shoal water (5-10') stations were established on both sides of the middle four (at river miles 10, 15, 20 and 25) regular channel stations and sampled on the same monthly basis using the 16' lined net. The success of this program led to the expansion of sampling with the smaller trawl to include the entire York River system:, utilizing a stratified random design covering all waters deeper than 3 feet. This new Survey was implemented in July 1972 and completely supplanted the fixed station, mid-channel survey two months later. Sampling in the James and Rappahannock was continued as previously through the end of 1972, at which time sampling with the unlined 30' trawl was terminated.

In June of 1973 a completely new regimen of sampling was begun. The entire lower Chesapeake Bay (Virginia waters) as well

as the three major river systems were sampled using a lined (1/4" bar mesh) 30' otter trawl and a stratified random sampling design. Because of the intensity of sampling, sampling periodicity was changed from monthly to semi-annually (except for the random survey using the 16' net in the York, which was continued on a monthly basis until the end of 1973). Intensive summer and winter random surveys using the 30' lined trawl were continued through the winter of 1978-79. During the winter of 1973-74,survey sampling was expanded into the Potomac River and sampling was extended upriver in the other three river systems as far as navigation requirements would allow. During the 1975 summer survey, supplementary sampling with the 16' net was added in order to sample waters too shallow (<3 meters) to be sampled with the larger net (and hence larger vessel). Because lined nets tend to clog with bottom debris much faster than unlined nets, tow times using the lined nets have been restricted to five minutes or 1/4 mile measured distance (approx. 6 min. at normal towing speed in slack water).

After the winter of 1978-1979 monthly sampling was resumed and areal coverage was again restricted to the channels of the lower portions of the major river systems. Monthly sampling has remained in effect since May of 1979, but there have been some seasonal changes in sampling design and gear as responsibility for the survey was apportioned seasonally between two different groups through 1985. Fixed station sampling, utilizing the same stations occupied from 1955-72, was done during the months of May through November. From December of 1979 through April of 1982, stations occupied during the other months of the year were selected randomly, but selection of stations was limited to the channel and stratification was based on five mile blocks, resulting in a very similar distribution of effort. Since April of 1982 the same fixed stations have been sampled throughout the year. Although the recent trawl surveys have returned to the same sampling design as was originally implemented, the gear used is considerably different. The lined 30' trawl has remained in use and the addition of a tickler chain was made with the resumption of monthly sampling (although temporarily not used December 1979-April 1980).

VIMS and other institutions in Virginia have also had many other fish and invertebrate sampling programs which have involved sampling with otter trawls and other types of trawl gear (mid-water trawls, pushnets, etc.) which were done in conjunction with projects whose goals were other than long-term monitoring.

Present Programs

VIMS presently monitors 22 fixed mid-channel stations in the James, York and Rappahannock Rivers on a monthly basis. A pilot project which involves stratified random sampling of the Lower Chesapeake Bay on a monthly basis is also underway.under funding from the Chesapeake Bay Stock Assessment Committee Program (CBSAC). This work is described in the Maryland chapter of this

publication.

Future Plans

The VIMS trawl survey program is currently undergoing considerable expansion, with the immediate intent of developing an expanded randomized sampling scheme which will cover both the lower Chesapeake Bay and major tributaries on a monthly or bimonthly basis. Efforts are being made to develop a standardized trawl sampling program for the entire Bay (under CBSAC). The outcome of this effort may well shape the final choice of gear and sampling design for the future survey.

District of Columbia Trawl Survey

Stephen M. Smith

The District of Columbia's Fisheries Management Program currently does not sponsor any trawl survey activities, however, future plans include bottom trawling to assess local fisheries resources. Past trawling experience in the District have been limited and primarily restricted to anadromous fish collections with mid-water gear. Bottom trawling in the channel areas has been sporadically conducted for specific fish collections, however, no effort has been made to perform standardized tows or utilize this gear to address monitoring and assessment objectives.

The present Resident Fish Survey includes plans to incorporate bottom trawling into the sampling methodology. Transect stations have been established that include each of three different habitat types; nearshore/beach, shoal (>8') and channel. Beach seines and electrofishing gear are used to sample the shallow habitats while it is expected that trawling will be used in the deeper channel zones. Surveys are conducted four times a year with two separate sampling trips per seasonal survey. The seasonal sampling period extend from June 1 to August 31, September 1 to November 30, December 1 to February 28 and March 1 to May 31 for summer, fall, winter and spring respectively. A two week period at each end of the season is excluded to insure that sampling is conducted at least five weeks apart and minimize the effect of seasonal overlap. Sampling weeks are randomly selected from the remaining time period with a single day dedicated to each habitat/gear type. Any additional days remaining in the sampling week are available for weather contingencies or time overruns.

The proposed trawl survey component of the Resident Fish Survey is designed to complement sampling of the beach and nearshore/shoal fish communities by providing fisheries independent information from the extensive channel regions. All survey data are used to evaluate fish stocks and develop management strategies for the local recreational fishery. Specific objectives include determination of size of stock, relative abundances, age composition and community structure. The formation of long term data cases for each of the habitat types will permit tracking of species stocks over time, discerning habitat intradependence relationships and to assist in the formulation of management decisions.

Because of the limited availability of potential transect regions that include the habitat types and suitable bottom for trawling, it will not be possible to employ a randomized survey design. It is anticipated that some element of randomization can be introduced by considering each transect as an individual strata and randomly selecting a single quadrant for trawl sampling. All tow times will be standardized from set to

retrieval. Consecutive tows will be conducted in opposite directions so that both the upstream and downstream tidal components will be sampled. Owing to the difficulty in obtaining quantitative data from electrofishing techniques, consideration will be given to trawl sampling of the nearshore/shoal habitats. Initial work will evaluate the effectiveness of shallow water trawls and include gear comparison studies. Future expansion of the trawling effort into the nearshore/shoal habitats will be predicated on the availability of trawl sites proximal to the transect regions and the ability of the gear to adequately sample the habitat.

While the present sampling agenda has been in effect since January 1988, the channel habitats have not been sampled due to the lack of a suitable vessel to deploy trawl gear. A 25' Sea Hawk equipped with stern davits and a winch system is currently on order and is expected for the 1989 survey. It is anticipated that trawling in the channel zones will be conducted with a 16' semi-balloon otter trawl lined with 1/4" cod end mesh towed at 2 - 3 knots. While potential trawl regions have been identified along the established transect, final selection of sites will be predicated upon the ability to complete a sampling tow.

Biological data collected from the trawl sample will be similar to data collections from the beach and nearshore/shoal habitats. All fish captured will be enumerated by species and measured (mm FL) and weighed to the nearest gram. When large catches of a single species are taken, a random sub-sample of at least 30 individuals will he measured and weighed. Total counts and weights shall be taken for all remaining fish. As a result of the gear dimensions and habitat, it is not anticipated that tows large enough to necessitate sub-sampling of the entire catch will be encountered. In the event of two or more distinct age groups co-occurring in the same sample (e.g. YOY, adults), fish will be separated by size group and considered as separated species. Any additional data, (scales, otoliths, sex, stage) may be taken as needed. Whenever possible, samples will be returned alive to minimize the impact of survey mortality.

Hydrographic sampling will be conducted simultaneously with each biological sample. Measurements taken shall include surface and bottom temperature and DO, pH and conductivity at 1 meter and secchi depth. Wind speed, direction, weather and sea state will also be noted.

Data collections are currently entered and stored in separate biological and hydrographic data files. Unique collection numbers are used to cross reference the data bases or combine selected physical and biological parameters to working files. All data is stored in the dBase II format and is transferable on diskette to compatible computer systems. Hardcopy code keys also are available for data interpretation.

North Carolina Marine Fisheries Trawl Surveys

Paul S. Phalen and Dianne C. Stephan

Introduction

The North Carolina Division of Marine Fisheries (NCDMF) is charged with the protection and management of the State's coastal fisheries and wetland resources. Accurate data are necessary for the sound management of these resources. Coastal fishery data are collected either by monitoring catches of commercial or recreational fisheries, or by surveys which are not dependent upon fishery landings. One of the fishery independent survey methods most widely used by the NCDMF is the trawl survey. Trawl surveys have provided the information for long term monitoring databases, as well as for short term, simple, local stock assessments.

A brief description of each of the on-going or historically important trawl surveys performed by the NCDMF follows. A selected bibliography of reports or publications based upon each of these surveys is also included. Presently, on-going surveys will be supported for the next year, and no new surveys have been proposed. Other studies involving trawl gear conducted by the NCDMF include net mesh selectivity and the effectiveness of certain trawling efficiency devices (TEDs).

Juvenile Striped Bass Survey

North Carolina State University conducted a juvenile striped bass survey from 1955 to 1977. The NCDMF adopted the same methods in 1984 and conducted a comparative survey through 1987. Starting in 1988, the NCDMF will maintain the survey to continue the historic index of juvenile abundance. Fixed stations (n=7) are sampled twice a month (July-October) with a 5.49 m balloon trawl towed 15 min in 2-3 m of water by small (approximately 6 m) work vessels. The codend was initially 6.35 mm in early samples and 12.7 mm in later samples. Starting in 1984, all nets had a 12.7 mm stretched mesh codend. All striped bass were measured (nearest mm) and released. Other economically important species were counted and measured.

The index has become very important over the last few years due to the depressed striped bass stock. Yearly CPUE values have been published for all years and have been used in stock assessments and in determining optimum flow for the Roanoke River during the spawning season. Analyses concerning accuracy and precision are in process.

R/V DAN MOORE Surveys

The R/V DAN MOORE, a 30 m steel stern trawler, collected over 4,400 samples during service with the NCDMF, 1968-1981. Surveys included anadromous fish, flounder, calico scallop, rock

shrimp, industrial fish, and others. Many different trawl types and methods were used over the years. Cruise results were summarized in bulletins from 1968-1974. Complete cruise reports describing methods and results were filed for the remaining cruises. In many instances, these data are the only biological data for certain areas of the continental shelf. Complete analysis of the data have been limited due to poor accessibility. The NCDMF is now entering these data into the Division's database.

Calico Scallop Survey

Calico scallops have historically been found in specific areas or "beds" off North Carolina. Commercial harvests occurred intermittently during 14 years between 1959 and 1988. The objectives of the calico scallop survey are to determine if commercially harvestable quantities of calico scallops are present at these historical beds, and determine the relative quantity of seed scallops.

Initially, calico scallops were sampled as a R/V DAN MOORE survey project. Beginning in 1985, stations on the historical scallop beds are sampled in the spring and again in the fall. The NCDMF R/V CAROLINA COAST, a 13.4 m fiberglass hull shrimp trawler, is rigged with a 3.7 m scallop trawl (2.5 cm bar body mesh and 1.9 cm bar mesh codend) spread by a pair of 0.5 m x 0.9 m wooden doors, which is towed for 5 minutes. Total catch weight (kg) and scallop weight (kg) is recorded, along with the number of scallops present. A sub-sample of 30-50 scallops is obtained at each station and measured for shell height (mm) and meat weight (gm). These are then sub-sampled for gonad weight (gm). An overall list of species encountered is completed for each station.

Results for each cruise are made available to interested fishermen. Data analysis has been minimal, consisting primarily of a species list, number of scallops encountered and station location. More recently, length frequencies for shell height, meat weight, and gonad weight are presented in an annual cruise report.

Brown Shrimp Survey

The goals of the brown shrimp survey are to gather information on shrimp populations for forecasting and assessment purposes and to collect data needed to provide management recommendations. Approximately 120 stations are sampled during late April through early June to collect juvenile brown shrimp and environmental data. Samples are collected with a 3.2 m headrope, 6.4 mm bar mesh body, and 3.2 mm codend during 1 min tows. All shrimp are counted and a sample of 30-50 shrimp are measured. Surface and bottom temperature and salinity are taken with each sample. During 1971-1977, tow times and gear varied. Beginning in 1978, the above procedures were adopted.

During the summer and fall, samples are taken with a 3.2 m or 6.4 m trawl. The samples are taken to monitor open areas for occurrence of small brown shrimp and monitor closed areas for reopening. This monitoring is done in accordance to needs, which are based on shrimp abundance, growth, and environmental conditions.

Estuarine Trawl Survey

The NCDMF established a long term, statewide, estuarine trawl survey in 1978. The primary objective is to develop indices of juvenile recruitment of economically important species such as spot (Leiostomus xanthurus), Atlantic croaker (Micropogonias undulatus), weakfish (Cynoscion regalis), blue crab (Callinectes sapidus), brown shrimp (Penaeus aztecus, and flounder (Paralichthys sp.). The survey is divided into a primary and secondary nursery area survey.

The primary nursery area survey is conducted in shallow (0.1-1.2 m) upper reaches of dead-end creeks or bays where initial post-larval development occurs. These areas are sampled with a two-seam trawl with a 3.2 m headrope, 6.4 mm bar mesh body, and 3.2 mm codend towed by small (approximately 6 m) work vessels. The tow times are 1 min per station. The secondary nursery area survey is conducted in the lower and/or deeper portions of creeks and bays where later development occurs. These areas are sampled with a two-seam trawl with a 6.1 m headrope, 19 mm bar mesh body, and 6.4 mm codend. Tow times for these areas are 5 min per station. Starting in 1987, a heavily chained net was used where habitat permitted. Both primary and secondary nursery areas are sampled once a month, March-November, at fixed stations. Total stations sampled statewide per month exceeded 300 in 1988.

For sample workup, the economically important species are counted and a sub-sample of 30-60 individuals of each age group are measured (nearest mm). The remaining species are identified and counted. The bottom type, depth, and bottom and surface temperature and salinity are recorded at each station.

Several reports have been published using the survey data. These data have been used to characterize nursery area habitat, identify brown shrimp abundance, and help identify new nursery areas. There is a current study funded by the Albemarle-Pamlico Estuarine Study to analyze the estuarine survey data. Other than the above, very little data analysis has been conducted. The NCDMF is currently designing a proposal that would describe the methods to analyze the data. Recommendations on future sampling will be made based on the above analyses.

Pamlico-Albemarle Sounds Survey

The Pamlico-Albemarle Sounds Survey, which is the newest trawl survey performed by the NCDMF, was initiated in 1987 to establish a long term database of fishery independent information on the finfish and decapods of the survey area. The specific objectives of the survey are to monitor and determine finfish and decapod distribution, relative abundance, and size distribution in the survey area.

The survey area includes Pamlico Sound, Albemarle Sound, Croatan Sound, and lower portions of the Neuse and Pamlico Rivers, which encompasses approximately 3,000 square kilometers. Six strata were identified based on geographic location and depth, for the employment of a random stratified sampling design. These strata were then subdivided into 1' latitude x 1' longitude grids which each represent a station. The number of stations sampled per stratum was calculated based upon the number of stations which could feasibly be sampled each quarter, and the respective area of each stratum. The specific stations to be sampled in each stratum are then determined by generation of random numbers.

Survey cruises are completed each quarter aboard the NCDMF R/V CAROLINA COAST fiberglass shrimp trawler. A total of fifty-two stations are sampled over a two week period with double rigged demersal Mongoose trawls (9.1 m headrope, 1.0 m x 0.6 m doors, 2.2 cm bar mesh body, 1.9 cm bar mesh codend and a 100 mesh tailbag extension) towed for 20 minutes. The sample is sorted by species and sub-sampled if extremely large. Target species are weighed by species (kg) and measured individually (mm), and incidental species are weighed and enumerated by species. Environmental data including depth, surface and bottom salinity, and surface and bottom temperature are recorded.

After each cruise, a cruise report is compiled which includes summary statistics and length frequency analysis and capture location of target species of special interest. At the completion of two years of sampling, an evaluation of sampling design will be performed.

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A complete listing of publications prepared by the Division of Marine Fisheries is available from: Research Section, NCDMF, P.O. Box 769, Morehead City, NC, 28557.

South Carolina Trawl Survey Program

Charles Barans

The South Carolina Wildlife and Marine Resources Department was contracted by the National Marine Fisheries Service to conduct groundfish trawl surveys on the continental shelf of the Southeast Region between 1973 and 1980. The surveys were part of the Marine Resources Monitoring, Assessment and Prediction (MARMAP) program, and were designed as an extension of the NEFC fall groundfish survey. Standardized collections were made with a 3/4 Yankee No. 36 net at randomly selected stations stratified by depth (Wenner, et al. 1979).

Positive experiences of the surveys include: 1) the groundfish community structure of trawlable habitats (sand bottom) was quantitatively characterized; 2) catches indicated the seasonal importance of large rays and several groups of coastal pelagic species; 3) pre-recruit indices of relative abundance might be developed from the occasional catches of juveniles of priority species; and,4) species composition and CPUE information may be good indicators of the general "health" of the regional marine environment.

Negative experiences of the surveys include: 1) trawl nets did not adequately sample the priority offshore groundfish species (snapper-grouper complex); 2) bottom trawls destroyed low relief live bottom habitat or hung in high relief rocky outcrop habitats, 3) nets' configuration, ground contact and efficiency were unknown; and, 4) nets were very expensive to repair and replace.

Shrimp populations of the estuarine and nearshore habitats are routinely monitored by SCWMRD with small 21' shrimp trawls at fixed stations. Information from the surveys is used to manage the commercial shrimp fishery. Data on catch goes back to 1953, while standardization of gear occurred in 1974.

During the early 1980's, trawling was directed at characterization of groundfish communities of the low relief live bottom habitats with several types of trawl nets (Wenner, 1983). Much of the research was funded by the Bureau of Land Management, presently Minerals Management Service (Sedberry and Van Dolah, 1984) and the MARMAP program. Since 1973, numerous special studies involving the collection of fish with bottom trawls have been designed and conducted to address estuarine and coastal groundfish communities. Most of the studies were for less than three years duration and were funded by various sources. The exception was a five year trawl survey (1973-1977) with a 6 m otter trawl at fixed stations in the Cooper River and Charleston Harbor system (Wenner, et al. 1984). My colleague, Dr. Wenner, presents information on South Carolina's more recent trawl survey efforts in the SEAMAP regional program which is described earlier in this report.

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Georgia Shrimp Trawl Survey

Jim Music

Georgia's major commercial fishery is the shrimp fishery with the white shrimp being the dominant species. Trawl sampling is conducted to supply fishery managers with up to date fishery independent data on stock abundance and count size within Georgia's territorial waters.

In 1967, trawl sampling was conducted in three sound systems (St. Andrew, Sapelo, and Ossabaw) with sample sites distributed over a variety of habitats. The objective of this first study was to provide basic biological information relative to making sound management decisions regarding opening areas and seasons for Georgia's commercial shrimping industry. Seven trawl stations, ranging from the heads of the tidal creeks to five miles offshore, were sampled bimonthly with 20-foot flat trawls from a 26 foot inboard/outboard vessel. Tow time was 15 minutes with all shrimp, crabs, and fish sorted and counted. One hundred of each species were sexed, measured, counted; and weighed to determine the number per pound. Water temperature, salinity, and turbidity were also recorded. Concurrent sampling with castnets seines and plankton nets supplemented trawl data.

By 1969, trawl sampling graduated from the smaller 26 foot boat to the 60 foot trawler ANNA. Trawl tows remained 15 minutes and catches were processed much the same as with the smaller boat. Supplemental data collection with plankton nets continued.

From 1970-1973, a different type survey was conducted to catalog species diversity, seasonal abundance, habitat and other life history information for Georgia's estuaries. Trawl surveys were conducted in annual segments with the southern section (St. Simons and St. Andrew systems) studied first in 1970-1971, the middle section (Sapelo and Doboy systems) studied in 1971-1972, and the northern section (Wassaw and Ossabaw systems) studied in 1972-1973. Each system was divided into four geographic components -- smaller creeks and rivers, larger rivers, open sounds and nearshore ocean waters. The latter three areas were sampled via the large trawler while the smaller tributary creeks were sampled by small seines. Trawl sampling was conducted monthly using a 40-foot flat trawl of two-inch stretch mesh webbing and 4' x 2' doors. Trawl time was 30 minutes. Catches were sorted and recorded as to species, number, and weight. A random sample of 50 of each species of shrimp, 30 blue crabs, and 30-50 of each species of food fish were measured, sexed, and examined for gonadal development. Other finfish species were recorded as to total number, weight, size range and number per pound. Environmental data were also recorded.

Additional trawl sampling was conducted during the late summer and early fall to determine current count sizes for commercial shrimp trawling. The legal shrimp season for the

sounds runs from September 1 through December 31 provided that the shrimp meet the minimum count size of 45 per pound with the heads on. Prior to 1977, the sounds routinely opened to shrimp trawling once this 45/lb count size was reached. Since 1977, the sounds have opened only on a conditional basis in 1983, 1985, 1986, and 1988, for a limited number of days each year.

From 1974-1977, trawl sampling was geared down to sample only the commercially important shrimp and crab populations. Most of these stations were selected among more productive areas from the previous study with 36 stations within the six commercially important sound systems. Tow time remained 30 minutes with the same 40 foot flat net as the gear. However, the 44 foot fiberglass vessel COBIA was employed to conduct sampling. Only shrimp and blue crabs were weighed, measured, and sexed. Environmental parameters were also recorded.

From 1978-1981, trawl sampling was again modified so as to concentrate sampling efforts primarily during those months where crucial management decisions were forthcoming. The trawl sites in each of the three sections (creeks, sounds, and nearshore ocean water from the beaches to three miles offshore) of each of the nine sound systems were sampled for a total of 54 stations per cruise during the first annual segment. In the later two segments, this was reduced to 30 stations per cruise with station locations in only five of the commercially important sound systems. Trawling was conducted on both the COBIA and the ANNA.

From 1982 to the present, all tow times have been 15 minutes with two stations in each of the three sectors in each of the major commercial sound systems. The only significant changes have been that: 1) the Altamaha system is no longer sampled, and the Ossabaw system has been sampled since 1988; and, 2) Cumberland stations have been altered as per closure of military security areas adjacent to the Kings Bay Trident submarine base in Camden County. However, today all six commercially important sound systems are sampled each month for a total of 36 stations.

Since 1978, a supplemental juvenile study has been conducted to supply recruitment information for critical management decisions. Until recently, there were 20 stations sampled each month, but these are being reduced and may even be discontinued in lieu of other work due to budgetary reductions. Current emphasis is being directed toward three major commercial sound systems (Sapelo, St. Simons, and St. Andrew) to streamline sampling and more directly link it with commercial harvest rates in an attempt to develop a stock recruitment index.

Florida's Fisheries Independent Monitoring Program

Kristie A. Killam, R.H. McMichael, Jr., M.E. Mitchell

The Florida Department of Natural Resources, Marine Research Institute (FMRI), has initiated a juvenile finfish monitoring program with funding provided by a Wallop-Breaux grant. This program was introduced in the Tampa Bay area due to the proximity of the lab's facilities but eventually, will be extended to include all coastal areas of Florida with support from eight field stations.

The FMRI will be responsible for the collection of all samples and environmental data. This will keep the data independent of any commercial or recreational fisheries influence. Also, since we are specifically targeting juveniles and subadults, data should be unaffected by fishing pressure, size and bag limits or closed seasons.

Specific objectives and long term goals of the project include: (1) detection of abundance trends through time; (2) correlation of juvenile abundance with future adult stocks; (3) prediction of future year class strength; and, (4) providing information on stock sizes to fishery managers before the juveniles reach fishery vulnerable sizes. Many short term objectives must be resolved prior to obtaining our long term goals. These include: (1) establishing a sampling protocol, with procedures being standardized throughout the state; (2) describing physiographic parameters such as salinity gradients and habitat profiles for each estuary examined (These will be determined by actual infield observations, combined with information provided by aerial photography and satellite imagery.);and, (3) determination of appropriate sampling gears for each habitat type.

Establishing the Juvenile Monitoring Program will require a long term data base. Many years of data will be necessary to identify normal fluctuations in juvenile fish populations before changes in stock abundance trends due to fishing restrictions, large scale weather events or habitat alteration can be identified. Eventually, we will predict future adult stocks by developing a relationship among juvenile, subadult and adult stocks.

This monitoring program will examine all species captured rather than isolating on a few "target" species. This multi-species approach will allow us to examine the ecosystem as a whole and determine interrelationships among fish species. Some species may serve as indicator species for more economically important species and could influence their juvenile stock levels.

During the past year of the program we have initiated the Juvenile Monitoring Program in Tampa Bay. We have standardized collection methods, determined habitat and salinity profiles, and determined adequate samples sizes needed to statistically detect specific changes in numbers and species composition of the juvenile fish populations.

A large portion of time has been spent on gear testing; looking at variability between replicate samples, examining catch efficiency, determining acceptable standardized deployment techniques, and identifying appropriate gears for specific habitat types. Florida's coastline extends from tropical to temperate regions, resulting in extreme variability in coastal habitats. For this reason, we are required to utilize numerous gear types to sample these diverse areas. Some of the gears utilized include seines, otter trawls and multi-panel gill nets. We are also experimenting with purse nets, pound nets and drop nets. Tampa Bay will be sampled during the spring and fall of each year for a period of 10 weeks each. Sampling is randomly selected within each of the habitat types. This random sampling ensures that there is no bias in selection of sampling sites and stratifying by habitat will ensure that each habitat type is sampled.

The FMRI has recently received additional funding from the state legislature, and will be expanding the monitoring program to three other estuarine areas. These areas are: Charlotte Harbor, Apalachicola Bay and Indian River.

Preliminary investigations must be conducted in each of these areas prior to the actual monitoring program, however, it is anticipated that the program can begin in one of these areas this spring.

APPENDIX I - TRAWL SURVEY WORKSHOP PARTICIPANTS

List of participants in the ASMFC-NMFS Trawl Survey Workshop; Woods Hole, MA; November 1-3, 1988

Atlantic State Marine Fisheries Commission, Washington, D.C.
202-387-5330
McGurrin, Joseph
Perra, Paul

Biosonics, Seattle, WA 206-527-0905
Dawson, Jim

Chesapeake Biological Laboratory, Solomons, MD
Bhandary, Mathusudan

Connecticut Department of Environmental Protection
203-443-0166
Howell, Penny
Simpson, Dave

Delaware Division of Marine Fisheries 302-736-4782
Seagraves, Rich

District of Columbia, Fisheries Management Program
202-767-8414
Fulton, Jean M.
Smith, Stephen

Florida Department of Natural Resources 813-896-8626
Killam, Kristie

Georgia Department of Natural Resources 912-264-7218
Music, Jim

Maine Department of Marine Resources 207-633-5572
Langton, Rich

Maryland Department of Natural Resources 301-269-2242
Jones, Philip W.

Massachusetts-Division of Marine Fisheries 508-888-1155
Correia, Steven
Currier, Tom
Howe, Arnold B.
Witherell, David

Mid-Atlantic Fisheries Management Council 302-674-2331
Hoff, Tom

National Marine Fisheries Service-Gloucester 508-281-9300
Mears, Harry
Olsen, Susan
Seamans, Richard

- Narragansett 401-782-3345

Blott, Al

- Sandy Hook 201-872-0200

Wilk, Stuart J.

- Woods Hole 508-548-5123

Almedia, Frank
Azarovitz, Tom
Bisack, Kathryn
Bowman, Ray
Burnett, Jay
Byrne, Charles
Chang, Sukwoo
Clark, Stephen
Clifford, Roger
Flescher, Don
Fogarty, Michael
Forrester, Janice
Gabriel, Wendy
Lange, Anne
Mace, Pamela
McBride, Margaret
Morrissey, Tom
Nelson, John
Nicolas, John
O'Brien, Loretta
O'Gorman, Brian
Patanjo, Linda
Pennington, Michael
Polacheck, Tom
Richards, Anne
Silverman, Malcolm
Terceiro, Mark
Waring, Gordon

New England Fisheries Management Council 508-281-3600
Testaverde, Sylvatore

New Jersey-Bureau of Marine Fisheries 609-441-3292
Byrne, Donald
Himchak, Peter

North Carolina Division of Marine Fisheries 919-726-7021
Moye, David
Phalen, Paul
Stephan, Dianne

Pennsylvania State University-Center For Statistical Ecology
814-865-5212
Balgiano, Nick
Boswell, M.T.
Patil, G.P.

Rhode Island Division of Fish & Wildlife 401-294-4524
Lynch, Tim

South Carolina-Wildlife and Marine Resources Department
804-795-6350
Barans, Charlie
Wenner, Elizabeth L.

Virginia Institute of Marine Science 804-642-7307
Colvocoresses, Jim

Wilcox Marine Supply, Mystic, Connecticut 203-536-4206
Wilcox, Peter

APPENDIX II - TRAWL SURVEY WORKSHOP AGENDA

TRAWL SURVEY WORKSHOP AGENDA
November 1-3, 1988, Candle House, Woods Hole, MA

Tuesday, November 1, 1988

1:00PM Welcome and Introduction,
Paul Perra, ASMFC.
Allen E. Peterson, Jr., Scientific and Research Director, Northeast

1:30 - 5:00 PM Overview of state and federal survey programs.
Chair, Thomas Azarovitz, NMFS, Woods Hole.

Wednesday, November 2, 1988

8:30am - Noon Overview of survey programs continued.

Noon - 1:30 PM Lunch and tour of Woods Hole facilities and research vessels.

1:30 - 5:00 PM Special discussion sessions (I-VI).
Chair, Richard Seagraves, DE Division of Fish & Wildlife.

Session 1 Trawl survey design - random vs fixed stations.
Speaker and discussion leader: Michael Fogarty, NMFS, Woods Hole.
Rapporteur: Stephen H. Clark

Session 2 Selection and standardization of sampling gear.
Speakers and discussion leaders: Charles Byrne, NEFC, Woods Hole and Janice Forrester, NEFC, Woods Hole.
Rapporteur: Thomas Azarovitz

Session 3 The joys of sub-sampling and making sense of the data the day after.
Speakers and discussion leaders: Thomas Currier, Massachusetts Div. of Marine Resources and Linda Despres-Patanjo, NMFS.
Rapporteur: Don Flescher

Session 4 Alternative and/or complementary sampling techniques.
Speakers and discussion leaders: Charles Barans, SC Wildlife & Marine Resources Department and Jim Dawson, Biosonics, Inc.
Rapporteur: Joseph M. McGurrin.

Session 5 Exploring new applications for trawl survey data.
Speakers and discussion leaders: Thomas Polacheck, NMFS, Woods Hole and Stuart Wilk, NMFS, Sandy Hook.
Rapporteur: Jay Burnett.

Session 6 Potential areas of cooperation and coordination, conclusions and recommendations.
Discussion leaders: Paul Perra ASMFC , Richard Seagraves DE and Thomas Azarovitz NMFS, Woods Hole
Rapporteur: Scott Moseley