

Twenty-five Years of Fish Surveys in the Northwest Atlantic: The NMFS Northeast Fisheries Center's Bottom Trawl Survey Program

LINDA I. DESPRES-PATANJO, THOMAS R. AZAROVITZ and CHARLES J. BYRNE

The return of NOAA's R/V *Albatross IV* to Woods Hole, MA, in November 1987 marked the completion of 25 years of autumn bottom trawl survey cruises conducted by the Northeast Fisheries Center (NEFC) of the National Marine Fisheries Service, NOAA. Although surveys had been completed by the Woods Hole Laboratory for several years, the 1963 autumn survey cruise was unique in that it was the first of an uninterrupted series of standardized surveys designed specifically to provide broad-scale multi-species biological data.

The conception, design and implementation of the survey was a team effort lead by Robert L. Edwards, Marvin D. Grosslein, Richard C. Henne-muth, and John R. Clark of the Woods Hole Laboratory, Bureau of Commercial Fisheries (now NMFS). These and a host of other scientists have continued, expanded, and modified the survey. Today, it is recognized as an invaluable source of information for fisheries management and marine ecosystem studies. When the surveys were initiated, gadid

stocks, especially haddock, *Melanogrammus aeglefinus*, were of primary interest, but the aforementioned researchers had the foresight to collect data on all fish species taken as well as to use repeatable, statistically valid procedures that would provide a solid foundation for subsequent years. The scope of the program has since been broadened considerably and now provides scientific data for a wide range of applications.

History

At its inception, the Woods Hole survey program included summer, autumn, and winter surveys on the Northwest Atlantic continental shelf, from Nova Scotia to Hudson Canyon in depths of 27-365 m (15-200 fathoms). In 1967 the survey area was expanded southward to Cape Hatteras, NC, and, 1 year later, a spring series was initiated. In 1972, coverage was extended to inshore areas landwards of the 27 m (15 fathom) isobath from Nantucket Shoals to Cape Canaveral, FL. Survey work has also been conducted south of Cape Hatteras in certain years by NEFC personnel as well as by the State of South Carolina under contract. Special-purpose bottom trawl surveys include a summer series of surveys from 1977 to 1981 to obtain more information on species of recreational importance and a series of winter surveys originated in 1981 primarily to collect biological data on Atlantic herring, *Clupea harengus harengus*. This series was discontinued 4 years later (Azarovitz, 1981). The autumn and spring surveys have been repeated annually and provide the backbone of the

NEFC resource survey program. Various adjustments have also been made over the years to accommodate fluctuating resource needs, although the basic integrity of the survey remains unchanged.

Current Program

The bottom trawl survey uses a stratified random design. Assuming the stratification scheme is valid, this design increases precision relative to simple random sampling and assures a fairly uniform distribution of stations throughout the survey area. Thus all ecological zones are adequately sampled.

The survey area from Cape Hatteras to Nova Scotia covers approximately 268,000 km² (78,000 n.mi.²). The average allocation is 350 stations per seasonal survey. This translates into a sampling density of one station about every 760 km² (220 n.mi.²). Strata are delineated primarily by depth. Stations are allocated to strata in proportion to area and are assigned to specific locations within strata at random (Azarovitz, 1981).

In all surveys from 1968 to 1972 and since 1981, a standard "Number 36 Yankee" bottom trawl has been employed. This net is rigged with rollers to assist in working over rough bottom. It also has a 12.5 mm stretch mesh liner in the codend to retain juvenile fish. From 1973 to 1981, a modified, high opening, "Number 41 Yankee" otter trawl was used during spring surveys in an attempt to improve monitoring of pelagic fish abundance. A third net, the "3/4 Yankee" trawl, was used for 3 years during the early inshore Mid-Atlantic cruises (Grosslein and Azarovitz, 1982).

The R/V *Albatross IV* has been used since 1963 for most of the survey work, although the R/V *Delaware II* has also participated sporadically since 1970. Be-

ABSTRACT—The history and methods of the NMFS Northeast Fisheries Center's bottom trawl survey program are described. Since the autumn of 1963 over 60 standard bottom trawl survey cruises have been conducted, providing information on the abundance, biology, and distribution of the living marine resources of the Northwest Atlantic and environmental conditions affecting them. The resulting database is temporally the longest and most comprehensive of its kind. It also has proven invaluable for resource monitoring and biological research. Survey design and procedures have been basically unchanged throughout the history of the survey although technological improvements have been made as necessary to improve precision and operational efficiency.

The authors are with the Woods Hole Laboratory, Northeast Fisheries Center, National Marine Fisheries Service, Woods Hole, MA 02543.



The R/V *Albatross IV* passing through the Cape Cod Canal on her way to conduct an autumn bottom trawl survey.

cause of possible differences in fishing power between the two vessels, studies have been initiated to develop coefficients to standardize the data. Another recent change involves the trawl doors. From 1963 to 1984, wood and steel oval trawl doors were used. By 1985, doors conforming to the NEFC specifications were no longer available, necessitating a change to all steel polyvalent doors. Possible effects of this change on survey catch rates are now being evaluated.

Trawl configuration and performance during towing is also being monitored with new technology. In the past, all trawls used on a survey had been certified for use during previously conducted gear mensuration cruises. Presently, an acoustic trawl monitoring system allows trawl mounted transducers to send information back to the ship on headrope height, wing spread and bottom temperature. This system can be used to detect problems during the tow such as hang-ups and crossed doors.

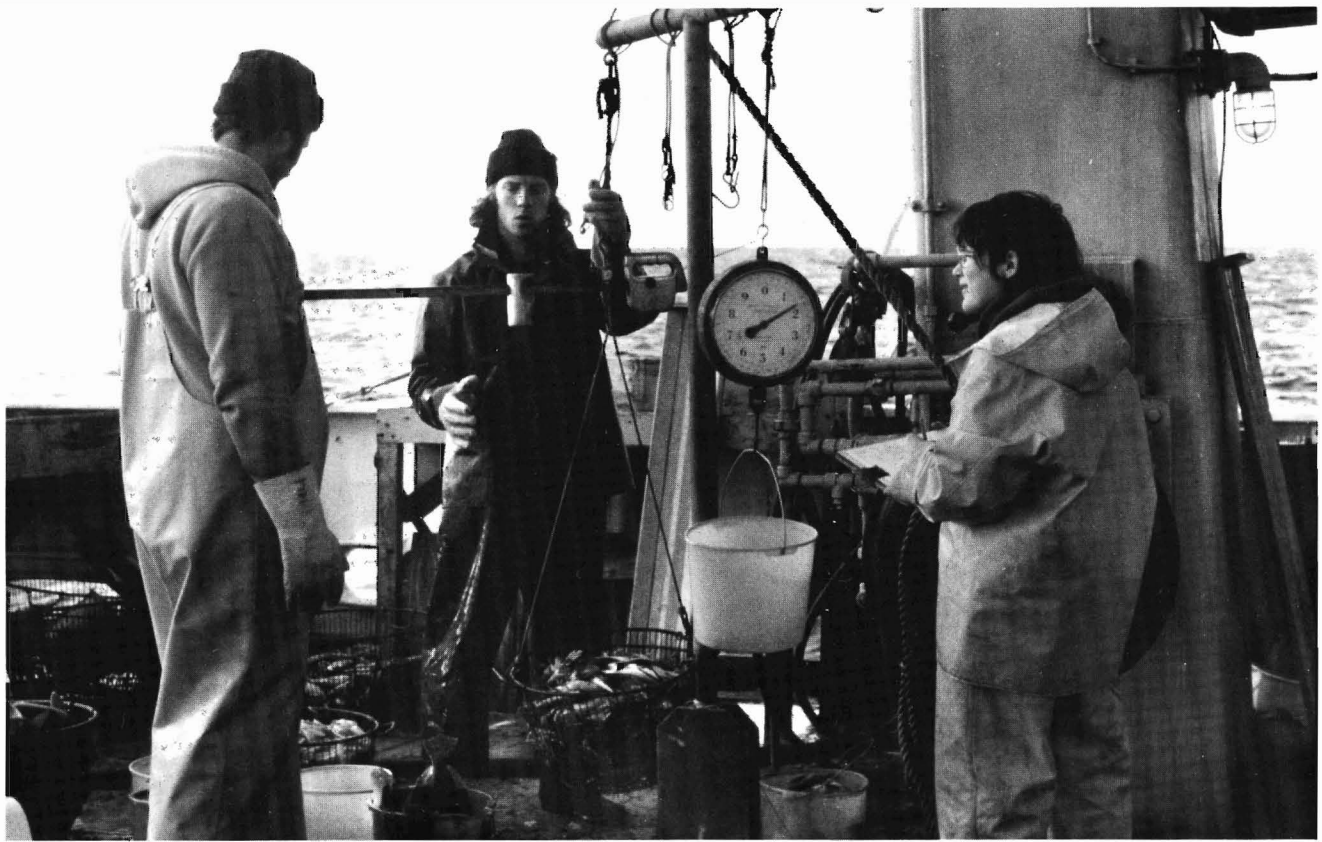
Typical surveys take between 45 and 55 days to complete, with a cruise broken into 2-week segments or "legs." On each leg, up to 13 Center scientists and volunteers sample fish and shellfish populations and collect environmental data at each station. Throughout the 25-year program, data collection has occupied over 30,000 person-days. Universities and colleges, high schools, and state and Federal agencies have contributed personnel to this effort, and private citizens have also assisted.

Work is conducted on a 24-hour basis with two watches of 5-6 individuals standing 6-hour on and 6-hour off schedules. At each station the net is towed for 30 minutes at 6.5 km/hour (3.5 knots) relative to the bottom measured by the ship's doppler speed log. The catch is sorted by species, weighed to the nearest 0.1 kg, and measured. Age samples and stomach content observations are taken, and sex and maturity stage data are noted. Location, depth,

time, weather conditions, water temperature, and trawl performance data are also recorded.

Efforts have been initiated to process data as soon as possible. Environmental data are now transmitted directly to land-based computers via satellite, and a prototype data entry system is presently being designed to expedite data entry and analysis for immediate assessment and management needs. Electronic measuring and recording devices are also being investigated. New methodology being tested allows for more efficient use of sea time and equipment, decreases the chance of oversampling, and data errors can be corrected soon after workup of the catch. Preliminary data are made available to interested parties in the form of "Fishermen Reports" shortly after a cruise is completed. Data files are then placed in final form and merged into the master survey database.

The utility of the NEFC surveys as a monitoring and predictive tool has been



Weighing the catch. Each species is weighed individually for every tow.

well documented (Clark, 1981; Grosslein and Azarovitz, 1982). Unlike commercial data, the NEFC surveys have not been subject to bias from gear improvements or changes in fishing practice and consequently provide the most reliable indices of abundance we have for a given species throughout its life-span and distributional range.

Such information has been the primary basis for monitoring trends in abundance in NEFC stock assessment work including evaluation of the impacts of foreign fishing on Northwest Atlantic fishing resources during the late 1960's and early 1970's. This research provided much of the impetus for implementation of the Magnuson Fishery Conservation and Management Act (MFCMA). Also, since juvenile fish are effectively sampled, the surveys have been extremely useful for predicting recruitment and harvest levels. Other essential information (such as growth and mortality rates and other biological parameter estimates

required for determination of yield and spawning potential) has also been generated by these surveys.

In addition to assessment-related applications, the surveys have provided data and sample material for countless studies on the biology and distribution of fish and invertebrate species which could not have been obtained from any other source. Cooperative work with researchers in other Federal and state agencies and academic institutions, including collection of plankton and pathology samples and observations on sea birds and marine mammals, has been a major responsibility. On a broader scale, the NEFC survey database is being used extensively for ecosystems research, focusing particularly on predator-prey relationships, recruitment processes, effects of environmental changes and impacts of pollution, oil drilling, and ocean dumping.

As more sophisticated ecosystem models are applied to fishery research

and management problems, time series data of the type provided by these surveys will become even more important. The scientists who began the survey had the foresight to collect essential data for broad-scale fisheries research and to provide the capability for modifications to meet future requirements. It has become obvious, after 25 years, that their vision was indeed uncannily perceptive.

Literature Cited

- Azarovitz, T. R. 1981. A brief historical review of the Woods Hole Laboratory trawl survey time series. *In* W. G. Doubleday and D. Rivard (editors), *Bottom trawl surveys/Relevés au chalut de fond*. Can. Spec. Publ. Fish. Aquat. Sci. 58:62-67.
- Clark, S. H. 1981. Use of trawl survey data in assessments. *In* W. G. Doubleday and D. Rivard (editors), *Bottom trawl surveys/Relevés au chalut de fond*. Can. Spec. Publ. Fish. Aquat. Sci. 58:82-92.
- Grosslein, M. D., and T. R. Azarovitz. 1982. Fish distribution. *In* MESA New York Bight Atlas. New York Sea Grant Inst., Albany. Monogr. 15, 182 p.