CRUISE RESULTS
NOAA Fisheries Research Vessel DELAWARE II
Cruise DE 06-15 (Parts I - III)
Atlantic Herring Acoustic Survey

CRUISE PERIOD AND AREA

Cruise operations were conducted on the continental shelf (depths to 350 m) in the Gulf of Maine and northern Georges Bank regions, including the Canadian Exclusive Economic Zone on eastern Georges Bank. The 2006 Fall Atlantic Herring Acoustic Survey was conducted during three parts between 5 September and 13 October 2006 (Figures 1-3). Part I of the survey (5-15 September) was dedicated to calibrating the scientific echo sounders on the FV Delaware II, testing the Advanced Fisheries Tow Vehicle (AFTV), and conducting acoustic research and biological sampling in the Jeffreys Ledge region. The annual systematic acoustic and biological survey of Atlantic herring and collaborative research with the long-range sonar experiment were conducted in the Georges Bank region during Part II (18-29 September). Part III of the survey (2-13 October) was dedicated to a fine-scale acoustic survey and experimental acoustic and optical measurements in conjunction with the long-range sonar experiment in the Georges Bank region as well as a systematic survey of Atlantic herring in the Jeffreys Ledge region.

OBJECTIVES

The Northeast Fisheries Science Center (NEFSC) conducts annual Atlantic Herring acoustic surveys each autumn on the historical spawning grounds of Atlantic herring (Clupea harengus) in the Georges Bank and Gulf of Maine regions. The main goal of this cruise was to provide timely and accurate fisheries-independent estimates of herring spawning stock biomass using state-of-the-art technologies. Operational objectives were to (1) calibrate the EK500 Scientific Sounder, (2) participate in a multi-institutional and multi-vessel acoustic experiment on Georges Bank, (3) conduct performance tests and evaluate the new Advanced Fisheries Tow Vehicle, (4) conduct systematic acoustic surveys of selected Atlantic herring spawning stocks, (5) collect in situ target strength data with the EK500 and EK60, and (6) collect biological data to verify species-specific acoustic measurements using midwater trawls and underwater video.

METHODS

Calibrations and Ambient Noise Tests of the EK500: Calibrations are required during each survey to ensure data quality and verify echo sounder performance. The EK500 was
calibrated by suspending standard calibration spheres of known target strength under each transducer from three monofilament lines. The calibration sphere was centered in the far field of each transducer and moved throughout the acoustic beam beneath the vessel using remotely controlled downriggers. The 38- and 120-kHz split-beam transducers were calibrated at either the Woods Hole Oceanographic Institution’s pier or in Cape Cod Bay, and the 18-kHz split-beam transducer was calibrated in Cape Cod Bay. Noise tests of the EK500 were conducted dockside and while the vessel was underway at 10 knots (survey speed).

**Simrad EK500 Scientific Sounder:** The Simrad EK500 Scientific Sounder was the primary sampling gear used during the acoustic surveys for providing species-specific abundance estimates. The EK500 operated three hull-mounted transducers (18-, 38-, and 120-kHz split-beam transducers). The EK500 was interfaced via TCP/IP Ethernet to the FRV DELAWARE’S SCS server for data logging using SonarData EchoLog software. RS232 connections were used for navigational (Differential GPS) input. An EchoConfig script file was executed to start EK500 data acquisition to ensure that the same parameter settings were used throughout the cruise. The SCS Event Log was used to record all operational events (e.g., begin and end points of transects, stations, gear deployments, and other events that affect the track cruise and vessel speed) during the cruise.

**Advanced Fisheries Towed Vehicle (AFTV):** The AFTV is a recently constructed platform designed to deploy integrated acoustical, optical, and environmental sensors for verifying acoustic backscatter from the water column and seafloor. The AFTV was deployed using a portable fiber optic winch system equipped with 2000 m of 0.322 cable, and has an overall weight of about 5,000 lb. The cable has three single mode fiber optic and three copper conductors, and has an 11,000 lb/ft breaking strength rating. The AFTV towbody weighs about 900 lb and is approximately 7 ft in length. The AFTV also had a 100 lb counter weight arranged about 20 m in front of the towbody to dampen the vessel motion for maintaining the horizontal stability of the towbody. This required a two point deployment approach using the vessel’s A-frame and articulating crane on the aft deck. The AFTV was configured with an EK60 38 kHz, CTD, motion sensor, and various underwater cameras and lighting. The AFTV was towed intermittently at relatively slow speeds (1-3 knots) above the seafloor and throughout the water column to collect in situ target strength data and verify acoustic backscatter.

**Acoustic Survey Operations:** EK500 data were collected continuously throughout the cruise. During the surveys, a constant ship speed of 10±1 knots was maintained. Vessel speed was reduced to no less than 8 knots during rough seas. EK500 operations were generally suspended when seas exceeded 2 m. Each transect was assigned a sequential number throughout the cruise. A transect was defined as a portion of the cruise track with a constant heading and ship speed. All scientific gear deployments were also assigned a unique, sequential deployment number.

**EK500 and EK60 Target Strength Measurements:** Target strength measurements with the hull-mounted EK500 split-beam transducers and with the AFTV-mounted 38-kHz EK60 split-beam transducer (ES38-DD) were collected on selected fish aggregations.
The vessel was positioned over aggregations, and the towbody was deployed from the vessel’s aft A-frame while drifting for 30-60 minutes.

**SonarData Echoview Post-processor:** SonarData software (v. 3.3.6) was used for data acquisition and post-processing of EK500 data during the cruise. Echoview was used to conduct preliminary post-processing of EK500 data at sea, which involved removing extraneous bottom echoes and/or water column noise. Echoview was also used to partition acoustic backscatter to Atlantic herring. EK500 data and Echoview files were logged and archived directly to the SCS system via a TCP/IP Ethernet connection. Three computers were set up for the acoustic data. One computer was used for EK500 data acquisition using EchoLog. This computer was located in the SCS room and was part of the SCS system. The other two computers were set up in the dry lab, with one computer used for post-processing and the other used for viewing data in real time.

**High Speed Midwater Rope Trawl (HSMRT):** The HSMRT midwater trawl was used to collect biological samples and verify species composition of acoustic backscatter. The HSMRT was designed to be fished at high speeds (4-5 knots) with minimal drag. Its symmetrical four-seam box design had 53.1 m (174') footrope, headrope, and breastlines providing a mouth opening of roughly 400 m². The trawl was rigged with four 54.8 m (179'9") bridles to 1.8 m² US Jet double-foiled suberkrub-type doors with double door weights. Optimal tow configuration was set to a total (forward and aft sections) setback of 2.5 m (5') with 600 lb (275 kg) tom-weights for each side, and bridle attachment to doors for maximum spread. The HSMRT was deployed during survey operations, and targeted on acoustic backscatter. The HSMRT was towed between 4 to 5 knots, depending on trawl performance and water currents. The duration and depth of the trawls were not standardized, and the Chief Scientist or Watch Chief communicated with the bridge officers as to the haul duration and depths. The Simrad FS903 was deployed with every haul. Officers recorded the time, date, navigational, and station data in FSCS, while the scientists recorded the catch and ITI data for each station deployment. Catch data was recorded using the FSCS on-board entry system.

**Simrad FS903 Trawl Monitoring and Third-wire Winch System:** The trawl was monitored during fishing operations using the FS903. The Simrad FS903 Trawl Monitoring System was a third-wire device that provided real-time trawl performance information through its sonar images of the trawl opening. The scientific party recorded measurements on hardcopy forms at specified intervals during each deployment.

**Scientific Computer System (SCS) and Fisheries Scientific Computer System (FSCS):** The SCS system is a PC-based server, which continuously collects and distributes scientific data from various navigational, oceanographic, meteorological, and sampling sensors throughout the cruise. The SCS Event Log program was configured for NEFSC Fisheries Acoustic Survey operations, and was used by the scientists to document all operational events (e.g., begin and end of transects and deployments). Dates and times were synchronized using the vessel’s GPS master clock and Dimension IV software. The FSCS system was used for on-board data logging of the biological and catch data.
**Conductivity-Temperature-Depth (CTD) Profiler:** A Seabird CTD profiler was deployed at the beginning and ending of each transect, and at the beginning of each scientific gear deployment to define the hydrographic conditions in the study area. Water bottle casts were also deployed twice per day to collect salinity samples.

**Vemco Minilog Probes:** Temperature-depth probes (set at a 1 or 2 sec sampling rate) were attached to the midwater trawl headrope and footrope during trawl hauls.

**Biological Sampling:** Trawl catches were sorted by species, weighed and measured (to the nearest cm FL) according to standard NEFSC procedures. For Atlantic herring, subsamples were taken for each trawl haul for detailed lengths (FL in mm), individual weights (to nearest 0.1 g), sex/maturity staging, and otolith samples (freeze herring whole). Subsampling protocol was 1 fish per centimeter length class for herring less than 25 cm and 3 fish per centimeter length class for herring 25 cm and longer. The FSCS system was used for on-board entry and auditing of trawl station and biological data. Biological data were transferred to the NEFSC for auditing.

**RESULTS**

**Part I**

The first portion of Part I was dedicated to calibrating the hull-mounted EK500 and mounting and testing the Advanced Fisheries Tow Vehicle (AFTV). The DELAWARE II moved to the Woods Hole Oceanographic Institution’s pier on Sept. 6 to calibrate the 38- and 120-kHz echo sounders. Calibrations were attempted on Sept. 6 and the morning of the 7th, but due to excessive amounts of sea grass in the water, the calibrations were aborted and scheduled for Cape Cod Bay. The AFTV was delivered to the DELAWARE II on Sept. 5, and initial testing, trouble shooting, and evaluation required the vessel to be dockside until the 9th. A shakedown cruise was conducted on Sept. 9 in Vineyard Sound to test deployment procedures, evaluate towing capabilities and characteristics, and test the electronics of the AFTV. The AFTV was deployed three times. The DELAWARE II departed the Fisheries dock on Sept. 11 and headed to Cape Cod Bay to calibrate the EK500.

The 18-, 38-, and 120-kHz EK500 echo sounders were successfully calibrated in Cape Cod Bay. S, and TS gain setting changes were within tolerance levels (± .25 dB). A CTD profile was collected at the calibration site. The calibration site was located about five miles southwest of Provincetown, MA. After the calibrations, the vessel steamed to Jeffreys Ledge to conduct a systematic survey for Atlantic herring. The systematic survey consisted of parallel transects, oriented east-west with 5 nmi spacing between transects. CTD profiles were collected at the beginning and end of each parallel transect. Trawl locations were chosen on an *ad hoc* basis when fish were present. This survey was conducted from September 11 to 14. At the conclusion of the survey, the DELEWARE II steamed back to Woods Hole and arrived the evening of Sept. 14.

During this portion of the cruise 47 deployments (3 AFTV, 40 CTD, and 4 trawl
deployments) and 38 transects were completed.

**Part II**
The primary goal of Part II was to conduct the annual systematic acoustic survey of Atlantic herring along the northern edge of Georges Bank and southern Gulf of Maine. In addition to the survey, we participated in a research project that was investigating the utility of long-range sonar for detecting and enumerating Atlantic herring. Survey operations included EK500 acoustic data acquisition, midwater trawl hauls, and CTD profiles. The vessel departed Woods Hole on Sept. 18 and steamed to the northeast peak of Georges Bank. The vessel arrived on station on Sept. 19 and we commenced the survey (Fig. 2). The survey consisted of parallel transects oriented north-south with 10 nmi spacing. Survey speed was consistently 10±1 knots. CTD profiles were completed at the beginning and end of each transect and immediately prior to each trawl haul. Trawl locations were selected on an *ad hoc* basis to sample the acoustic backscatter.

Due to swells from off-shore hurricanes and windy conditions throughout most of Part II, trawling operations were limited to relatively calm periods. The sea state did not prevent acoustic operations, thus it was necessary to collect acoustic data along the transects, mark locations of herring aggregations, and when the weather calmed down, backtrack to trawl on the marked sites. In these cases (there were two occasions during the survey when we needed to backtrack), we steamed 10 nmi north of the trawl mark along that parallel transect, steamed south until we encountered herring and then set the trawl. After the trawl was completed, we steamed 10 nmi north of the next mark and repeated the process until all trawl sites were completed. We then steamed back to where we previously stopped transecting and resumed normal operations. This survey was completed on Sept. 29, with a total of 24 trawls, 77 CTD profiles and 37 transects (parallel and crossover) completed.

In addition to the survey, we participated in an acoustic experiment to evaluate the potential for a long-range sonar system (Ocean Acoustic Waveguide Remote Sensing - OAWRS) to detect and enumerate Atlantic herring and to monitor their behavior. The OAWRS system has a detection range of nearly 50 km radius, thus may be able to observe large-scale movements of the herring. We collected echo sounder data and trawl catch information at locations where the OAWRS system was detecting fish. We were able to work with the R/V ENDEAVOR, R/V OCEANUS, and R/V SHARP on Sept. 27 – 28 before completing the survey.

**Part III**
The first portion of Part III was dedicated to fine-scale acoustic and optic data collection in conjunction with the OAWRS system. We met the other vessels on the northern edge of Georges Bank and commenced fine-scale surveys (order of 10-20 nmi transects) and trawling operations in locations where the OAWRS system was detecting fish. On one occasion the R/V SHARP was able to image our midwater trawl with its Reson multibeam by steaming behind the FRV DELAWARE II. The experiment was scheduled to end on Oct. 6, but ended on Oct. 5 due to high seas. At the conclusion of the
experiment, we steamed to Jeffreys Ledge to conduct a systematic survey of Atlantic herring.

We commenced the survey for Atlantic herring on Oct. 6 at the north end of Jeffreys Ledge. The survey consisted of parallel transects, oriented east – west with 4 nmi spacing. CTD profiles were collected at the beginning and end of each parallel transect and trawl locations were selected on an *ad hoc* basis. This survey ended on Oct. 9 and we steamed back to Georges Bank to continue acoustic and optic measurements of Atlantic herring.

During Oct. 9 – 11, we conducted day-night comparison transects to examine whether diurnal patterns in Atlantic herring behavior affect abundance estimates. Transects of about 40 nmi, oriented north-south and with 5 nmi spacing, were arranged so that a transect was sampled twice during the day and once during the night. Acoustic data were collected along the transect, and one trawl was completed during the day, and one trawl at night. High seas on Oct. 11-12 forced us to Cape Cod Bay where we calibrated the 18-, 38-, and 120-kHz EK500 echo sounder. This calibration was done at the same site southwest of Provincetown as during Part I. At the completion of the calibration we steamed back to Woods Hole to end the cruise.

This survey was completed on Oct. 12, with a total of 27 trawls, 2 AFTV deployments, 77 CTD profiles and 49 transects completed.

**DISPOSITION OF DATA**

Data and results were archived at the Northeast Fisheries Science Center (NEFSC). Data and results are available on CD-ROM or other media. Cruise reports and results are also available at the NEFSC website: [http://www.nefsc.noaa.gov/femad/ecosurvey/acoustics/](http://www.nefsc.noaa.gov/femad/ecosurvey/acoustics/)
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### Schedule  
- **Part I:** 5 – 15 September 2006  
- **Part II:** 18 – 29 September 2006  
- **Part III:** 2 – 13 October 2006  

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Figure 1. Part I (September 5-15, 2006) area of operations and cruise track for DE200615, Atlantic herring acoustic survey.

Figure 2. Part II (September 18-29, 2006) area of operations and cruise track for DE200615, Atlantic herring acoustic survey.
Figure 3. Part III (October 2-13, 2006) area of operations and cruise track for DE200615, Atlantic herring acoustic survey.