4 January 2006

CRUISE RESULTS

NOAA Fisheries Research Vessel DELAWARE II
Cruise DE 05-12 (Parts I - III)

Atlantic Herring Acoustic Survey

CRUISE PERIOD AND AREA

Cruise operations were completed 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 2005 Fall Atlantic Herring Acoustic Survey was conducted during three parts between 6 September and 14 October 2005 (Figures 1-3). Part I of the survey (6-16 September) was dedicated to calibrating the scientific echo sounders on the FV Delaware II, calibrating and testing an Edgetech broadband acoustic system, and conducting acoustic research and biological sampling in the Georges Bank and Jeffreys Ledge regions. A systematic acoustic and biological survey was conducted in the Georges Bank region during Part II (19-30 September). Part III of the survey was dedicated to a fine-scale acoustic survey and experimental acoustic and optical measurements in the Georges Bank 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) calibrate the Edgetech broadband acoustic system, (3) conduct pilot acoustic surveys on Atlantic herring, silver hake, and Acadian redfish using the EK500 scientific sounder and the Edgetech system, (4) conduct *in situ* target strength measurements with the EK500 and Edgetech systems, (5) measure resonance frequencies of the above species, (6) conduct systematic acoustic surveys of selected Atlantic herring spawning stocks, and (7) 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 for 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 the Woods Hole Oceanographic Institution's pier, 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.

Edgetech Acoustic System: The Edgetech 3200-XS consisted of a towbody, tow cable, winch, and topside electronics. The topside electronics were housed in a 2.5'L x 2.5'W x 1.5'H rack, which was located in the SCS room. Edgetech operations were conducted in the SCS room. The SB-512i towbody housed three broadband transducers, receiver array, attitude sensors, and electronics. Towbody dimensions were 63"L x 49"W x 19"H. Frequency ranges of the transducers were 0.5-6 kHz, 4-24 kHz, and 30-110 kHz. The Edgetech towbody was stowed and deployed from the forward A-frame. The Edgetech system's winch was mounted just forward of the bridge and CTD winch. The SSSG SeaMac winch had a footprint of 4'x4' and a height of 4' and it required 480vac with 30 amp power.

Edgetech Standard-Target Calibrations and Target Strength Measurements: At selected locations, calibration, target strength measurements, and measurements of transmitted waveforms were obtained while the vessel was drifting. For calibration measurements, a 200-mm-diameter aluminum sphere was suspended approximately 20 m below the towbody using 200-lb-test monofilament. The towbody (and sphere) was lowered over the side to a depth of 1-5 m, depending on side-lobe interference from the vessel hull. The towbody and sphere were then lowered, at 5-m increments, to within 30 m of the bottom to monitor changes in acoustic backscatter measurements as a function of towbody depth.

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. Navigational, meteorological, and

environmental data were collected throughout the cruise using the FRV DELAWARE'S Scientific Computer System (SCS).

EK500 and EK60 Target Strength Measurements: Target strength measurements with the hull-mounted EK500 split-beam transducers and with a towbody-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 forward A-frame while drifting for 30-60 minutes. The towbody was deployed using the CTD wire (without CTD attached) and with the transducer cables taped to the CTD wire at regular intervals. The EK60 echo sounder was located in the SCS room.

SonarData Echoview Post-processor: SonarData software (v. 3.30) 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 m^2. The trawl was rigged with four 54.8 m (179'9") bridles to 1.8 m^2 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.

Codend Aquarium: The aluminum codend aquarium was attached to the midwater trawl at selected locations. The codend aquarium was designed to capture live specimens for further research at sea or kept in captivity, in the live well until back at the dock.

Live Well & Fish Sorting Checker: Due to space limitations on the FRV DELAWARE, a live well was integrated with the standard fish sorting checker table. A constant water supply to the live well was required. A 120-VAC water chiller was added to the live

well. Unfortunately, a few problems in the design of the live well (e.g., the hatch was not water tight) and chiller (e.g., the chiller will require a cover) were encountered and this system was not used during the cruise.

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.

Underwater Stereo Video System: Two underwater cameras, two lights, and a Jasco attitude sensor were attached to the acoustic towbody for collecting optical images and for monitoring the pitch and roll of the towbody. The towbody was suspended from the video winch and the towbody was lowered to a maximum depth of 170 m. The towbody was deployed from the forward A-frame and the transducer cable was taped to the tow cable at regular depth intervals. Matched DSP&L SuperSeaCam 5000 underwater video cameras were mounted on the towbody to obtain stereo imagery. The cameras had a CCD 10^{-3} lux low-light sensor with 97^0 horizontal and 77^0 vertical angles of view and automatic backlight compensation. Two DSP&L MultiSeaLites provided illumination. The Jasco attitude sensor recorded real-time depth, temperature, compass bearing, and three-dimensional orientation to measure the in-situ orientation of the towbody. Video and environmental data were recorded through a 330 m multi-conductor cable to digital tape recorders. The video recordings were synchronized using a time-code generator and the vessel's GPS clock for accurate analysis in relation to the acoustic data collection.

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 once per day to collect salinity samples.

Vemco Minilog Probes: Temperature-depth probes (set at a 1 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). 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

Part I began with calibrations of the FRV DELEWARE'S Simrad EK500 Scientific Echo Sounder, and system testing of the Edgetech broadband system at the Woods Hole Oceanographic Institution's pier during Sept. 6-7. The EK500 38 and 120-kHz echo sounders were successfully calibrated. Edgetech system integration, performance tests and mounting the Edgetech's winch to the deck were completed with the assistance of the ship's engineers and WHOI personnel. Upon completing the 38- and 128-kHz calibrations and Edgetech system testing, the vessel departed on Sept. 7 to calibrate the Simrad EK500 18-kHz echo sounder and perform performance tests on the Edgetech system in Cape Cod Bay (Fig. 1). Acoustic interference among the EK500, Edgetech, and ship sounders was evaluated and it was determined that we needed to suspend transmission of the EK500 38-kHz echo sounder during Edgetech deployments. Unfortunately were unable to complete a full calibration of the 18-kHz due to water currents and wind. However, we were able to complete enough of the calibration to verify that the 18-kHz was operational and we departed to begin steaming to Georges Bank to commence pilot acoustic research using the Edgetech system and Simrad EK500.

On Sept. 8 the midwater trawl was set to test the FS903 and trawl operations. The trawl got severely twisted and the deck crew worked for nearly eight hours repairing the net. After repairing the net, the Edgetech towbody was deployed for a series of tow tests to determine towing characteristics. During initial tests, the towbody and cable tended to veer towards the vessel. A number of modifications, such as changing the tow-point configuration and adding fins, to the towbody were tried to keep the towbody away from the hull. Ultimately a tow configuration was chosen to maximize the distance between the tow cable and hull. However, Edgetech deployments required the wind or currents to be from the starboard side to maintain a safe distance between the Edgetech tow cable and the vessel.

Upon completion of the test tows, we commenced a systematic survey over Georges Bank on Sept. 9. The survey consisted of parallel transects (oriented north-south), with an adaptive strategy. Survey operations included EK500 acoustic data acquisition, midwater trawling, CTD profiles, and Edgetech deployments. CTD profiles were collected at the beginning and end of each transect, and before each deployment or set of deployments. EK500 data acquisition was continuous throughout the survey, with the exception of during Edgetech deployments where the EK500 38-kHz echo sounder was set to "passive".

When fish aggregations were located, CTD casts, midwater trawls, and Edgetech deployments were conducted. In general, a CTD profile was completed, a midwater trawl was conducted to determine the species composition and size distribution of the

acoustic backscatter, and then the Edgetech towbody was deployed and retrieved. The Edgetech towbody was towed at a variety of depths to a maximum depth of 300 m, depending on the depths of the fish aggregations. Tow speed of the Edgetech was generally below 4 knots. At two locations, the codend aquarium was attached to the midwater trawl for collection of live specimens. We were unable to maintain live herring because the hatch cover on the live well allowed water and debris from the checker table into the tank, which made the tank water uninhabitable for the fish and clogged the chiller's circulation unit. We attempted to modify the seal on the hatch cover and put a screen on the chiller, but were unable to get an optimal configuration. Upon completion of the survey in the Georges Bank region on Sept. 14, we steamed to Jeffreys Ledge to conduct experimental work on Jeffreys Ledge, Stellwagon Bank and Cape Cod Bay. Operations were completed on Sept. 15.

Overall this portion of the cruise was very successful, with a considerable amount of broadband acoustic data, environmental and biological data collected. A total of 80 deployments (27 Edgetech, 39 CTD, and 14 trawl deployments) and 29 transects were completed.

Part II

Part II was dedicated to systematic acoustic surveys of Atlantic herring along the northern edge of Georges Bank, Gulf of Maine and Jeffreys Ledge. Survey operations included EK500 acoustic data acquisition, midwater trawl hauls, and CTD profiles. The vessel departed Woods Hole on Sept. 19 and steamed to the northeast peak of Georges Bank. The vessel arrived on station on Sept. 20 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. This survey was completed on Sept. 27, with a total of 18 trawls, 55 CTDs and 38 transects (parallel and crossover) completed.

At the completion of this survey, we steamed to Jeffreys Ledge to conduct a systematic survey of Atlantic herring (Fig. 2). This survey commenced on Sept. 28 and consisted of parallel transects oriented east-west with 5 nmi spacing. CTD profiles were conducted at the beginning of every other transect. Trawl locations were selected on an *ad hoc* basis to sample the acoustic backscatter. High winds forced us to suspend operations on Sept. 29 and we steamed to Cape Cod Bay to attempt a calibration of the 18-kHz EK500 echo sounder. However, the seas were too rough for operations and we steamed back to Woods Hole for arrival at the dock on Sept. 29. Six trawls, 13 CTDs and 11 transects (parallel and crossover) were completed in the northern section of Jeffreys Ledge.

Part III

Part III was dedicated to a second calibration of the EK500 38-kHz echo sounder, a complete calibration of the 18-kHz, a systematic acoustic survey of Atlantic herring along the northern edge of Georges Bank and experimental transects to investigate the diel variability of acoustic backscatter. The vessel departed Woods Hole on October 4

and steamed to the northern edge of Georges Bank. We commenced a systematic survey of the northern edge of Georges Bank, beginning just west of the Hague Line (Fig. 3). This systematic survey consisted of parallel transects oriented northwest-southeast and was designed to survey for Atlantic herring and to find spawning aggregations of Atlantic herring. During this survey, we observed that Atlantic herring were less abundant in this area than during Part II, so we steamed to the Cultivator Shoals area of Georges Bank where an aggregation of Atlantic herring was located. We conducted a set of experimental transects to monitor diurnal changes in Atlantic herring spatial distribution, density, and abundance. These transects were approximately 4 nmi long, and had identical begin and end locations. A 24 hour series was conducted, and then completed midwater trawl hauls and collected *in situ* target strength measurements. At the completion of these experimental transects on Atlantic herring, we located an aggregation of Acadian redfish (*Sebastes fasciatus*) in the Franklin Swell and Franklin Basin areas and commenced a set of transects similar to those on herring. After these transects were completed, we completed midwater trawls hauls and collected *in situ* target strength measurements. During Part III, 21 CTD profiles, 5 midwater trawls, 8 *in situ* target strength deployments, and 54 transects were 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/

SCIENTIFIC PERSONNEL

National Marine Fisheries Service, NEFSC, Woods Hole, MA

Michael Jech (Chief Scientist – Parts 1, 2)	Research Fishery Biologist	Parts I, II, III
William Michaels (Chief Scientist – Part3)	Research Fishery Biologist	Parts II, III
Joseph Godlewski	Electronics Engineer	Parts I, III
Sean Lucey	Sea-going Technician	Part I
Sarah Pregracke	Fisheries Biologist	Part I
Richard Raynes	Gear Specialist	Part I

Woods Hole Oceanographic Institution, Woods Hole, MA

Dezhang Chu	Acoustic Scientist	Part I
Timothy Stanton	Acoustic Scientist	Part I

Naval Postgraduate School, Monterey, CA

Benjamin Reeder	Acoustic Scientist	Part I

National Marine Fisheries Service, NER, Gloucester, MA

Ellen Keene	Research Fishery Biologist	Part III

Contractors, NEFSC, Woods Hole, MA

Lisa Bonacci	Acoustic Technician	Parts I, II, III
Jakub Kircun	Sea-going Technician	Part II
Hassan Moustahfed	Acoustic Scientist	Part II
Yvonna Rowinski	Sea-going Technician	Part III

University of Rhode Island, Narragansett, RI

Rebecca Bannon	Graduate Student	Part II

Volunteers

Joshua Mishler	Houston, TX	Part II
Natalia De La Rosa-Martell	Shippensburg, PA	Part III

Part I: 6 – 16 September 2005
Part II: 19 – 30 September 2005
Part III: 3 – 14 October 2005

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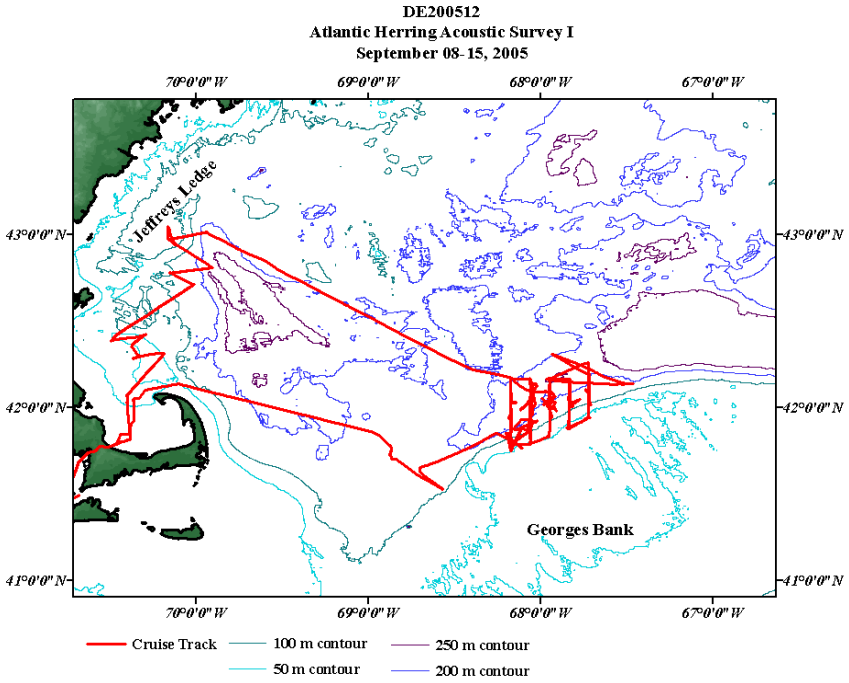

Figure 1. Area of operations and cruise track for Part I (September 8-15, 2005) of DE200512, Atlantic herring acoustic survey.

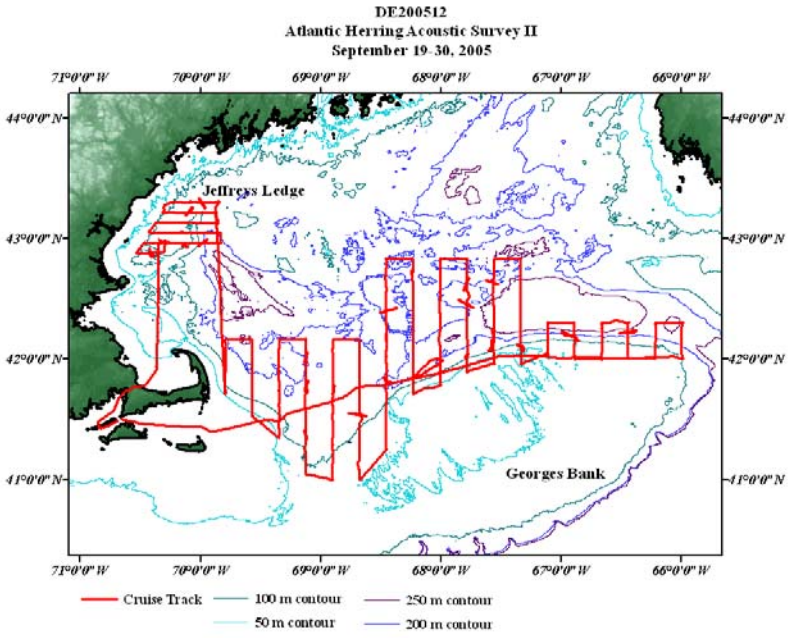

Figure 2. Area of operations and cruise track for Part II (September 19-30, 2005) of DE200512, Atlantic herring acoustic survey.

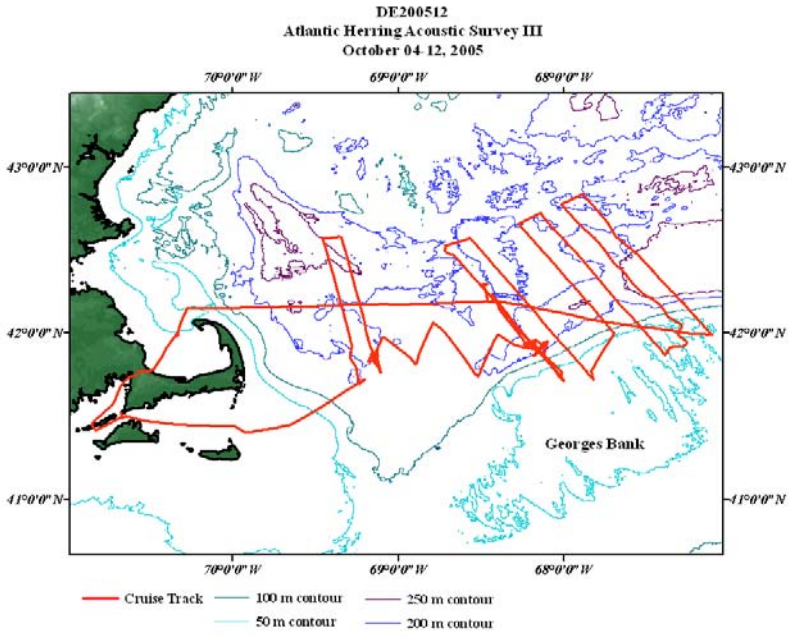

Figure 3. Area of operations and cruise track for Part III (October 4-12, 2005) of DE200512, Atlantic herring acoustic survey.